Mobile Computing in Work-Integrated Learning: Problems of Remotely-Distributed Activities and Technology Use.

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Dissertation submitted to the University of London in partial fulfilment of the requirements for the award of the Degree of Doctor of Philosophy in Information Systems

January 2005

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P.O. Box 1346
Ann Arbor, MI 48106-1346

Abstract

Recently, the continuing digitalisation of our social and analogue lives has assumed a new dimension. This dimension has resulted from of the introduction of portable information and communication technologies (ICTs) – notably mobile phones, personal digital assistants (PDAs), laptop computers, smart phones and tablet computers – whose physical, instrumental and functional properties provide opportunities for mobility of interaction, information processing, learning and work. A parallel development along this dimension is the contemporary remote distribution of erstwhile-localised human activities, subsuming some dissolution of distance and time boundaries by portable ICTs.

This is a dissertation about the problems of remotely-distributed activities and technology use, in general; and specifically about the mutual shaping between remotely-distributed work-integrated learning and mobile computing. The study is underpinned by a developmental psychology perspective to purposeful human activities being seen as processes which are mediated by psychological and physical tools. It explores this mutual shaping by addressing related parameters such as motives, mobility, power, control, distribution and mobile computing. The aim is to unearth an understanding of how this mobilisation of technology, humans and mobile computing shape each other within the framework of purposeful mobilised activities.

The analysis carried out after an in-depth theoretical and empirical study of these relationships reveal the following: a paradoxical relationship between human mobility and flexible computing; a high tendency for ICT users to reconstruct portable artefacts based on a drift in utility between the satisfaction of objective and personal motives; power relations between remotely-separated authorities of an activity translate into control of workers' or learners' actions (including computing actions) and contribute to reconstruction of artefacts. Based on these findings, this dissertation makes a theoretical contribution through the proposal of an action-based model of remotely-distributed activity that can be drawn upon to analyse computing in contemporary technology-mediated distribution of work and learning.

"Tager du mig for en lærd og belæst mand?"
"Selvfølgeligt," svarede Zi-gong, "er du da ikke?"
"Ikke det mindste," svarede Confucius.
"Jeg har blot greb om een tråd der forbinder alle de andre"

"Do you think me a learned, well-read man?"
"Certainly," replied Zi-gong, "Aren't you?"
"Not at all," said Confucius.
"I have simply grasped one thread which links up the rest"

[Recounted in Sima Qian (145-ca. 89 BC), "Confucius," in Hu Shi, *The Development of Logical Methods in Ancient China*, Shanghai: Oriental Book Company, 1922; quoted in Qian 1985:125, in Castells 1996, p.1.]

To my family.

Mum, your sacrifices have not been in vain.

Acknowledgements

The production of this thesis is the culmination of a long excruciating period of hard work inspired by my undying desire for scholarship and knowledge. This period of formal education has spanned from my early years of learning at UST Primary School in Ghana to these current times as a research student at the London School of Economics. That I have come through this period of severe financial, social and emotional challenges is an accomplishment simply beyond my comprehension and a feat I never imagined my physical, financial and mental resources would enable me to tackle in this short period. It is in this context that I thank God for His abundant grace and unfailing compassions, and for endowing me with sufficient health, wealth and understanding which have sustained me throughout this period. It is also in this context that I find Psalm 30:1 appropriate:

"I will extol thee, O LORD; for thou hast lifted me up, and hast not made my foes to rejoice over me."

The Information Systems Department of the LSE has been a wonderful academic environment since my days as a master's student, and immediately afterwards as a PhD student and Graduate Teaching Assistant. One outstanding personality of this department is Dr. Carsten Sørensen: affable, supportive, diligent and honest are the few, among many, resounding epithets I will use to describe him. He has not only been always supportive as my research supervisor, but was always responsive to my requests even during master's degree studies. **Dear Carsten, please be assured of my most profound appreciation for the confidence you have had in my academic abilities that made you choose to supervise my research, and for the encouragement you offered me at the beginning when my ideas seemed to be heading nowhere.**

I also thank my assessors, Dr Susan Scott and Antonio Cordella, as well as Dr. Jannis Kallinikos, my tutor, whose suggestions on my early writings about this research have been invaluable.

I cannot leave out my Ghanaian teachers, masters and lecturers through whose lowly-paying efforts and sacrifices I acquired a sound academic foundation upon which my current level of knowledge has been built. Although it is often euphemistically said that their "rewards are in heaven", they are worth every bit of my earthly glorification.

Dr. Roger Kneebone of Imperial College London and his PSP project team, as well as the PSPs whose learning activities I studied, deserve a special mention because coming into contact with them was the most decisive encounter of my research. I thank Roger for allowing me to study the project throughout its duration, and even to study it as an action researcher which allowed me overwhelming access to data and was immensely beneficial. I thank his team members – Harry Brenton, Amanda Burgess, Jackie Younger, Michael Singh and Heather Fry – for their invaluable support. I also thank the 12 PSPs for their cooperation during my interviews and tutorials, and for all those times when I was in desperate need of data from them.

Special thanks also to Prof. E. Y. Safo who, over the years, has contributed significantly towards my educational progress.

There are some brilliant people whose ideas I have drawn upon to develop my own in this thesis; some of them I have never met before and have passed away, some still alive today. I am greatly indebted to the departed Lev Vygotsky and Alexei Leont'ev, and the living Yrjö Engeström, whose expositions on Developmental Psychology, Learning and Activity helped me to clearly understand the research problem.

I am also grateful to all my friends who have kept me happy during my research. Mr Joe Appiah-Brantuo, Anthony Tuffour, Benjamin Acquaye, Clement Twumasi, Richmond Adjei, Regina Osafo-Adu, Collins Asare, Eugenia Sasu, Kofi Agyenim Boateng, Lawrence Dzakpa, Peter Fosu and James Owusu are a few of an uncountable and valued number of friends in this respect. Their patience, love and understanding over the period when I was a virtual social recluse are particularly appreciated.

To all my colleagues whom I encountered at the LSE, especially Daniel Osei-Joehene, Dr. Frederick Wamala, Jan Kietzmann and Daniel Pica, I thank you very much for the invaluable pieces of advice you have offered me.

Last but not least, I have enjoyed being a player of the LSE football team since my enrolment, and I thank all the players over the period for the wonderfully cherished times. My captains over the period, Dean Taylor, Gavin Peck, Jan Wojna, Tom Winston and Matt Davenport, deserve special mention for their organising efforts.

> *"It is certainly regrettable, that under the circumstances many frequent and notable species cannot be referred to due to lack of space and a great number of them, which would definitely have been worthy of further attention, can only be mentioned in general"* – Richard Heymons, 1915.

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Chapter 1: Research Issues

1.1 Prelude

Recently, the continuing digitalisation of our social and analogue lives has assumed a new dimension. This dimension is a corollary of the introduction of portable information and communication technologies (ICTs) – notably mobile phones, personal digital assistants (PDAs), laptop computers, smart phones and tablet computers – whose physical, instrumental and functional properties provide opportunities for mobility of interaction, information processing, learning and work. A parallel development along this dimension is the contemporary remote distribution of erstwhile-localised human activities, subsuming some dissolution of distance and time boundaries by portable ICTs.

'Mobility' is now a popular catchword not only in the realm of information systems (IS) research but a really pervasive and ubiquitous term in contemporary society. 'Mobile' is its concomitant or substitute term normally applied as an adjective to describe traditional phenomena that have experienced some mobility due to the stimulus of portable ICTs. Also closely related to 'mobility' and 'mobile' is Kleinrock's (1996) "anytime, anywhere", which portrays the capacity of portable ICTs to overcome spatial and temporal boundaries. In addition to these, Lyytinen and Yoo (2002) have recently coined the phrase "nomadic information environment" to illuminate the magnitude, pervasiveness and ubiquity of mobile computing that have enabled the digitalisation, miniaturisation, and integration of information, as well as the unprecedented possibilities to access, manipulate and share information on the move (*Ibid.*). Many others have used the terms 'pervasive' and 'ubiquitous' computing to draw our attention to the fact that mobility is now an integral aspect of our lives at both personal and institutional levels (e.g. Kopomaa 2000).

Portable 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. For

instance, how professionals' work and learn in distributed environments with portable ICTs, as well as the dynamics of the mutual shaping between those activities and their mobile computing have seen little investigation and clarification. This study takes up the challenge to explore how mobile computing and remotely distributed learning activity shape each other.

This introductory chapter sets up the research agenda and provides a preview of the entire organisation of the whole dissertation. In Section 1.2, I present the precursors and rationale that represent the grounds upon which the inspiration for this study was derived. Section 1.3 discusses some of the socio-technical challenges inherent in these precursors that inspire this research endeavour. Based on this, the research question, the objectives that guided this study, a brief introduction of the empirical study are presented under Section 1.4. Finally, the organisation of the rest of this dissertation is previewed in Section 1.5.

1.2 Precursors and Rationale

Information revolution and information society are captions used to represent the rapid development and diffusion of ICTs, notably the Internet and World Wide Web (WWW) (Castells 2001). In their wake, we have seen the development of portable ICTs to meet users' demands for information processing and interaction anytime, anywhere (Kleinrock 1996). It is not uncommon therefore to see almost everywhere people communicating through mobile phones with colleagues who appear not to be co-present. It does not take too long before one encounters people busily working with laptop computers in the train. And we see others organising themselves and their tasks assisted by the functionalities of PDAs in both social and organisational mobile settings. Thus we witness pervasive and ubiquitous computing triggered by dramatic developments in ICTs such as WAP[1], Bluetooth™,[2] and 3G[3] mobile phones, and their users' nomadic behaviour (Lyytinen and Yoo *op. cit.*).

[1] WAP means Wireless Application Protocol. It is an open global standard that specifies standards for mobile users information and service access. Visit www.wapforum.org for more information.
[2] Bluetooth™ is a de facto standard for wireless communication among various devices in short to medium distance. For more information visit www.bluetooth.com.
[3] 3G refers to the third generation mobile phone systems that allow broadband access for enhanced wireless service. For more information refer to www.3gpp.org.

The ubiquity and pervasiveness of portable ICTs uses facilitate human geographical movement in urban life, work environments and other social milieus (Bergquist *et. al.* 1999, Dix and Beale 1996, Kristoffersen and Ljungberg 2000, Kopomaa 2000); they also facilitate the speeding up of transactions and time savings; that Barley (1988) conceptualises under structural and interpretive temporality; and they influence changes in the context or situatedness of mobile interaction (Kakihara and Sørensen 2002a). Moreover, the spatial, temporal and contextual aspects of mobility have resulted in the emergence of mobile professionals whose work practices are mobile in the operational, locational and interactional senses (Kakihara and Sørensen 2002b).

These emerging issues are inducing new forms of organisations, organising, work and learning. Compared with traditional organisations, mobility and distribution enables work and learning to transcend organisational boundaries, and facilitates the organisation of these activities among interdependent professionals who are geographically distributed and mobile. As mediating technologies, portable ICTs are transforming activities through the restructuring of practices, of institutional arrangements and of the cognitivisation of work (Ciborra 1993).

However, in terms of communication, coordination and collaboration of mobile activities, while portable ICTs are fulfilling Kleinrock's vision of anytime, anywhere interaction, the process presents new mobile information services challenges. These challenges manifest in the complexities and uncertainties in information processing and generation, and interaction (Mathiassen and Stage 1992, Sørensen *et. al.* 2002); they are also reflected in the deficiencies of technology mediation, which are explained in concepts such as Media Richness (Daft and Lengel 1986), Social Presence (Short *et. al.* 1976), Cognitive Cues (McCarthy *et. al.* 1991, McCarthy *et. al.* 1993) and Remediation (Bolter and Grusin 2000). Furthermore, mobile computing and interaction are also confronted with the socio-technical problems associated with remotely distributed activities (Olson and Olson 2000).

1.3 Inspiration

In recent years, society in general and IS research in particular have been confronted with the development, uptake and deployment of portable ICTs by individuals and organisations alike. It may even be fair to say that IS research has been overwhelmed

by this phenomenon. For example the problem of learning induced by portable ICTs has received relatively inadequate attention in technology-mediated learning (TML) research so far. Given the current rapid pace of technological advancement, it is imperative that IS research efforts on learning match this pace before the whole concept of mobile TML is hopelessly left unexplored and as a cumbersome legacy. At a time when the mobility discourse itself lacks any rigorous analytical underpinning, leaving mobile TML unexplored would be self-defeating.

From another angle, traditional localised activities are increasingly being remotely mobilised and distributed. This new phenomenon results from the demands of modern knowledge work which has given birth to concepts such as mobile work, mobile learning, "postmordern nomads" (Bauman 1993, 2000), "postmodern professionals" (Kakihara and Sørensen 2002b), and "social mobility" (Goldthorpe 1987, Hope 1972).

The pervasiveness and ubiquity of portable ICTs has placed mobility in a central position within human-centred disciplines such as sociology, social psychology, anthropology, economics, and urban geography – disciplines upon which IS research largely draws. There has been some mobility research studying how portable ICTs relate to phenomena such as Knowledge Management (e.g. Wiberg and Ljungberg 2001), work patterns (e.g. Kakihara and Sørensen 2002b), collaboration (e.g. Dix and Beale 1996, Luff and Heath 1998) and CSCW[4] (e.g. Wiberg 2001). There are also emerging research efforts into the design and uptake of mobile and wireless ICTs (e.g. Dix *et. al.* 2000). Furthermore, there has also been extensive research on technology-mediated learning (TML) which relates to desktop ICTs.

But there does not seem to be a proper understanding of the relationship between mobile computing and mobile and distributed learning from the individual, social and organisational perspectives. We apparently lack the desired understanding of how mobile computing shapes a fundamental aspect of our physiological, sociological and psychological abilities – our ability to learn. Moreover, as Kakihara (2003) has indicated, the current discourse on mobility is very unstable and seems to lack any

[4] Computer-Supported Cooperative Work

rigorous analytical foundation. The diverse nature of mobility requires some unification to bring a clarified understanding in this discourse. These unfilled gaps represent significant theoretical challenges as well as an inspiration to make a contribution in this direction. An attempt to fill these gaps is the main challenge of this thesis.

1.4 Research Question and Scope

Against this background, this thesis aims to explore the mutual shaping between mobile computing and mobile work-integrated learning (WIL), and to contribute new ideas concerning the social and organisational impact of mobility and distribution of activities on technology use. This challenge also incorporates the examination of the impact of portable ICTs on several key issues in mobile WIL. These issues, which also define the scope of the study, are the essential matters of examination towards the achievement of an enhanced understanding of portable ICT adoption and deployment in distributed activities.

First, the problem of computing in WIL is situated within the problem of *mobility vs. stability*. Specifically, it is confronted with fluid mobile learning in remote locations versus stable social networks of those distant locations that challenge the purposes of the WIL setup. Flexibility emerges because of the need to fit learning into the work process as a means of ensuring learning-in-practice; at the same time, it implies instability as learning instructors are removed from the learning practice. On the other hand, the community of professionals whose practice is being learnt present challenges in terms of the learners' continuous striving to become integral members of those communities.

In relation to mobility and stability, *monitoring and coordination* of the distance learning actions of the learners is also critical in terms of the efforts of learning instructors' tendency to control actions from remote locations. Very typical of learning, monitoring and coordination are aimed at accreditation and accountability of the learning process and contents. In this regard, the adoption and deployment of portable computers as controlling measure takes place through instructors' design of inscriptions into the technology.

However, the success of these controlling inscriptions is engrossed in the *politics of technology use* of those who are in immediate control of the learning process. These portable computers are meant to achieve their *independence of computing support* for the learners, and eliminate their dependence on existing ICT infrastructure of their immediate learning environments. The challenge is in the degree of remote control achieved by these inscriptions towards this form of independence.

Based on the dynamics of experience of using these technologies, another interesting issue which cannot be overlooked is the *reconstruction* of these portable artefacts by the learners, given the conditions and circumstances within which the learning and computing actions will occur. One significant challenge, therefore, will be an examination of the process of reconstruction of the portable computers within the learning conditions.

To achieve this aim, I seek to address the overarching question: *How do the phenomena of mobile computing and the distribution of work-integrated learning mutually shape each other?*

This question translates into some decisive sub-questions:

- *What is the role of portable computers in distributed work-integrated learning?*
- *To what extent do the design properties of portable computers affect their uses in mobile learning settings?*
- *How do the situational effects of mobile work-integrated learning shape mobile computing?*
- *What is the role of work-integrated learning in the reconstruction of portable computers?*
- *How constraining, in terms of computing, is the distribution of an activity?*

In order to address these questions, I have conducted a longitudinal empirical study of the use of portable computers in a natural, real-world archetype of *distributed work-integrated learning*. Although the study is idiographic, it is undoubtedly an epitome of a distributed activity that is mediated by portable ICTs. Based on an action research strategy, I have been directly involved in this work-integrated learning project as a

facilitator; and this immediacy offered me a deep insight into the complexities inherent in the process. The central arguments of this thesis are derived from the comprehensive and intensive analysis of the data collected in the empirical study which is briefly sketched below.

1.4.1 Empirical Study

The Perioperative Specialist Practitioner (PSP) is a new medical professional role in surgery created to take over some of the functions that were performed by Junior Doctors in the National Health Service (NHS) of United Kingdom (UK) as of early 2003. Before August 2004, Junior Doctors in the NHS used to work for more than the number of hours per week allowed under the European Union Working Time Directive (EUWTD). The working time directive stipulated, among others, that junior doctors must not work for more than an average of 58 hours per week. This legislation has since been in full force since August 2004. Since the production of junior doctors in UK was suffering at the time, and even training of many more of them would take more than a few years to complete, pressure was mounting on the NHS to fill the impending vacancies with a new category of health professionals. On Tuesday 15 July 2003, Wayne Versey reported the looming crisis in the London *Evening Standard* as follows:

> "Restrictions on junior doctors' hours could force hospitals to close their casualty departments overnight, (...).
>
> Employment rules will mean trainee doctors will be limited to a 58-hour week from August 2004 to protect them from exhaustion. The current maximum is 72 hours.
>
> But the royal college of physicians (RCP) argue that extending the EUWTD to trainee doctors will impose an added burden on the overstretched NHS.
>
> A survey of emergency cover at 211 hospitals in England by the RCP found that if these restrictions were already in place, more than 40 of them would find it "very difficult" to cope." (2003, p.2).

Thus, PSPs were to be trained to acquire and provide pre- and post-surgical clinical care skills. The trainees were constituted by existing medical staff who served in various capacities in other hospitals under the NHS. Their learning was work-integrated because they trained in the same hospitals in which they worked in different locations across UK, and their learning took place within the work practice. Personal Digital Assistants (PDAs) were deployed to be used by the trainees 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 use the PDAs 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. The results of the pilot would be fed into the institution of subsequent mass-scale training schemes for PSPs in future.

1.4.2 Research Objectives

This thesis aims to establish an understanding of the relationship between portable ICTs and distributed WIL. In other words, the study focuses on unearthing the complexities inherent in the use of current portable ICTs such as PDAs for distributed WIL. It is approached from a human development viewpoint grounded in the principles of Cultural-Historical Activity Theory (AT). As a psychological theory of learning and development, AT lends itself for use as a framework for analysing this relationship. While the theory offers a cogent set of postulates for the aims of this study, it does not properly address the problems of the distribution of activities which are mediated by complex and portable ICTs. In order to address this deficiency, this dissertation seeks to build upon AT by proposing a computing-based model of *distributed activities* to guide the study of contemporary activities which are integrated with mobile computing.

We cannot expect to derive meaningful explanations of the dynamics involved in modern mobile and distributed activities if we rely on theoretical frameworks built on traditional localised or concentrated activities. The nature of these activities makes the role of portable ICTs in communication, collaboration and cooperation crucial. In this respect, a computing-based model of distributed activities will serve as a methodological foundation for future research endeavours on mobile and distributed activities. It will lend itself as a useful framework to be drawn upon in subsequent research efforts on distributed activities.

The influx of portable ICTs in contemporary society and the concomitant marketing gimmicks have ensured that, in most instances, they are erroneously adopted and deployed in most learning activities of recent times. It is well known that most of these artefacts and their inscribed software are pre-packaged products. And for pre-packaged products, since they are not tailored to suit peculiar learning activities, their adoption and deployment can result in complete misplacement of priorities.

Furthermore, the mediocrity of current understanding of the concepts of distribution and mobility has left decision makers with virtually no source of theoretical knowledge to draw upon when they are adopting and deploying portable ICTs for learning purposes. Against this background, this dissertation will contribute practical insights on the role of portable ICTs in mobile and distance learning activities.

1.5 Organisation of the Thesis

In Chapter 2, the literature on portable ICTs is reviewed in relation to emerging conceptions of mobility. It presents an analysis of the relationship between human activities and portable ICTs in a review of the potential information services they offer. This is followed by a review of the learning literature relevant for the aims of this study. The learning review is centred on the notion of learning as a socially mediated phenomenon. This leads to a discussion of how the mediation by contemporary ICTs has reshaped contemporary learning processes and styles. Against this background, the challenges presented by portable ICTs in technology-mediated learning research are presented.

Chapter 3 presents the methodology that guided the theoretical and empirical aspects of this study. It discusses the methodological decisions taken and their justifications – from the philosophy of approach, strategy, type of data collected, methods of their collection and analytical techniques.

Chapter 4 presents the theoretical framework that gives perspective to this study. An overview of Activity Theory – discussion of its structure, system and principles – is undertaken to depict its suitability for the aims of this study. Within this, mediation by ICTs in learning activity is brought into focus and discussed in relation to the concept of affordance.

Chapter 5 introduces the case study – the training of the Perioperative Specialist Practitioner including the research findings. This comprises a detailed presentation of the relevant data and information obtained from the empirical study of mobile computing in WIL.

In Chapter 6, the data obtained from the case is thoroughly analysed and synthesised to shed more light into the complexities involved in the use of portable computers in distributed learning settings. Analysis breaks down the data and elucidates the intricacies of the WIL from an activity theoretical perspective. There, I address the key issues discussed in this chapter within the context of the empirical study. Further, the problem of mobile computing is treated from a combination of technological determinism and constructivism. Finally, synthesis siphons the emerging themes from the analysis leading to a proposal of a flexible computing model.

Then in Chapter 7, a further step is taken to propose a computing-based model of remotely-distributed activities in a discussion based on an integration of Chapters 2 to 6. This is purely a theoretical discussions chapter that delves into abstract deliberations and general propositions, and in which I draw from my understanding of both the theoretical and empirical aspects of the study.

Chapter 8 concludes the dissertation, and presents the key contributions, limitations, future challenges and leads to stimulate further research in the areas which this study has covered and uncovered.

Chapter 2: Portable ICTs, Mobility & Technology-Mediated Learning

2.1 Introduction

In accordance with the objectives of this study, this chapter presents a review of the literature on portable ICTs, and those of the phenomena of mobility and learning. Although the predominant problem of this dissertation is to address the question in which all three phenomena show intrinsic interdependencies, the review process undertaken in this chapter slightly separates the literature on mobility and learning. Thus, the first part tackles the mutual relationship between contemporary portable ICTs and mobility, while the second part takes up the problem of learning and technology-mediated learning, culminating in a review of mobile learning mediated by portable ICTs.

In the first part, I attempt to improve the clarification of this relationship through a review of the literature on portable ICTs and mobility. Section 2.2 presents an elucidation of the significance of portable ICTs in contemporary society based on their interaction and computing affordances, and the impetus it has given to mobility research in the IS field. In Sub-section 2.2.1, the modalities of human mobility are presented within the context of factors that affect the use of portable ICTs. Next, Sub-section 2.2.2 places mobility of humans and ICTs within three fundamental dimensions – space, time and context – with an aim to illustrate the potentialities of portable ICTs for overcoming spatial, temporal and contextual constraints. Finally, Section 2.2.3 presents an analysis of the relationship between human activities and the use of portable ICTs in a review of the potential information services they offer.

In the second part, the problem of learning is placed within the dimension of objective and subjective ontology and epistemology in Section 2.3: a review of existing learning literature and research on technology-mediated learning (TML) along these subjective and objective dimensions. Sub-section 2.3.1 presents a discussion of constructive and instructive learning leading to the placement of learning within social systems. I argue that learning is inherently social, and relies on physical and

psychological tool mediations of various forms. In Sub-section 2.3.2, literature on technology-mediated learning is also reviewed; within this, the potential of physical mediating tools such as current mobile and portable ICTs, which comprise the other phenomena under study, are discussed in detail. I conclude this chapter, in Section 2.4, with a summary of my key arguments.

PART I

2.2 Portable ICTs and Mobility

There is no doubt that portable ICTs have completely revolutionised contemporary society; and the desire to elucidate their impact has preoccupied researchers from several disciplines – urban sociology, geography, anthropology, town planning, information systems and economics, to name the most dominant. In other realms, attempts to improve the understanding of the relationship between portable ICTs and mobility have been approached from technical and social perspectives (see Kakihara 2003). However, existing mobility literature portrays a murky understanding of this relationship.

The term 'mobile' is usually applied as an adjective to describe entities that exhibit or are capable of moving; related and similar words are motile and nomadic. Mobility is the noun representation of mobile and it signifies diverse abilities, states and qualities of being mobile. In studies of mobility, there have been some attempts to define the concept, but so far we have not seen any recognisable definition within existing literature; and in organisation and information systems research in particular, 'mobility' has more been described and explained than defined. Among the several mobility-related research publications, even the most frequently cited authors (e.g. Bellotti and Bly 1996, Dahlbom and Ljungberg 1998, Dix *et. al.* 2000, Kleinrock 1996, Kopomaa 2000, Luff and Heath 1998, Sørensen *et. al.* 2002) have always emerged with publications that fail to address our need for an appropriate definition: "Mobility is one of the words that is virtually impossible to define in a meaningful way. You either develop a definition that excludes obvious instances or the definition is too vague..." (Kristoffersen and Ljungberg 2000, p.140). Even though their claim that it is "virtually impossible to define" is unacceptable, their concerns reflect the mediocre development of emerging mobility research in IS, especially with respect to

its theorising. Kakihara was more explicit in illuminating the diversity of opinions underlying the understanding of what is 'mobile':

> "In fact, the concept of mobility and the significance of 'being mobile' are used in strikingly diverse ways. In some cases, 'mobile' is simply interchangeable with 'portable' or 'wireless' such as portable technology or mobile operations. In other cases, 'mobile' is mostly synonymous with 'remote' such as mobile work and mobile office. Furthermore, 'mobile' sometimes refers to a 'flexible' or 'opportunity-abundant' situation, for instance, mobile society and mobile life" (Kakihara 2003, p.21).

There is no doubt that this particular stage of 'mobility', in its development and theorising terms, can be described as rudimentary. Nevertheless, many of the recent works on mobility together provide descriptions and explanations of generic notions of the concept, which sufficiently represent foundations upon which an improved clarification can be built.

Mobility is an intrinsic and fundamental characteristic of all entities, be they physical or non-physical, tangible or intangible, and is a phenomenon that emerged with the beginning of time. For example people have always been mobile in their instinctive desire to satisfy their biological, social, economic and emotional needs. Even non-living matter exhibit mobility – as we see in various forms of rock weathering and erosion, cloud movements, and wind migrations. Mobility is a human attribute as fundamental as communication. The relationship between mobility and communication can be described as mutually complementary: people's communication needs motivate them to move while mobility brings people together to create avenues and possibilities for communication. Yet, so generic is the existing understanding of 'mobility' that most often it is followed by the question that demands a description of its particular form – 'what form of mobility?' In other instances, the question of relevance in mobility has concerned the scale of human mobility, which usually surrounds the distance covered by a mobile individual – on a continuum from local to remote. For instance, in their discussion of the contemporary mobile society, Kristofferson and Ljungberg (2002) classified human mobility under three broad categories or modalities – travelling, visiting and wandering (see sub-section 2.3.1).

In IS research, new mobile and portable ICTs have generated a new wave of research efforts which seek to understand how they impact on society and organisations. Most

notably, explanations of the significance of portable ICTs in IS research are premised, most luridly, on perceptual psychology. The concept of "affordance" (Gibson 1979, Norman 1988, Gaver 1991, 1996, Zaff 1995), drawn from ideas in the psychology of perception, is the fundamental principle underlying current conceptualisations of mobility that espouse the differences in portable technologies. Gibson (*Ibid.*) defined affordances as the opportunities for action for the observer provided by an environment. Gibson's affordances mirror what Ortega y Gasset (1941) describes as "facilities" and "frustrations" that are not properties of the world but properties that lay solely in our "interaction with the world" – our interaction with reality. This sense of affordance is reflected in physical objects of human design such as portable ICTs – what they afford affects the fluidity or incoherence and clumsiness in our activities (Cook and Brown 1999). Mobility of technologies and how that has impacted on our lives is not a contemporary phenomenon. Simple portable technologies such as paper, to complex ones such as the motor car and wrist watch were invented many years ago and have lived with us for centuries, yet their emergence never generated as much interest among IS researchers to pursue mobility studies as it is in contemporary times. Recent enthusiasm in mobility research can be explained by the fact that contemporary portable ICTs afford mobile interaction and information processing. Complemented by the proliferation of wireless networks and internet communications, portable ICTs have revolutionised modes of computing and interaction in society.

Mobility of ICTs in IS research was energized in the mid 1990s by Leonard Kleinrock's popular thesis which espouses a vision of *anytime anywhere* access to computing and interaction (see Kleinrock 1996). Consequently, nearly all publications on mobility make reference to 'anytime, anywhere.' With reference to humans, he revealed the lack of systems support needed to assist various forms of 'nomadicity', and discussed the intrinsic technical challenges and solutions. These challenges are inherent in the possibility of incoherence or frustration in the utilization of objects which often result in the 'immobility' of portable ICTs. This is the cornerstone of Wiberg and Ljungberg's (2001) claim that anytime anywhere access may not necessarily imply everytime everywhere access. Portable ICTs, together with the proliferation of mass digital communication and the convergence of ICTs (Lyytinen and Yoo 2002), have founded new fertile IS research interests as academics seek the

understanding of their impact, and as organisations and individuals in society pursue the maximisation of returns from their use in timely information processing and interaction.

2.2.1 Mobility of Humans and Objects

The various descriptions which 'mobility' can assume are infinite due to the fact all entities and phenomena can assume an ability, state or quality of being mobile. However, the different types of mobility do not always occur on the same level: some mobility types are nested within or premised on other types. Fundamentally, humans are mobile, and therefore human mobility assumes a basic type of mobility upon which other types develop. Recently, human mobility has been reconceptualised based on how the affordances of modern ICTs have reshaped modern forms of human migration and activities. This reconceptualisation is exemplified by phrases such as 'postmordern nomads' (Bauman 1993, 2000), 'postmodern professionals' (Kakihara and Sørensen 2002b), and 'social mobility' (Goldthorpe 1987, Hope 1972).

2.2.1.1 Modalities of Human Mobility

The modes of mobility which humans beings exhibit are very diverse: they can be conceptualised from the slightest movement of the individual to very long distant travels into space. In-between these two extremes, there is an uncountable number of variations of human mobility that are possible, depending on the motives and needs of the individual.

Perhaps the closest anyone has come to theorising human mobility can be seen in the work of Kistoffersen and Ljunberg (2000). While they clearly admitted their inability and the virtual impossibility to define the concept, their in-depth elucidation of the modalities of human mobility has significantly improved the understanding of mobility in IS research. Particularly, their application of ICTs in clarifying their three modalities of human mobility makes their work analytically useful in this study. Modality, according to their definition is the description of the "fundamental patterns of motion" of humans as they move around – *travelling*, *visiting* and *wandering* (see Figure 2.1). These fundamental patterns represent a modest and simple functional characterisation of the complexly variegated nature of human mobility, and are often strongly criticised as lacking any analytical rigour, sometimes unfairly. Unfortunately,

many of the critics do not take the portable-technology-use context within which Kristoffersen and Ljungberg placed these modalities. In the context of the objectives of this study, they are useful in the sense of their intrinsic linkage with the portable technology and the environments of use.

Travelling, as also conceptualised extensively in the work of Urry (2000a, 2000b), 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" (Kristofferson and Ljungberg *op. cit.*, p.142). He or she does some limited travels and visits in a localised environment.

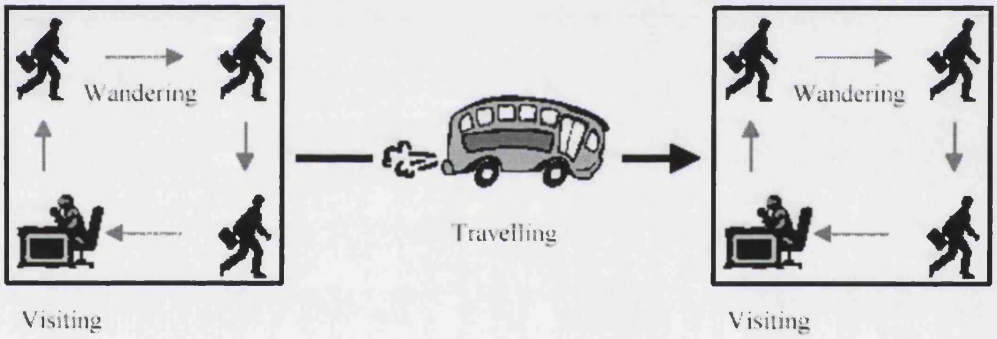


Figure 2.1: Modalities of Human Mobility
[Source: Kristofferson and Ljungberg (2000)]

For the purposes of this study, their categorisation of mobility of humans enhances the understanding of mobility of work-integrated learners, and hence an appreciation of the particular modalities their movements exhibit over time.

Equally important, however, is knowledge about the mobility of objects of utility which humans carry around as mediators of their activities. Here, emphasis must be laid on the utility of the object within mobile conditions: utility is a factor of the immediate variables associated with humans, objects and the environment. Kristofferson and Ljungberg argued that the utility of mobile and portable ICTs (e.g. mobile phones, PDAs, wearable computers) is dependent on three factors – modality,

environment and application (see Figure 2.2). The immediate nature of the physical and social surroundings defines the environment; applications represent the characteristics of ICTs such as hardware, software and data; and modality stands for the fundamental patterns of human movement – travelling, visiting and wandering.

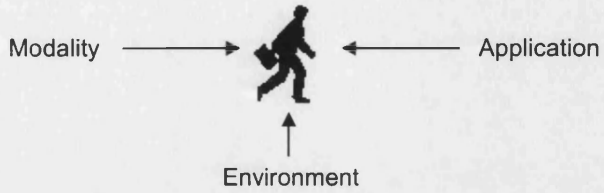


Figure 2.2: Factors affecting portable ICT use
[Source: Adapted from Kristofferson and Ljungberg (2000)]

The model transcends Kleinrock's (1996) oversimplified vision of anytime anywhere use of portable ICTs. Consistent with Kakihara and Sørensen's (2002a) space, time and context dimensions of mobility, the 'environment' dimension introduces some contexts under which portable ICTs uses may not be possible everytime everwhere (Wiberg and Ljungberg 2001). The utility of a portable computer is dependent on the dynamic relationship between what its physical, systemic and interfacial functionalities afford and the task or activity which it is mediating. What it affords is inherent in a combination of the 'application' component of the model and the motive which dictates the fundamental pattern of movement of the individual using the application to perform or support an activity.

The mobility of objects – natural or artificial, physical or non-physical, tangible or intangible – is largely dependent on human mobility. While most objects are capable of self-mobility as depicted in rock weathering and erosion, wind migration and robotic machines, most objects achieve their mobility within human mobility (cf. Dix *et. al.* 2000). To this extent, in most instances, object mobility implicitly implies a fusion human and object mobility. The fusion of human and object mobility is dictated by the biological and environmental needs of humans that motivate and direct their activities. In these instances, objects are either applied as tools for use in production, distribution, consumption and exchange activities; or are themselves the products to be consumed, distributed or exchanged. This point clarifies the relationship between human mobility and the motives that engender mobility: object

mobility depends on human mobility and necessarily on human motives. Thus, the need to operate objects, and for that matter portable ICTs, may themselves be the motives that induce human mobility. The theorisation of the significance of objects' mediation of human activities dates back to the seminal works of Bacon (1620). Later the idea of objects' mediation of activities became the premises of, most notably, Marx's (1976) Political Economics, Vygotsky's (1962, 1978) Developmental Psychology, Leont'ev's (1978, 1982) Activity Theory and Engeström's (1987) Expansive Learning.

Thus far, what is depicted by Kristofferson and Ljungberg is the mobility of humans and the utility of portable ICT objects. As long as the artefacts are the portable objects-in-use, their interaction and computing affordances imply that there is a possibility of the emergence of a countless variety of mobile human activities: for example, the mobility of location, interaction and occupation as corollaries of mobility of humans and objects is luridly conceptualised by Kakihara and Sørensen (2002b). Nevertheless, the mobility of humans, objects and all other types are conceptualised within the dimensions of space, time and context: any analysis of mobility has to deal with questions about *where*, *when* and *under what circumstances* (Kakihara and Sørensen 2002a).

2.2.2 Dimensions of Mobility

2.2.2.1 Spatial Dimension

The definition of mobile inherently incorporates the notion of space: one cannot understand mobility without referring to location because it is the movement of an entity from one location to another which defines mobility. The spatial mobility of some modern ICTs have ensured the possibility of interactions between people who are geographically independent: "the boundary between 'here' and 'there' dissolves" (Kakihara and Sørensen *op. cit.*). People are expected to be geographically independent nomads supported by the 'wirelessness' and portability of ICTs including their information services (Makimoto and Manners 1997). However, spatial mobility does not only describe mobility of people; it also includes the mobility of objects, symbols and space itself (Castells 2001, Urry 2000a). Objects – including artificially designed objects – exhibit mobility because they are carried by mobile humans to mediate certain activities which satisfy particular needs, intentions and motives. These

objects possess symbols that are manipulated during their use; hence object mobility implies mobility of symbols.

The essence of the spatial mobility of artefacts lies in the mobility of information services they afford. It is the mobile information service (Sørensen *et. al.* 2002) of a mediating artefact in a particular activity that gives meaning to spatial mobility. Without mobility of the service, we are left with the mobility of the object, which, in the context of human activities, is non-essential or insignificant.

A point of relevance is that, ultimately, the spatial mobility of humans, objects and symbols and services are interrelated and intertwined. For example, an individual who carries a PDA, laptop computer or a mobile phone certainly does so with an intention to use the service provided by the artefact to perform an activity aimed at satisfying a motive. During this activity, he or she captures, processes or transmits information using the artefact's symbolic properties; and here, the mobility of the individual, the object and symbols occurs simultaneously. If he or she interacts with others using the device, then spatial mobility of the particular information service occurs. Therefore, the interaction and computing information services provided by portable ICTs (*ibid.*), together with the fundamental mobility of humans and objects, achieve spatial mobility in terms of "humans independence of geographical constraints" (Kakihara and Sørensen 2002a, see also Dahlbom and Ljungberg 1998, Deleuze and Guattari 1986, Fagrell *et. al.* 1999, Wiberg and Ljungberg 2001).

2.2.2.2 Temporal Dimension

Just as the concept of spatial mobility becomes meaningful and significant when the phrase 'of information services' follows it, the conceptualisation of temporal mobility is also only meaningful when it is linked to the information service supporting a particular human activity. Technological development has always aimed at automating human operations. To 'automate' (Zuboff 1988) is to adopt new time-saving ways of doing work through technology. Zuboff's idea of automation was largely related to static ICTs, yet it incorporated temporal efficiency. However, temporal efficiency in static ICTs is only achieved when the user of the technology is attached to the technology and hence also static. Portable ICTs ensure that automation transcends the realm of static computing. For example, PDAs and laptop PCs can

automate human operations as they are carried around; in short, enhanced temporal efficiency is achievable with portable ICTs.

In addition to time saving, portable ICTs also afford mobile interaction. Interaction through fixed telephones and exchange of paper-based mails is asynchronous and characterised by time delays. With the fixed telephone, interaction confines the user to a specific location; otherwise he or she has to set voicemail up to allow callers to save their messages for later reading. Reading of voicemail messages and paper-based mail all constitute asynchronous interaction. Portable ICTs ensure synchronous interaction because users can interact with others anytime anywhere. PDAs and laptop PCs are wirelessly connectible to the internet for synchronous interaction via instant e-mail exchange, or ICQ[5] or MSN Messenger. In this sense, interaction and computing information services provided by portable ICTs can be interpreted as temporally mobile – the time it would take to interact or process information is mobilised.

The temporal efficiency established by the use of portable artefacts, and ICTs in general, has seen much explication in organisation studies (see for e.g. Barley 1988, Orlikowski and Yates 2002). Barley's work illuminated two strands of temporality – structural and interpretive. He applied objectified parameters such as sequence, duration, temporal location and occurrence rates to measure structural temporality. Interpretive temporality denotes how organisational actors interpret these objectified parameters enabling them to "form opinions and make pronouncements about the behaviour of persons operating in alternate temporal systems" (p.129). Arguments surrounding temporality also point to considerations of whether time is symbolised as monochronic or polychronic (Feldman and Hornik 1981, Hall 1959, 1983, Kaufman *et. al.* 1991a). Monochronicity refers to the treatment of time as linear and separable, and doing things "one thing at a time" (Cotte and Ratneshwar 1999), while treating time polychronically means understanding time as naturally recurring and using it for many purposes concurrently. Portable ICTs and their information services enable people to deal with multiple tasks at the same time and therefore exhibit polychronicity. Kakihara and Sørensen note: "the temporality of human interaction

[5] ICQ is a mnemonic for 'I Seek You' – an internet-based text chatting application that connects and facilitates interaction between people who share similar interests. Visit www.icq.com for more information.

can no longer be explained from a linear clock-time perspective; it is now highly mobilised into multiple temporal modes based on each actor's perspective and interpretation of time itself" (2002a, p.4).

Spatial and temporal mobility have together aroused interest in contemporary Computer Supported Cooperative Work (CSCW) research. Before the introduction of portable ICTs, CSCW researchers concerned themselves with communication, collaboration and coordination issues of organisational actors and actions, and support for these attributes through static computing. For example, they have concerned themselves with the spatial and temporal dimensions of interaction among interdependent workers in relation to technological innovations such as the Internet, groupware and other information sharing systems. Recently, many CSCW researchers are integrating mobility into their work (see Luff and Heath 1998, Dix and Beale 1996, Bergquist *et. al.* 1999, Bellotti and Bly 1996, Wiberg 2001). In their studies of air traffic control, newsrooms, ship navigation and financial institutions for instance, Luff and Heath illuminate how "the mobility of personnel and artefacts is critical to communication and collaboration (p.306). This assertion is true. However, the crux of our understanding of mobility also has to include expositions of mobile computing and interaction with contemporary portable ICTs.

2.2.2.3 Contextual Dimension

A third dimension of mobility – contextual – has been propounded by Kakihara and Sørensen (*op. cit.*) in their *Extended Perspectives* of mobility. They argue that the contexts in which humans act, frame and are framed by their performance of the act recursively. Drawing parallels between context and Suchman's (1987) situated actions, they bring to the fore the interactional aspects of mobility referring to questions such as "in what way", "in what particular circumstances" and "towards which actors". These questions supplement the conventional spatial and temporal dimensions of mobile interaction that respectively treated the questions of "where" and "when" only (see Table 2.1).

Dimensions of Mobility	Aspects of Interaction	Extended Perspectives
Spatial	• Where	• Geographical movement of not just humans but objects, symbols, image, voice, etc.
Temporal	• When	• Clock-time versus social time (objective versus subjective) • Monochronicity versus polychronicicy
Contextual	• In what way • In what circumstance • Towards which actor(s)	• Multi-modality of interaction (obtrusive-unobtrusive versus ephemeral-persistence) • Weakly and strongly tied social networks

Table 2.1: The spatial, temporal and contextual dimensions of mobility
[Source: Kakihara and Sørensen (2002a)]

The relationship between interactors forms the basis of their contextual arguments, and it reflects the fact that the flexibility of portable technology-mediated interaction (TMI), as presented in Table 2.1, can alleviate many contextual difficulties in human interaction, just as it alleviates spatial and temporal difficulties. For example, an unobtrusive and persistent medium such as a Post-It note can be used to "lubricate" what would otherwise be an obstacles-ridden face-to-face interaction between two parties due to unfamiliarity and weak social relationships. Various mediating technologies provide people with access to a wider society of weakly tied actors and a wider set of contexts, extending communication possibilities beyond various contextual boundaries (Feldman 1987, Granovetter 1982, Haythornthwaite 2001, Sproull and Kiesler 1991). To the extent that mediating technologies such as portable ICTs afford lubricated interaction with others relatively devoid of contextual constraints, "the relationships between interaction among people and [the] contexts in which they operate [are] becoming mobilised in terms of the flexible patterns across [their] different contexts" (Kakihara and Sørensen *op. cit.*, p.6). It has to be said that, just like the spatial and temporal dimensions, it is the mobility of context *of information services* that gives a substantive meaning to the context dimension of mobility.

Kakihara and Sørensen's notion of context mobility was founded on interaction via portable ICTs – context mobility of interaction services. It is another issue altogether if one concerns him- or herself with an understanding of context mobility of handheld computing services. The environmental changes associated with human mobility and related activities are inherently context changes. This is the foundation of Suchman's

(1987) arguments on situated actions: "The coherence of situated action is tied in essential ways not to individual predispositions or conventional rules but to local interactions contingent on the actor's particular circumstances" (p.28). Human actions are therefore determined by two forms of context: on the one hand, by the particular circumstances or 'conditions' in which they are performed, and on the other hand, by the motive of the activity in which actions are embedded (see Leont'ev 1978). The motive of the activity being performed will determine the individual's fundamental pattern of motion and the necessity to compute while being mobile. The activity context is related to the biological and sociological needs of the actor, and the situational context is related to the circumstances that underlie human actions. In this sense, the motive may remain constant but the situational conditions and circumstances may be continuously dynamic and mobile. The trajectory of mobile computing involves a continuous experience of changing contexts. Every situation presents a different context in which the actor is forced to adapt. For example, in Kristofferson and Ljungberg's (2000) terminology, a wanderer cannot do as much computing with a laptop PC as a visitor can do because the visitor can and will find him- or herself a flat surface to place his laptop PC. This implies that, unlike the mobility of interaction services, the context mobility of mobile computing services – the elimination of contextual constraints – may not be possible everytime everywhere (Wiberg and Ljungberg 2001).

2.2.3 Mobile Information Services

Mobile information services are not automatically given but accessed from portable ICTs in human activities. The task of accessing information services can be a dominant or passive component of an activity depending on both the functional diversity of the portable ICT (Mathiassen and Sørensen 2002) and the level of activity (Leont'ev 1978). Consequently, the type of information service that can be obtained from a portable ICT within the activity is a measure of several factors – the physical nature of the portable ICT, the nature of the task, and the conditions provided by time, space and context within which the user uses the artefact to perform the task. In other words, the information services are directly related to a combination of the information processing and interaction affordances of the portable ICT, and the nature of the activity it is mediating.

In their General Task-Based Theory of Information Services, Mathiassen and Sørensen (2002) developed a taxonomy of information services to depict the functional diversity of modern ICTs in terms of Mintzberg's (1983) idea of task *complexity* and *uncertainty*. According to them, modern ICTs offer four types of information services – computational, adaptive, networking and collaborative services (see Table 2.2).

Complexity \ Uncertainty	Low	High	
Low	*Computational service*: **Server** Technology Standardising **Process** Potentially **Structure** Overload. **Examples**: News services, simple WAP services, video streaming	*Networking service*: **Infrastructure** Technology Standardising **Connection** Potentially **Interaction** Overload **Examples**: Mobile phone, mobile email, SMS, MMS, Instant Messaging, AwareWare	*Encounter Service*
High	*Adaptive service*: **Client** Technology Standardising **Information** Potentially **Information** Overload. **Examples**: Adaptive and personalised WAP services. Location based services.	*Collaborative service*: **Workspace** Technology Standardising **Material** Potentially **Transaction** Overload **Examples**: Mobile logistics and supply chain systems. Mobile Groupware systems. Mobile location-based games.	*Relationship Service*
	Information Processing	*Information Generation*	

Table 2.2: Task-based Mobile Information Services depicting four analytical types [Source: Sorensen *et. al.* 2002)]

Computation and interaction services constitute the main branches of IS research on contemporary portable ICTs. Mobile information services have been classified under computing and interaction services: consequently, it is evidently clear that Sorensen *et. al's* (2002) networking and collaborative services, and to some extent, adaptive services are all based on the interaction affordances of portable ICTs.

2.2.3.1 Mobile Interaction Services

Based on this, Sorensen *et. al.* (2002) analysed the different services which portable ICTs can potentially offer. Their analysis is, however, parochially centred on mobile interaction via mobile phones predominantly. Although computational mobile services were discussed in some detail in their work, their analyses primarily centred on mobile networks and collaboration – on interactions between client WAP-enabled devices and centralised servers, and on peer-to-peer interactions with mobile-enabled

applications such as short messaging services (SMS) and multimedia messaging services (MMS). What was not sufficiently dealt with is the dynamics of computational mobile services in terms of mobile computing or information processing with a PDA, tablet PC or laptop computer without necessarily interacting with others in remotely distributed locations. Interestingly, it was in their analysis of 'adaptive mobile services' that mention was made of AvantGo®[6] computing services on PDAs. The bias for mobile interaction analysis against mobile computing is not a characteristic of Sorensen *et. al.* alone. Similar analysis and discussions of mobile interaction at the apparent neglect of task-based mobile computing or information processing dominates the literature on mobility (see e.g. Weilenmann 2001, Green 2002, Kakihara and Sørensen 2002a, 2002b).

2.2.3.2 Mobile Computing Services

Mobile computing is as relevant for understanding the impact of portable ICTs as mobile interaction. An integration of mobile computing and interaction analysis in relation to the specific human activities that they mediate will provide a holistic understanding of its pervasiveness or ubiquity. For mobile computing, it is necessary to re-conceptualise Mintzberg's notion of complexity. Complexity in the context of mobile computing will not only relate to "the information available in the situation" (Sørensen *et. al. op. cit.*). Complexity also relates to the 'facilities' and 'frustrations' (Ortega y Gasset 1941) associated with portable computers during the very process of their use for information capture and processing on-the-move. Mobile computing is a complex dynamic process that is deeply rooted in psychological phenomena such as sensuousness, perception and action, and motives. Mobile computing is not a simple transmutation of static or desktop computing which analysis can be based solely on the principles of desktop computing. The essence of mobility is premised on the fact that even without portable computers, human movement is always an action or operation conducted to satisfy a need. Motives are therefore integral aspects of human movement. The introduction of mobile computing can potentially introduce additional actions or operations to those which originally caused the movement of the individual. In this sense, the nature of the individual's goal-oriented actions bears significantly on the complexity of mobile computing. In other words, the degree of complexity in

[6] AvantGo is a mobile Internet service that delivers rich, personalized content and applications to mobile device users. For more information, see http://www.ianywhere.com.

mobile computing will vary depending on the modality of mobility that is demanded or dictated by the needs and motives of the mobile individual.

Using Mathiassen and Sørensen's framework (*ibid.*), interaction can be deemed an information generation task, and computing, an information processing task. Mobile computing tasks are largely characterised by low uncertainty within which, according to the degree of complexity, they can offer computational or adaptive services. On the one hand, information capture and processing tasks are normally undertaken with structured forms designed in applications. In this scenario, the portable computer is deemed to provide a computational service: and the degree of freedom of the user in terms of the adaptability of the portable computer to the demands of the task is relatively limited. For example, drop-down menus have proven to be the easiest means of capturing information using portable ICTs; but structured applications, in lowly complex situations, are likely to result in a "dysfunction" which Sørensen *et. al.* call "structure overload" (*ibid.*). On the other hand, if the mobile device's applications to be used in the task exhibit relative flexibility that allows the user to reconfigure those applications to suit the objectives of the task, then it is said to be "adaptive." "Adaptive mobile services are aimed at supporting situations where the exact unfolding of the process cannot be programmed a priori because of a relative high degree of complexity." (*ibid.*). The applications underpinning adaptive mobile services are less structured; but their manipulation to achieve goal-oriented actions can be counterproductive in the sense that extra 'useless' information can be captured and processed leading to information overload (Ljungberg and Sørensen 2000, Schneider 1987).

The presence or emergence of information services derived from portable ICTs is directly linked with the activities which they are deployed to mediate. Learning, which constitutes a major theme in this study, is also an activity which has experienced technology integration in recent times. In the second part of this chapter, the relevant learning literature are reviewed in relation to its problem of technology-mediation.

PART II

2.3 The Problem of Learning

Many variants of learning have been espoused from various perspectives reflecting proponents' focus on slices of the multifaceted problem of human development. They also reflect fundamental differences in assumptions of the nature of knowledge resulting in several learning theories. Existing understanding of the problem of learning can be categorised under two main themes: subjectivism and objectivism in epistemology – about whether knowledge and truth are based on objective facts or on subjective judgements. On the one hand, those who believe that knowledge is objective argue that instruction by experts or teachers should be the foundation of learning; on the other hand, those who believe that knowledge is subjectively judged argue that what is learnt by an individual is founded on his or her own construction. The former hold the view that reality is 'out there' and independent of anyone's feelings, while the latter see reality as dependent on the perception, perspective, attitudes and feelings of the observer.

I begin, in Section 2.3.1, with a review of perspectives on constructive and instructive learning leading to the placement of learning within social systems. Sub-section 2.3.1.1 presents learning communities – communities of practice – as epitomes of social learning systems which generate psychological tools which in turn mediate learning. Sub-section 2.3.1.2 discusses information processing theory leading to an emphasis on the relevance of information processing support tools such as modern ICTs in learning activity. In Sub-section 2.3.1.3, I draw on, among others, the mediation principle of activity theory to present learning as an activity. The section is concluded with an explanation of WIL which is the particular phenomenon under investigation in this research. This leads us to Section 2.3.2 where the potential of physical mediating tools such as current mobile and portable ICTs are discussed in a review of technology-mediated learning literature.

2.3.1 Learning as Construction and Instruction

The philosophical assumptions of constructivism suggest that learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledge. Constructivists challenge objectivist assumptions of learning as acquisition and assimilation of other people's knowledge that are operationalised in

instructive teaching methods. The principles of objectivism rest on metaphysical assumptions, which hold that the purpose of the mind is to mirror the real world and its structure through thought processes that are analysable and decomposable (Jonassen 1991). Constructive learning is a process of knowledge construction during which learners make sense of the world by integrating new information and experiences into what they have previously come to understand, revising and reinterpreting old knowledge in order to reconcile it with the new (Billett 1996). Constructivists argue that knowledge and reality have no absolute or objective values. This is the premise on which Bruner (1986, 1990, 1996) based his constructionist arguments – on the social and cultural aspects of learning. Recently, modern educators have studied and applied the principles of constructivism. But due to "ethnocentrism within various constructivisms" (Derry 1996), and consistent with other paradigms, this has clearly led to the development of several perspectives of constructive learning. These various perspectives have produced 'radical,' 'social,' and 'situated' constructivism, to name the very common ones.

It is fair to say that the true foundations of constructive learning were laid in Plato's and Xenophon's accounts of the Socratic dialogues[7]. Later, constructivism was properly systematised by the influential works of, most notably, Piaget, Dewey and Vygotsky.

Dewey's contribution is reflected in his famous quotation: "If you have doubts about how learning happens; engage in sustained inquiry: study, ponder, consider alternative possibilities and arrive at your belief grounded in evidence." (Thirteen Ed 2004)[8]. He developed his inquiry-based idea of learning by repudiating the authoritarian teaching methods based on instructive education. His works led to popular education methods such as progressive education and experiential learning which have had their share of criticism in the learning literature (see for example Hirsch 1997). To him, "the only true education comes through the stimulation of the child's powers by the demands of the social situations in which he finds himself" (Dewey 1897). Dewey's constructivism, founded mainly on pragmatism, makes the claim that what is learnt must be the individual's own construction.

[7] See http://www.philosophypages.com/ph/socr.htm for more information.
[8] Visit http://www.thirteen.org/edonline/concept2class/month2/index_sub4.html for more information.

Piaget, a biologist and psychologist, is renowned for constructing a highly influential model of child development and learning – the Cognitive Development Theory (Piaget 1970, 1977). His theory weaves four cognitive structures of child development with processes of knowledge construction called assimilation and accommodation. Cognitive structures are patterns of physical or mental action that underlie specific acts of intelligence and correspond to stages of child development. In learning terms, a person's cognitive or knowledge structure depends on his or her stage of development. Piaget's ideas mirror Dewey in the sense that both of them lay emphasis on individual constructivism and social cognitive development. Von Glasersfeld (1995, 1987) drew on Piaget's cognitive development theory to develop conceptions of knowledge based on radical constructivism. But radical constructivists' views on knowledge acquisition – based entirely and strictly on the belief in individual knowledge construction – reflect the naïve philosophical assumptions of extreme relativism.

In contrast, social constructivists have argued against the problematic nature of individual constructivism leading to conceptual formulations such as 'social development' (Vygotsky 1962, 1978), 'construction of social reality' (Searle 1995), 'social learning' (Bandura 1969), and 'communities of practice' (Lave and Wenger 1991). They claim that although learning is a matter of personal and unique interpretation by the perceiving subject, it takes place within the social context (Kerka 1997). It was based on social constructivism that Vygotsky, the most notable critic of Piaget, developed his theory of social development (1962, 1978). Vygotsky approached learning and development from a different perspective. He challenged Piaget – who stressed on the importance of social cognition, but focused narrowly on the individual – by emphasising the connections between people and the cultural context in which they act and interact in shared experiences (Crawford 1996). Contrary to Piaget's development based on the four-staged cognitive structures, Vygotsky's theory, premised on social interaction and construction, posits that social learning leads to cognitive development, and that the potential for cognitive development is limited to a certain span which he calls the "zone of proximal development" (ZPD) [1978]. He defined ZPD as "the distance between the actual development level as determined by independent problem solving and the level of

potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (*Ibid.*, p.86). It is apparent that there is a general agreement on knowledge construction in learning (cf. Dewey 1897, Piaget 1977, Vygotsky 1962), but the infamous argument between Vygotsky and Piaget on child learning (see Vygotsky 1962) reveals that Piaget sees individual construction as the origin and antecedent of child development while Vygotsky argued that individual construction is a consequence of social construction by the child within the ZPD.

Vygotsky's idea of social development is complementary to Bandura's (1969, 1977) Social Learning and a key component of Lave and Wenger's (1991) Situated Learning because of its philosophical assumptions about the influence of social interaction and cultural context. Social learning is founded on the power of the example and the impact of modelling, which Bandura claims is as influential as that of direct experience. His major premise is that we can learn through social construction – by observing and modelling the behaviours, attitudes, and emotional reactions of others. Social learning has been applied extensively to the understanding of aggression (Bandura 1973) and psychological disorders, particularly in the context of behaviour modification (Bandura 1969). Il'enkov's (1977) account of the sociality, externality or objectivity of knowledge in his analysis of the concept of the *ideal* strengthens the social constructivism argument further. The ideal forms of knowledge, according to him, are represented in objects, signs and symbols historically and culturally built collectively by society for society which mediate activities in the sense of Vygotsky (*Ibid.*).

> "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 *ibid.*).

This social learning view is also echoed by Golinski (1998) whose work on constructive knowledge, influenced by the ideas of Kuhn (1962), emphasises the *social* nature of constructivism.

Learning is a social activity, and knowing is socially situated. Social constructivism therefore draws parallels with situated constructivism (Spiro and Jehng 1990, Spiro *et. al.* 1991, Duffy and Jonassen 1992, Brown *et. al.* 1989, Jonassen 1991). In situated constructive learning, people draw meanings from patterns of their unique social

experiences that occur over time in a contextual, situated, and continually changing synthesis (Kanuka and Anderson 1999). In science and technology studies, the social construction of technology has grounded approaches to the study of technology and society as well as past and present philosophical inquiries in technology and philosophy (Winner 1993).

The crux of constructivism is that reality is individually or socially constructed and a lived experience (cf. Wenger 1998). But all reality is not absolutely socially constructed at least if we argue from the point of view of Searle (1995, see also Berger and Luckmann 1967). Searle's argument on social constructivism suggests that there are on the one hand, "brute", objective facts regardless of our agreement of their existence and which we only apply language to; and on the other hand, there are "institutional", social facts which are constructed by social institutions through collective human cognition. To the extent that certain phenomena exhibit ontological objectivity, the assignment of status-functions[9] and meanings to such phenomena in the creation of institutional facts[10] cannot be an individual constructive act. The construction of social meanings such as the acceptance of pieces of printed-paper as money – media of exchange and stores of value – requires collective agreement in society. But the existence of objective facts suggests that constructivism is not the only means of human development; and it is therefore the responsibility of educators to *instruct* learners to acquire objective facts. Other critics of constructivism (e.g. Hirsch 1997) also argue that constructivism does not adequately deal with learning as a moral concept; and in skills-based learning aimed at tackling specific problems, its principles become completely unreliable.

2.3.1.1 Learning in Communities of Practice

The theory of Communities of Practice (CoP) (Lave and Wenger 1991, Wenger 1998) – also known as situated learning theory – is a social theory of learning premised on the basic assumptions that human beings are social beings; that knowledge is competence with regards to a valued *enterprise* such as singing in tune; and that our *knowing* derives from participating in such enterprises: a meaningful engagement in which the negotiated *meaning* is what learning ultimately produces. CoP focuses on

[9] See Searle, *op. cit.*, Ch. 1.
[10] *Ibid.*

"learning as social participation" in which learners participate in the practices of social communities and construct *identities* in relation to these communities. It integrates four deeply interconnected and mutually defined components which characterise social participation as a learning process – community, practice, meaning and identity (see Figure 2.3).

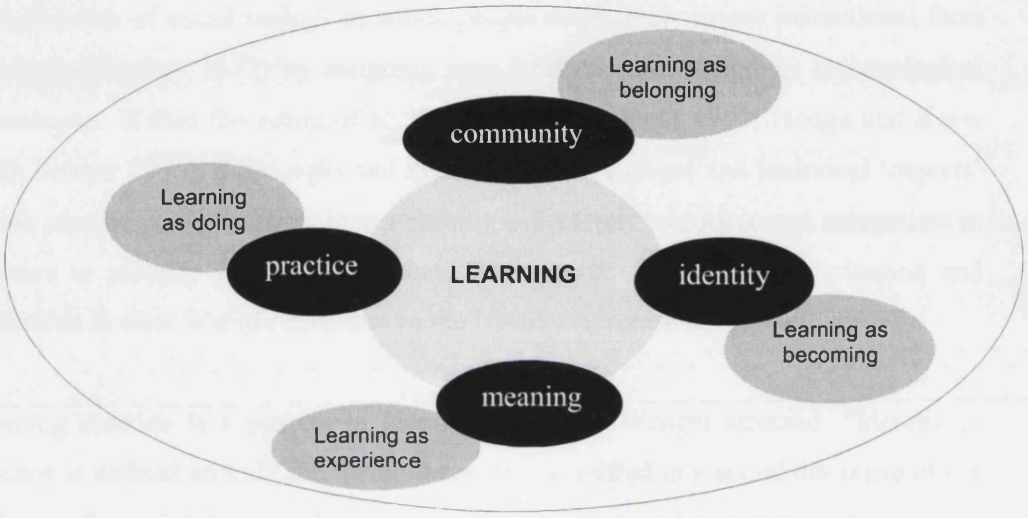


Figure 2.3: Components of a social theory of learning
[Source: Wenger (1998)]

The primary unit of analysis is neither the individual nor the organisation, but the informal "Communities of practice", even though "in reality,...participation in social practice – subjective as well as objective – suggests a very explicit focus on the person, but as person-in-the-world, as member of a social cultural community" (Lave and Wenger *op. cit.*, p.52). The three dimensions, which characterise practice as the source of the coherence of a CoP, are the *mutual engagement* by participants in their negotiation of a *joint enterprise* towards the development of a *shared repertoire*. CoP rejects Piagetian notions of learning understood in terms of acquisition and assimilation in favour of learning as meaning-in-practice through a dynamic interplay within the duality of *participation* and *reification*. Wenger's concept of participation is a slight twist of Webster's definition of the word: in a CoP, participation is an active process by members of the community who, through their shaping of each other's experience of meaning, mutually "recognise something of themselves in each other" (*op. cit.*, p.56).

Participation creates experiential "abstractions" which members congeal into "things", a process which Wenger describes as reification, and which Berger and Luckmann (1967) call the "social construction of reality". Reification is the process through which certain understandings – created during participation – are made ontological. It is the production of signs and symbols which become the focal points for the negotiation of meaning, a process which Searle (1995) describes as the "construction of social reality" in which people collectively create institutional facts or ideals (Il'enkov 1977) by assigning new functions and meanings to ontological phenomena. Within the realm of social semiotics (Thibault 1997, Hodge and Kress 1988, Jensen 1995), these signs and symbols denote cultural and historical 'objects' whose meanings members of the community collectively negotiate and renegotiate in practice to premise further experiences. The recursive nature of participation and reification is what Wenger describes as the "duality of meaning" (*op. cit.*, p.62).

Meaning creation is a process of identity formation. Wenger stressed: "Identity in practice is defined socially not merely because it is reified in a social discourse of the self and of social categories, but also because it is produced as a lived experience of participation in specific communities" (*ibid.*, p.151). Identities of members of a CoP are trajectories that entail experiences of the past as well as future projections in the process of their negotiation of the present. They are the contexts that determine what actually becomes significant learning. There are three modes of belonging to a CoP which depict identity construction as a learning process (see Figure 2.4). First, members *engage* in the negotiation of meanings. Second, they *imagine* broader perspectives by "creating images of the world and seeing connections through time and space by extrapolating from their own experience" (*ibid.*, p.173). Finally, they *align* their energies, "activities, and interpretations of events with structures, forces and purposes beyond their community of practice and so find place in broader business processes" (*loc. cit.*).

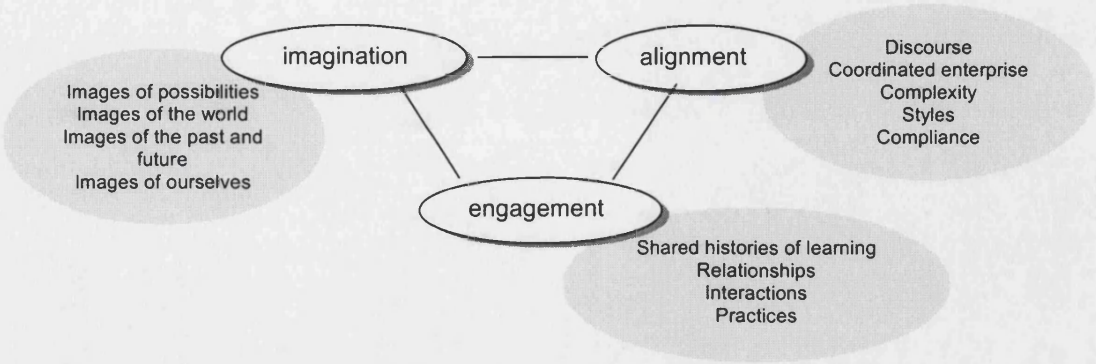


Figure 2.4: Modes of Belonging
[Source: Wenger (1998)]

Communities of Practice or Communities of Interest (CoIs)? Henri and Pudelko (2003) argue that interest is the antecedent of practice, and therefore communities of interest who share a common object should be the premises of analysis rather than CoP. Similarly, Fisher (2001), based on Rittell's (1984) "symmetry of ignorance" in solving design problems, argued that "CoIs have great potential to be more innovative and more transforming than a single CoP..." (p.4). The placement of interests ahead of practice is echoed in Leont'ev's (1978) psychological discussion of needs and emotions which develop into motives, and which in turn direct activities in which Wenger's notion of participation is embodied.

Brown and Duguid (1991) have applied CoP to explore workplace learning processes through which workers develop *non-canonical* meanings within their communities of practice to enhance their learning and innovative capacities instead of relying solely on the *canons* imposed on them in the form of conventional descriptions of jobs. Similar applications have been done in studies of virtual organisations and computer-mediated communications (see Kimble *et. al.* 2001, Hildreth *et. al.* 1998).

2.3.1.2 Learning through Information Processing

Information Processing Theory (Miller 1956) is another cognitive theory of learning whose framework is built upon two fundamental concepts about human memory - *chunking* and *information processing*. Miller draws parallels between the human brain and the computer: both take in information, perform operations on the information to change its form and content, store and locate it and generate responses to it. To him,

"...the span of absolute judgement and the span of immediate memory impose severe limitations on the amount of information that we are able to receive, process and remember." (*Ibid.*, p.96). This analogy seeks to understand human learning processes as phenomena in which information is gathered and represented (encoded), held (retained), and accessed when needed (retrieved) by the human brain.

A chunk, according to Miller, is any meaningful unit such as digits, words, chess positions, or people's faces. Chunks and the capacity of the learner's short-term (working) memory is combined in his idea that the human short-term memory can only hold five to nine chunks of information (seven plus or minus two). Thus the learner optimises his cognition by arranging the information available to him or her in five to nine chunks.

The information processing idea of memory limits clearly explains the difference between oral traditions of primitive societies who encode, retain and retrieve information from within the mind, and those societies whose knowledge systems have been founded on written language (Ong 1982, Scribner and Cole 1981). Furthermore, it seems to be the foundation of the notion of tool mediation (Vygotsky 1962) and intellectual prosthesis (Bruner 1990). Over the years, the limitations of the human short-term memory have coerced humans to develop objects of knowledge representation to supplement the information chunks held in memory. Typical examples are the "technologizing of the word" into written text (Ong *Ibid.*), and, more recently, development of information processing machines – computers. These codifications create permanent or semi-permanent external information objects whose communication in society leads to their idealisation in the sense of Il'enkov (1977). These ideal forms avail themselves to be drawn upon by societal members in their knowledge construction efforts. However, some critics (e.g. Bolgar 1969, Fichtner 1985) argue cautiously that written text in both paper and computers are mere static images, concepts and representations which can impoverish rather than enhance innovation. But to be fair, information processing theory has been highly influential in learning, and has manifested in the integration of various forms of learning support tools to 'encode' and 'retain' some of the information required for knowledge construction (cf. Papert 1982).

2.3.1.3 Learning as a Socially Mediated Phenomenon

The learning process is situated in social learning systems which are shaped by environmental phenomena such as practice, context, and culture. Thus learning and cognition are fundamentally situated (Brown *et. al.* 1989, Suchman 1987); and the social context, information processing artefacts and culture constitute the environment which provides facilities and frustrations (Ortega y Gasset 1941) for situated knowledge construction. Learning transcends the confines of the individual mind because a person's cognition cannot be separated from his or her socially mediating context. It is shaped by a combination of one's past experiences and interactions with what the environment affords him or her. All human actions – conceptions and observable actions – are hinged on cultural orientations because "it is [one's] participation in culture and the realisation of his or her mental powers through culture that makes it impossible to construct a human psychology on the basis of the individual alone" (Bruner 1990, p.12).

Bruner's notion of "mental powers" highlights the influential role of the environment, and is mirrored in Bateson's holistic and dialogical model of mind (1979) originally developed in his theory of learning categories (1972). The mind is an aggregate of interacting differentiated parts; the interaction between the parts is triggered by information (difference or news of difference) in its environment. And in this process, the holistic interacting parts act as filters or sieves that sort, select, collect and subsequently decode the information (Bale 2003). The mind is a system – Bateson calls it "mind system" or "mental system" – which is always enmeshed in a hierarchy of levels of other mind systems. Hence a mind system can itself be a differentiated part of a higher mind system. The essence of Bateson's model of mind is his emphasis on the social interactive nature of minds that is reflected in minds' dialogical exchange of information between different systemic levels. It is the mind that learns, and although it can be individual and holistic – as the human mind depicts – it is not an unrelated monad: its parts' activities are shaped by information in its environment.

Against this backdrop, it is now possible to argue that one's learning environment (context) combined with his or her past and current knowledge, play a crucial role in meaning creation and knowledge construction. Different situations reflect different

contexts which result in different constructed responses by individuals. Suchman's (1987) thesis on situated actions elucidates how, as a learning process, we respond to peculiar situations in our environment: "we walk into a situation, identify its features and match our actions to it" (p.63). In effect, we match our actions and interactions to the affordances of our environment. This picture becomes clearer if we consider the processes involved in mediated learning.[11]

2.3.2 Learning as Activity[12]

One's learning environment, combined with his or her past and current knowledge, play a crucial role in meaning creation because we match our actions and interactions to the affordances of our environment. Engeström's (1994) model (Figure 2.5) of productive learning, founded on the principles of Activity Theory sums up the mutual relationship between the learner, his or her environment and the phenomenon of study:

> "The *learner* is a curious observer and problem-solver. The *object* of learning is a problem of a phenomenon asking for explanation. The learner does not approach the object empty-handed. He or she turns to tools, books other people's explanation and other such sources of knowledge [in his or her environment] to explain and resolve the problem. Those sources of knowledge serve as *instruments* of learning" (p.12) [italics mine].

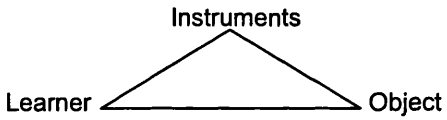


Figure 2.5: The Structure of Productive Learning in Everyday Situations
[Source: Amended from Engeström (loc. cit.)].

Engeström's model is a reformulation of Vygotsky's structure of the mediated act (see Figure 4.2 in Chapter 4). It draws attention to mediation in human activity by physical or technical instruments and signs. The signs are psychological tools such as language, theories, as well as norms and modes of acting. According to Vygotsky, "the tool's function is to serve as the conductor of human influence on the object of activity; it is externally oriented; it must lead to changes in objects. It is a means by

[11] Mediation as the essence of higher psychological processes in human learning is discussed in detail as a key principle of Activity Theory (Chapter 4).
[12] A more detailed discussion of Activity Theory and its suitability as an analytical lens for studying mediated learning is the focus of Chapter 4.

which a human external activity is aimed at mastering, and triumphing over, nature." (1978, p.137).

The model however reflects learning at the individual level. In social learning terms, Engeström, inspired by Leont'ev (1978, 1982), incorporated social learning denotations such as community, division of labour, and rules into the model leading to his development of the Activity System (see Figure 2.6).

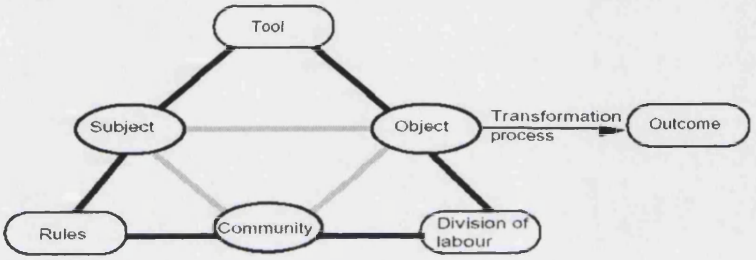


Figure 2.6: The Activity System
[Source: Kuutti (1995)].

In this system, technology in Work-integrated Learning (WIL) can be conceptualised as the mediating instruments or tools; the learners as the subjects; the phenomenon being studied as the object; the implicit and explicit norms emanating from the philosophy of learning governing the process as the rules; the network of learners and institutions as community; the distribution of learning tasks inherent in the organisation of the learning community as division of labour; and the learning objectives as the outcome or motive of the learning activity. WIL is thus an activity which is mediated by both technical and psychological tools, and influenced by rules, community networks and division of labour.

The system depicts the following: the relationship between the subject and object is mediated by psychological tools and instruments; the relationship between subject and community of those who share the object is mediated by rules and social relations; and the relationship between the community and object is mediated by the division of labour between members of the community (Kuutti 1995).

The foundations of mediated learning lie in the principle of intellectual prosthesis. We recall Bacon's *Novum Organum*, which inspired both Vygotsky and Bruner: "neither the hand nor the mind alone, left to itself, would amount to much; it is prosthetic devices that perfect them" (Bruner 1986, p.72). These prosthetic devices are the mediating instruments of learning activity explicated in Engeström's Activity System[13] – textbooks, notebooks, posters, videotapes and computers are typical examples. These artefacts carry – or are designed to carry – inscriptions (Akrich 1992, Akrich and Latour 1992, Hanseth and Monteiro 1997) and representations of other social phenomena that have been codified to support learning in different environments. They are embedded with other people's signs such as words, language, symbols, icons and indices – which have been integrated into their designs – to be interpreted by learners. They also tacitly embody shared cultural understandings (Perkins 1986, Il'enkov 1977). Essentially, mediating artefacts are socio-cultural and psychological. They are "culturally and historically situated, carrying the wisdom and hidden assumptions that went into their design" (Salomom and Perkins 1998).

AT is fast gaining ground as the predominant framework applied in Human-Computer Interaction (HCI) research. In *Context and Consciousness* (Nardi 1995), a majority of the contributors discussed the usefulness of AT and the paradigm shift of understanding HCI from applying information-processing-informed cognitive theories towards the application of the principles of AT. Kuutti (1995), for example, pointed out that "a debate against the use of information processing psychology as the foundation of HCI has surfaced, criticizing even the very basic assumptions."

2.3.3 Work-Integrated Learning

Work-integrated learning is an epitome of social learning in which the learner is immersed in the practice of what is being learnt – in which the engagement of learners in the experience is purposeful, deliberate and predetermined as a part of work arrangements of an organisation rather than accidental or coincidental engagement. WIL processes such as constructive learning and social and cognitive development, can best be explained by the experiential learning cycle of Kolb (1984), especially by

[13] See Chapter 4.

his concepts of internalised reflective observation and abstract conceptualisation (see Figure 2.7).

Experiential learning is more a theory of learning cycles or learning styles that are depicted in sequences of structured learning such as adult education and work-integrated learning than a substantive learning theory, which focuses on social and cognitive development. It seems to originate from the famous Oriental apothegm by Confucius[14]: "Tell me, and I will forget. Show me, and I may remember. Involve me, and I will understand." In experiential learning, the learner is involved in a direct encounter with the phenomena being studied rather than merely thinking about the encounter, or only considering the possibility of doing something about it (Borzak 1981). "Experiential" is used to describe and emphasise the role experience plays in the learning process and to differentiate on the one hand, experiential learning from cognitive learning that tends to emphasise cognition over affect, and on the other hand, from behavioural learning that denies any role for subjective experience in the learning process (Kolb *et. al.* 1999).

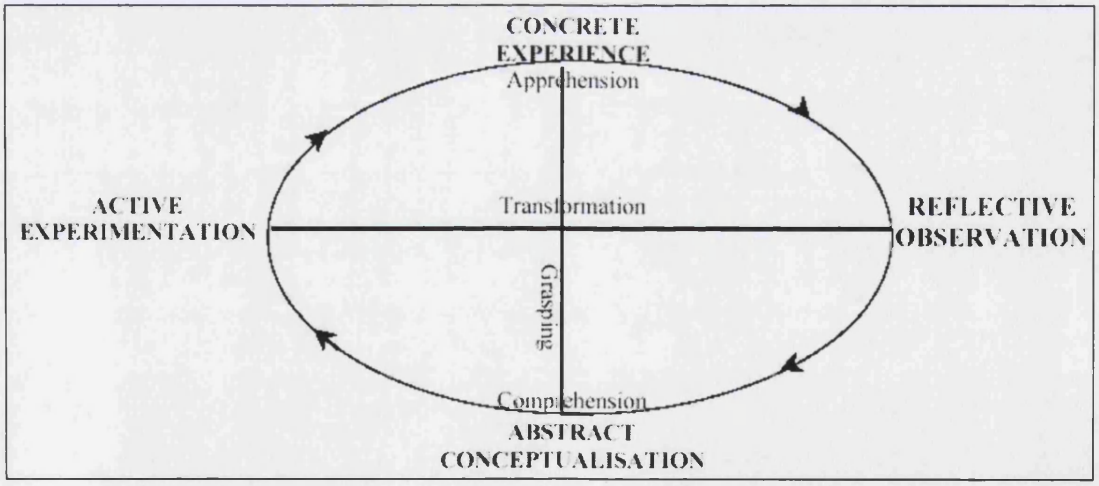


Figure 2.7: Kolb's model of Experiential Learning

The involvement of the learner in the practice and experience of what is being learned is the core principle of the model, which explores the process from experience through reflection, conceptualisation, action, and further experience – in a cycle. There are dialectics – between each of the learning characteristics lying along the axes

[14] Confucius, 551-479 BC.

– that represent what learners do with information. In the first dialectic, information is grasped by first hand experience (concrete experience) through a process he calls apprehension, and by calling up memory (abstract conceptualisation) through comprehension. In the second, the grasped information is transformed through the learner's involvement (active experimentation) and his or her internalised reflective observation of the learning phenomenon.

The purposeful and predetermined nature of WIL implies that there is a strong focus on specific skills acquisition by learners towards the solution of specific identified problems in an organisation. In this sense, we can expect to find some objectivist-oriented instructive practices adopted by educators or facilitators in the learning process. WIL is normally sanctioned by organisations in times of critical and radical changes when the skills of employees have to be necessarily upgraded. According to Pettigrew's "contextualism" (1985b, 1987), organisational change involving a particular phenomenon comprises of three interrelated ingredients – content, context and process.

While mainstream constructivists' arguments – that instructors must only provide conditions for learning – suggest a greater focus on the learning process and not on content, skills-based WIL stresses on both content and process. Content is crucial and unavoidable because of objectives that demand specific skills acquisition by learners towards the solution of identified problems. These specific skills form the objectified contents, and they require an instructional educational framework to accomplish. The processes that will provide optimal conditions for skills acquisition must be practice-centred (learning-by-doing or learning-in-action) and situated within the environment – the context – of the activities which skills are being learned. Therefore, within the instructional framework, constructive-oriented methods and processes can be effectively deployed. In other words, skills-centred instructions on content must form the guiding framework for knowledge construction in skills-based learning.

2.3.4 Technology-Mediated Learning

While learning depends much on epistemological phenomena such as one's present and past knowledge, situated meanings and shared understandings, it as much depends on situated affordances which are ontological; and these mediate our learning

in a variety of ways. Ontological affordances are found in objectified artefacts that we construct to support our learning. These artefacts possess inbuilt inscriptions and representations of other social phenomena which have been codified to support learning in different environments.

In the traditional form of social mediation of individual learning, there is a facilitating agent (e.g. teacher, parent, master, mentor or expert) who guides the learner to achieve critical conditions of learning. Technological advancements have induced into educational institutions and organisations what is described as technology-mediated learning (TML). Extensive research on TML in Information Systems has resulted in the formulation of alternative descriptions such as computer-supported learning (CSL), computer-supported collaborative learning (CSCL), technology-supported learning (TSL), computer-assisted learning (CAL) and a whole host of other related phrases understood to be synonymous with educational technology (Oliver 2000). The assumption behind TML emanates from the view that advanced information technology is an enabler of innovative and effective learning. Perhaps this is what Papert[15] envisioned in the early 1960s when he talked about children using computers as instruments for learning and for enhancing creativity. Papert, inspired by Dewey's and Piaget's cognitive constructivism (see for example Papert 1980, 1982), has argued extensively over the years in favour of the value of computers in child learning. Papert's ideas have impacted immensely on TML, especially in constructive environments. TML depends on ICTs to support both remote and distant learners, and have proven to be cost effective, accessible to learners, and able to remove temporal and spatial barriers within learners' experiences (Bates 1995) while being supportive of the enhancement of their higher order thinking skills (Newman *et. al.* 1995).

The 'support' or 'mediation' that is believed to be derived from learning technologies comes in various forms that range from simple content-delivery computers to interactive multimedia technologies such as video links. Over the years, TML research has been concerned with analysis of the dynamic linkages between learning

[15] Seymour Papert is a leading expert on integrating computer technology within a constructivist environment. He created the LOGO programming language to teach mathematics to elementary school children. Through LOGO, children create programs to perform various mathematical calculations and manipulate geometric figures. Visit http://www.papert.org/works.html for more works of Papert.

and ICTs with the aim of elucidating what 'support' or 'mediation' really entails. Since the achievement of positive outcomes with ICTs demands more than a simple combination of hardware and software in learning (cf. Cuban 2001), and given that the swiftness in the development of new technologies demands continuous research efforts, the challenges involved in TML research are huge. It brings in its wake, persistent demands for continuous evaluation of continuously changing technology and learning outcomes. This problem is reflected in existing literature on learning technologies, which demonstrate that judgements on the support – or potential support – offered by any learning technology have at least been divergent and sometimes contradictory. For instance, while some TML researchers have emerged with findings which portray learning technologies as significant supporters of knowledge building (e.g. Bates 1995, Scardamalia and Bereiter 1993, 1995, Christmann and Badgett 1999), others (e.g. Storck and Sproull 1995, Russell 1999, Wetzel *et. al.* 1994) have found that they make no or insignificant differences.

Existing evaluation judgements of learning technologies seem to be founded on a linkage of teaching and learning outcomes and their psychological implications such as cognition (e.g. McDougall 2002, Leidner and Jarvenpaa 1995), and perception and attitudes (e.g. Webster and Hackley 1997) with technology-related variables such as design (e.g. Murray 1998), interactivity (e.g. Alavi 1994), and implementation and sustainability (e.g. van Melle *et. al.* 2003). In many instances, those who put learning in the foreground of their analysis of learning technology (e.g. Kanuka and Anderson 1999) take the theoretical route by engaging themselves with the theoretical foundations of learning programmes and how technology can support them. However, it is an analysis of the task-technology fit (Goodhue and Thompson 1995) in any TML process that will provide an appropriate evaluation of learning technology. Thus the judgement of the efficacy of any learning technology is a direct measure of its support, its fit, in the learning process.

TML evaluation efforts have mostly centred on the differences in the processes or forms of learning. The differences in learning processes which are mediated by ICTs are usually derived from the location of learning subjects – local, remote, distributed, and distance are common adjectives used to distinguish these forms. The most notable ones cited in the literature are classroom learning (e.g. Leidner and Jarvenpaa

1993, Nulden 1999), workplace learning (e.g. Brown and Duguid 1991, Kerka 1997) and distance learning (e.g. Webster and Hackley 1997, Dillon and Gunawardena 1995, Svennson 2002). The learning processes and outcomes involved in these types are different, and hence the most appropriate forms of technology that can support these processes are different. However, within the milieu of formal education, learning can take place locally in classrooms or remotely where learners are either geographically distributed or concentrated in one location.

Of all these learning types, distance or remote learning has assumed a dominant position in current TML research efforts due to the introduction of the Internet and WWW which interactive affordances have enabled the evolution of new varieties of distance learning programmes such as virtual education (Albalooshi 2003), virtual universities (Ryan *et. al.* 2000) and virtual communities of practice (Hildreth 2003). Internet technology has emerged to complement erstwhile software-based TML enabling a leverage of learning activities even among remotely distributed learners.

2.3.4.1 Technology-Mediated Distance Learning

The aim to satisfy accreditation requirements is foremost in any formal educational process. Traditional classroom-based education programmes have always streamlined their programmes to meet accreditation requirements. Distance learning, a modern form of providing formal education to learners in distributed locations, has a relatively more difficult accreditation challenge because of the distance factor. Educational institutions that administer distance learning programmes have to ensure and prove that distance learners are going through similar learning experiences as do their classroom-based counterparts before the qualifications they award are accredited. This demand makes instruction-led education crucial in distance learning: educators have to ensure that distance learners follow objective instructions to achieve desired learning outcomes.

Furthermore, based on the truism that learning is inherently social (Vygotsky 1978), and that the individual mind is a part of an ecology of mind systems in constant interaction (Bateson 1979), the role of a social mediating or facilitating agent is inevitable in any learning process. Instructive methods in distance learning are designed along these principles to ensure that "scaffolding" (Salomom and Perkins

1998) plays an integral role in distance learning. Technology-mediation is one of the most modern and effective methods of scaffolding learning by eliminating distance barriers in access to teaching instructions.

Recently, the Internet and WWW has proved to be overwhelming in terms of its support for scaffolding distance learning activities. Currently, almost all forms of technology-mediated distance learning are internet-based. Prior to the Internet, the most sophisticated technology mediation in distance learning was achieved through video links or videoconferencing (see Webster and Hackley 1997). Obviously, these used to be very expensive processes since video links relied on telephone technology for communicating video footage to learners. The less expensive and most common means of technology mediation in distance learning was achieved through content-based and simulator-based computer software. Currently, these three forms of learning technology are applied in various proportions in distance learning; for example both video and application software can be communicated via the Internet to distant learners. The suitability of any technology for any learning process, however, is normally determined by the goals of the learning process, the nature of the process, the location and mobility of learners and, most significantly, the complex technical considerations which do not permit the use of certain communication technologies by learners in certain locations. The latter factor is epitomised in hospital environments where the phobia of wireless local area networks (wLANs) interfering with medical equipment exists among medical doctors and health administrators alike, especially in the UK.

2.3.4.2 Learning Technology and Inscriptions

In the absence of internet connectivity, technology-mediated distance learning based on learning software appears to be severely handicapped. But this is an oversimplified judgement given that it is the motive of any learning activity which determines the significance or supportiveness of any mediating technology (cf. Goodhue and Thompson 1995).

The design of learning software is grounded on pedagogical principles to surrogate the teachers' instructions, support and scaffolding for learners. Learning software contain "inscriptions" (Akrich 1992, Akrich and Latour 1992, Hanseth and Monteiro

1997) of instructors' desired patterns of expected use by learners. Through information infrastructure, instructors strive to make what they offer in any learning process – instruction and facilitation – available to distant learners by inscribing their desired learning scenarios into the technology.

> "The scenario is inscribed into the system. The inscription includes programmes of action for users, and it defines roles to be played by users and the system. In doing this, the designer is also making implicit and explicit assumptions about the competencies required by the users as well as by the system. (...) When a programme of action is inscribed into a piece of technology, the technology becomes an actor imposing it's inscribed programme of action on its users" (Monteiro 2000, p.77).

Instructors' inscriptions in learning software – their patterns of expected use – can be weak and flexible or strong and inflexible depending on implicit and explicit norms emanating from the learning philosophy that is embodied in the motive of the learning activity (see Engeström 1987). A more constructive-oriented process will involve flexible inscriptions whereas in a more objectivist-oriented process, instructors will structure the pattern of use relatively strongly.

Distance learners' perceptions of the strength of inscriptions are crucial in the assessment of the efficacy of learning technology. The situated actions (Suchman 1987) and circumstantial demands in learning actions may result in learners manipulating learning technology in unanticipated ways. In other words, learners may follow an "anti-programme" (Latour 1991). The technology use patterns of such learners' – "real users" – are a deviation from the designer's "projected users"; and therefore, in order to make an accurate evaluation of the efficacy of learning technology, it is always necessary to oscillate back and forth "between the designer's projected user and the real user" (Akrich 1992, p.209).

2.3.4.3 Mediation by Portable ICTs

Recently, a new strain of technology-mediated distance learning has emerged from conventional technology mediated learning due to the introduction of portable ICTs. The potentiality of portable ICTs has been embraced into current TML research, and it is not surprising that a whole special issue of the Journal of Computer Assisted Learning was devoted to "Wireless and Portable technologies in Education."[16]

[16] See the Journal of Computer Assisted Learning. Volume 19, Issue 3, September 2003.

Conventional technologies only supported learning in a limited fashion because of the relative immobility of artefacts such as desktop personal computers; and therefore the learning support offered by the artefact is confined to a particular location, time and context. When the learner moves away from the artefact, he or she is left alone to confront other situational, contextual and temporal learning challenges without the support of the artefact. Portable ICTs are therefore potential learning support systems because their portability allows easy handling and transportation by humans. Many of the types (e.g. mobile phones, tablet PCs and PDAs) exhibit greater portability and lightness thus creating possibilities for their carriage and use almost everywhere and everytime to support learning.

The literature on the use of portable or wireless ICTs in education or learning is somehow divided on the facilitative or disruptive capabilities of these devices. For example, while researchers like Roschelle (2003) tout the learning value of wireless mobile devices, others (e.g. Sharples 2000a) argue that "[a] mobile learning device may become a zone of conflict between teachers and learners, with both trying to wrest control, not only of the physical device but also the opportunities it affords for managing and monitoring learning." (p.14). Furthermore, similar to Kleinrock's prognosis of effective mobile computing through anytime anywhere connectivity, Soloway *et. al.* (2001) also prognosticated that mobile devices must be "ready-at-hand" – just like the pencils, papers and calculators – to make a difference in the classroom.

However, it has to be said that unsurprisingly, existing mobile TML publications largely focus on the impact of wireless technologies on communication and collaboration through interaction among distance learners. Consistent with mainstream portable ICT researchers, mobile TML researchers have largely dwelt on mobile interaction services (Sørensen *et. al.* 2002) of portable ICTs. Most of them (e.g. Lundin and Magnusson 2003, DiGiano *et. al.* 2003, Ketamo 2003) have focused their attention more on mobile interaction by distributed learners with wireless mobile devices connected to a central server. This orientation is reflected in extensive usage of the term 'wireless' as a synonym of or in combination with mobile to describe such ICTs in most publications. One cannot criticize such researchers for their neglect of mobile computational services (Sørensen *et. al. ibid.*) because it is evident that they aim at studying learning against the background of optimal information service

capacities of portable ICTs. When sub-optimal information services – such as the absence of wireless connectivity due to certain situational circumstances – can only be obtained from portable ICTs in learning, the assessment of the efficacy of these artefacts takes a different tack. Evaluation shifts from learning essentials such as collaboration through portable ICTs towards other learning essentials such as information processing, ease-of-use and perceived ease-of-use (Adams *et. al.* 1992), the reconstruction of the artefact (Wartofsky 1979), the politics of technology use, formative contexts (Ciborra and Lanzara 1994) and the negative capabilities (Keats 1973) experienced by the learners.

2.4 Chapter Summary

This chapter has presented a review of the literature on portable ICTs within the context of various aspects of mobility. The discussions revealed the fundamentality of human mobility as the substrate upon which all forms of mobility develop. The mobility of humans and ICTs was placed within three main modalities – visiting, wandering and travelling – to depict the complexities involved in the use of portable ICTs. These complexities were analysed against the background of three fundamental dimensions of mobility – space, time and context. The analysis revealed that portable ICTs can diffuse spatial, temporal and contextual barriers based on the potential mobile interaction and computing information services they offer. In harmony with Goodhue and Thompson (1995), the task-technology fit – the inseparability of the functionalities of portable ICTs and the activities they mediate – was identified as the key to successful analysis of the efficacy of portable ICTs.

Furthermore, the problem of learning as understood from objectivist and subjectivist perspectives was also reviewed under key theories of learning. The review began with a placement of learning within a historical perspective from the cognitive constructivist paradigm championed by influential authors such as Dewey and Piaget. This led the way towards a presentation of the arguments of social constructivists who claim that learning is inherently social. The sociality of learning implies physical and psychological mediation of learning which was espoused by Vygotsky. Physical and tool mediation are implied in learning through communities of practice, and internal and external information processing, which have also been discussed in sufficient detail. Following this, the mediation principle of activity theory was used to analyse

mediated WIL. Finally, the potentiality of portable ICTs as learning support tools are assessed within the context of the literature on TML, serving as a challenge upon which the objectives of this research are founded.

Chapter 3: Research Methodology

3.1 Introduction

This chapter tackles the *how* of the entire research effort. Presenting a detailed methodology of a piece of research is crucial in terms of internal validity of its outcomes. In particular, when the research is one that has very few preceding examples, the methodological choices made become crucial in validating its findings. I have already indicated that the development of the area of mobile computing in IS research is in its rudimentary stages; moreover, work-integrated learning as a contemporary form of learning is also an under-researched area (see Chapter 2). Therefore, this chapter is aimed at disclosing the methodological decisions made and the justifications underpinning those choices in the investigation. A methodology is a viewpoint, a perspective that evinces the researcher's outlook of the world in general and the phenomenon under investigation in particular.

The first phase of this chapter is a presentation of the overall philosophy adopted in approaching this research. This presentation begins with a brief explanation of research philosophy, followed by an outline of the key attributes of the major research philosophies – positivism and interpretivism – in Sub-sections 3.2.1 and 3.2.2 respecively. Next, in Sub-section 3.2.3, I justify my choice of philosophy with the objectives of this study. Phase two follows thereafter with an outline of the details of the research design in Section 3.3; this includes the strategy (3.3.1), type of evidence (3.3.2), sources of data (3.3.3), and analytical techniques (3.3.4). In like manner, the justifications for all the choices under the research design parameters are presented and related to the research objectives and adopted philosophy of approach. Concluding remarks concerning the chapter are given in Section 3.4.

3.2 Philosophy of Research Approach

The term 'philosophy' is an expression that is used to represent human attributes such as belief, viewpoint, attitude, value and way of life. The way of life of a researcher is directly associated with his or her perception of *reality* (ontology) and its relation to *knowledge* (epistemology). The purpose of science is to build an understanding of the

world based on a transition from perception towards knowledge – an inquisition which relies on evidence towards the advancement of knowledge and the establishment of scientific truth. This transition is expressed in simple terms as *I perceive and therefore I know.* In research terms, philosophy of approach is therefore understood as the *way* in which research is conducted – from the researcher's initial thoughts, through operationalisation of those thoughts, to the explanation of research results. In other words, philosophy of approach to any research endeavour is the most crucial as it underpins all other decisions and choices made in the operationalisation of the research.

In western scientific thought, interpretivism and positivism are two major philosophies of approach that have dominated scientific inquiry. Over the years, interpretive and positive research have largely been perceived as polar, and therefore interpretivists, for example, are usually labelled as antipositivists in certain disciplines (Galliers 1991). Recently, critical research has emerged as a third philosophy. While it has its quite outstanding attributes, it is usually seen as a quasi-interpretive philosophy because critical researchers also share an interpretive viewpoint of the world.

3.2.1 Ontology and Epistemology of Positivism

The positivist researcher sees reality as external in form and objective – reality is 'out there'. To him or her, reality is independent of the perception or mental state of the observer. Based on these, positive research is usually grounded on hypotheses concerning cause and effect laws about objective reality. The positivist's usual approach to inquiry is therefore governed by the avoidance of interference with the phenomena under investigation. In other words, the underlying rule is the isolation of the phenomena and a separation between the observer and the observed. Furthermore, positivism implies a belief in the repeatability of observations upon which generalised concepts and theories are developed.

This belief about reality translates into the idea that knowledge is based on objective facts. To the positivist, facts in the world that establish scientific truth and falsity must be independent of anyone's attitudes, perceptions or feelings about them. In positive research subjectivity is therefore ruled out completely; and knowledge is derived from

deductive proof or deduction. Deduction begins with a universal truth or a "connected view of a situation" (Dewey 1910, p.82) and works back towards the binding of fragmentary details of empirical phenomena through tests, confirmations, refutations and modifications with the aim of interpreting "isolated details into a unified experience" (*loc. cit.*).

Positivism has achieved significant research success over the years particularly in the natural and physical sciences ('hard' sciences); and in truth, it has been a very dominant force in scientific inquiry. In fact there have been periods in time when social and applied sciences ('soft' sciences) oriented towards positivism because knowledge claims not grounded in positivist thought were simply dismissed as ascientific and therefore invalid (Hirschheim 1985). Thus, it is not surprising to note Wilhelm Wundt's extraordinary attempts to 'scientify' psychology by aligning his introspective psychological inquiry with the 'hard' sciences' positivist philosophy. Apparently, the success of positivism in the 'hard' sciences has manifested because of the objective nature of phenomena that are subjected to investigation in the natural and physical sciences. Phenomena like chemical elements, biological entities, and physical matter, on their own, largely lend themselves for repeatability and isolation when they are subjected to the scientist's investigation.

Therefore, it can be said that the success of positivism in the physical and natural sciences is attributable to the nature of the phenomena that characterise those sciences, and not necessarily to the superficial 'tidiness' or objectivity of positivism. This assertion is buttressed by the fact that where the phenomena under investigation have not been natural and 'hard' but social and 'soft', positivism has been less successful. In other words, in circumstances where subjective phenomena come under investigation, positivism has been found wanting.

3.2.2 Ontology and Epistemology of Interpretivism

In interpretive research, the problem of the form or perception of reality is as subjective as its knowledge. 'Being' is relative to the observer. The concept of social reality implicitly incorporates the notion that reality is dependent on the feeling and mental state of the observer. Stated differently, reality does not exist outside the observer; rather, it is determined by the experiences, culture and other sociological

factors that have shaped the observer. The interpretive viewpoint of reality contrasts with that of the positivist outlook.

The fundamental epistemological assumption of interpretivism is that knowledge is socially constructed and based on subjective interpretation. The issue of subjective interpretation has led many positivists to question the scientific essence of interpretivism. If science aims at advancing knowledge – and hence generalised and objective knowledge –, how can general theories be developed and consequently validated? The problem of theory development, which is associated with an objective undertone of verification, seems to contradict the subjective interpretation of knowledge as a fundamental principle of interpretive research. However, the two-tiered process of interpretive research – *understanding* and *interpretation* – explains clearly the non-contradictoriness of its subjectivity and objectivity.

In the first tier, the interpretive researcher seeks to understand the world of the research subject through data collection. It must be realised that subjective interpretation is an attribute associated with understanding how the subjects make sense of their world in their everyday lives and activities. This is important in the sense of the fact that human beings are social cultural beings with varying belief systems and interpretations. It would therefore be erroneous to equate the natural world with the social world. Thus, it is very true that

> "the world of nature, as explored by the natural scientist, does not 'mean' anything to the molecules, atoms, and electrons therein. [However,] the observational field of the social scientist ... has a specific meaning and relevance structure for the human beings living, acting, and thinking therein." (Shutz 1954, p.267).

Subjectivity in interpretive research is necessarily an attribute of understanding the world.

The second tier is the interpretation of the data which has earlier been understood. This is the stage of analysis of the data with objectified parameters established in theories and concepts towards the development of scientific and general constructs, models, concepts and theories. Compared with understanding at the concrete, empirical level of the research, interpretation is sense-making at the abstract, theoretical level using established verified hypothesis or principles.

> "The scientific constructs formed on the second level, in accordance with the procedural rules valid for all empirical sciences, are objective ideal typical constructs and, as such, of a different kind from those developed on the first level of common-sense thinking which they have to supersede." (*Ibid.*, p.270).

Interpretations in themselves are therefore, part of the scientific knowledge being investigated and are scientifically validated through scientific induction. Scientific induction, according to Dewey (1910) refers to "all the processes by which the observing and amassing of data are regulated with a view to facilitating the formation of explanatory conceptions and theories." (p.86). In other words, it is a process in which the researcher proceeds from fragmentary and incoherent empirical details through a gradual insertion of universal facts and their properties towards the discovery of a coherent idea.

Interpretive research is embraced more in the social sciences and in the applied sciences that concern themselves with humans. These domains represent the areas where interpretivism has largely achieved its success. As Shutz's has indicated, "the human beings living, acting and thinking therein" within the field of observation of the social scientist cannot be overlooked. In fact, they constitute the most important aspect of all the phenomena under investigation by the social scientist. This is why many IS researchers (e.g. Hirschheim 1985) have questioned the suitability of positivism in IS research endeavours. IS, which is loosely defined as the study of the teleological interaction between people and ICTs, is, without doubt, a social science discipline. To analyse, design and manage this interaction, the IS researcher must understand those humans who act on technology by adopting an interpretive philosophy.

3.2.3 Justification for Choice of the Interpretive Philosophy

The study was founded on the interpretive philosophy of IS research; that is, an interpretive epistemology and ontology were adopted to understand the nature of the phenomena under study. Based on this, an understanding of the empirical data collected was founded.

It is true, that we all interpret the world and construct realities from our subjective interpretations. According to Klein and Myers (1999), research can be deemed

interpretive "if it is assumed that our knowledge of reality is gained only through social constructions such as language, consciousness, shared meanings, documents and artefacts". In a study of mobile computing in a distributed and work-integrated learning environment, sociological, social psychological and contextual principles become inevitable foundations. It is well known, at least in the European context, that IS is an applied science – a "combination of two primary fields: computer science and management, with a host of supporting disciplines e.g. psychology, sociology, statistics, political science, economics, philosophy and mathematics" (Boland and Hirschheim 1985). In IS, we are not only concerned with the design and development of technological systems, we are also concerned with other aspects such as planning, management, implementation, evaluation and maintenance of these systems.

Taking a closer look at these attributes, the human factor is as intrinsic as it is pervading. IS research, by implication, is social science research that relies on understanding based on social reality. The human perspective of understanding technology use therefore has to be necessarily premised on Weber's (1897) "subjective interpretation". In this regard, I am inspired by Alfred Shutz:

> "The primary goal of the social sciences is to obtain organised knowledge of social reality. By the term 'social reality', I wish to be understood the sum total of objects and occurrences within the social cultural world as experienced by the common-sense thinking of men living their daily lives among their fellow-men, connected with them in manifold relations of interaction" (Shutz 1954, p.261).

He further deciphered Weber's subjective interpretation

> "... as the experiential form of common-sense knowledge of human affairs, as an epistemological problem, and as a method peculiar to the social sciences" (*ibid.*, p.265).

The high degree of subjectivity inherent in human cognition, people's cultural orientation which gives meaning to their perceptions, and the contextual and situated interpretations of actions and activities in practice are revelations that point to the inter-subjectivity of understandings immanent in this study. The aim to understand work-integrated learning within the context of mobility through the meanings professionals assign to their activities and information processing actions requires the adoption of interpretive assumptions and methods. Furthermore, the aspiration to gain an insight into the way these professional learners construe, conceptualise and understand their computing with portable ICTs within their activities make the

examination of their social reality and interpretive meanings important (Bredo and Freinberg 1982a). Drawing on the work of Walsham and Waema (1994), interpretive assumptions in IS research are aimed at producing an understanding of the context of the information system, and the process whereby the system influences and is influenced by the context.

The aim of the study rejects positivist and critical research approaches to the investigation. The nature of this task does not favour a positivist philosophy of testing hypotheses through controlled experiments and statistical analysis (Kaplan and Duchon 1988). Neither does the tenet of critical research philosophy (e.g. Chua 1986) fall within the criteria required for unpacking the desired understanding.

Together, the ontological and epistemological foundations of the interpretivist philosophy provided the basis of understanding of the key issues and for theory development in this study. In conducting the study, I was careful not to base my understanding of technology use by the medical professionals on existing formulations and conceptualisations; rather, the data collected were understood within their context of emergence. That is, weight was placed on how their perceptions shaped their understanding, motives, goals within the conditions in which they performed computing actions.

The study was guided by the philosophical assumptions of Activity Theory (AT) adopted from the works of Vygotsky and Leont'ev, and applied lately to learning by Engeström (see Chapter 4 for a detailed discussion of AT).

3.3 Research Design

3.3.1 Action Research Strategy

Based on the aims of this research, vis-à-vis the interpretive philosophical stands taken and explained above, it was imperative to adopt an investigative strategy that would enable sufficient and rich insight into the empirical phenomena. Initially, I was oriented towards studying a particular case of mobile technology use in-depth to unearth the complexities involved. In the case study, I was aiming at the examination of the problem in its real-life context. According to Yin (1981, 1984), studying a phenomenon in its real-life context is most appropriate when the boundaries between

phenomenon and context are not clearly evident. In the sense of my research, mobile ICTs and the distribution of activities are contemporary phenomena in which research and theory in both areas are in their formative stages. Roethlisberger (1977) recommends that researchers adopt case study strategies for such contemporary phenomena. From another angle, Bonoma (1985) proposes case studying phenomena that involve sticky practice-based issues where the experiences of the actors and the context of action are critical. The problem of this study exhibited all of these features – real-life, contemporary, formative staged paradigms, and practice-based.

Subsequently, however, the research strategy used was Action Research (AR). AR is only different from a case study on the grounds that in AR, the researcher is not just an outsider who investigates through, most notably, interviews and observation, rather he or she becomes an integral part of the phenomenon being investigated. He or she is integrated through a mutual agreement between the researcher and the practitioner. The practitioner seeks the intellectual knowledge of the researcher to assist him or her to solve a particular problem related to the researcher's domain of study, while the researcher takes advantage of the problem solving contribution to gain a richer insight into the phenomenon more than he or she would gain in a case study. In this study, I was invited by the authorities of the PSP project to assist in the orientation, adoption and use of the PDAs since most of the PSPs were not familiar with this novel technology. Thus, the pre-planned case study strategy was transformed into an AR strategy.

An action researcher is like a "clinician" (Schein 1987), that is "he is also focused ... on the client's initial problem statement, the reasons given for why the clinician was invited into the organisation in the first place" (*ibid.*, p.40). AR is a practical problem solving exercise that aims at an increased understanding of an immediate and specific situation, with particular focus on the complex and multivariate nature of the situation (Hult and Lennung 1980). In AR, the two processes of *research* and *action* are integrated. It involves the researcher immersing himself or herself in a human problem situation – gaining from the immediacy of the involvement in the action process – with the aim of seeking learning out of the achievement of practical ends (Foster 1972). It has to be said that being invited by the practitioner into the immediacy of the context of the phenomenon is gratifying from the point of view of

the researcher. In this sense, the clinician stands in a stronger position to get access to critical data than even an ethnographer. Schein, for example, claims that

> "the clinician often has access to data that the ethnographer will never get because the client is not motivated to reveal it, and the clinician often has access to levels of the organisation that the ethnographer finds difficult to penetrate" (1995, p.43).

With the aim of gaining a holistic understanding of the underlying culture, context and complex social change processes associated with the technology use, I was directly involved in the initial planning of the integration of the mobile ICTs in the project. More specifically, I played the role of a participatory action researcher through active collaboration with the PSPs and the authorities of the project. In addition, I participated as a direct observer in many of the London-based modules and led the training of the PSPs on how to use the PDAs. Furthermore, I assumed the role of a 24-hour 'helpdesk' support to them – they could call me on the phone anytime for help when they encountered any problems with the use of the PDAs during their training. My role therefore oriented towards a facilitator and active participant. I have to emphasise that I was strictly an action researcher not a consultant: I accepted the invitation to participate in the project not to gain monetary rewards from the project but to use the opportunity as a means to obtain as much in-depth information as possible. In terms of each of Baskerville's (1999) five key parameters for distinguishing between an action researcher and a consultant – motivation, commitment, approach, foundation for recommendations, and essence of organisational understanding – I was an action researcher. That is, my activity was motivated by scientific interests and prospects for scientific knowledge development in accordance with the requirements of IS research.

My collaboration with the practitioners in solving their problems was immensely beneficial on several counts. The most significant was the induction of trust and confidence in me from the beginning. Offering myself as a facilitator for the adoption of technology and implementation of technology decisions in the project was welcoming to the practitioner not only in monetary terms; it was also welcoming to him on the grounds of my abilities to resolve most of the emerging problems I was assigned with. In so doing, I did not only win the trust and confidence of the project authorities; most crucially, I also won the trust and confidence of the PSPs who were using the PDAs. This achievement was very significant because it eased my access to

information and facilitated my process of data collection at all levels of the project set-up from the outset to its conclusion. The long list of personal e-mails, our numerous extensive informal conversations in the corridors of St. Mary's Hospital and their frank responses to my interviews all testify to the intimacy that resulted from my collaboration and facilitation in the project.

In my quest to emerge with research results that exhibit internal and external validity, I endured and prevailed in this role until its official completion after twelve months. To quote Baskerville, "[AR] produces highly relevant research results because it is grounded in practical action aimed at solving an immediate problem situation while carefully informing theory" (Baskerville 1999). My involvement, and hence understanding, have considerably shaped my findings and have eventually enhanced my goal of contributing original scientific knowledge to the Information Systems discipline.

3.3.2 Type of Evidence

Given the aim to understand phenomena-in-context through PSPs' intersubjective judgements of their use of technology, the study relied heavily on qualitative data. Qualitative data are continuous and analogue, compared with the discrete nature of quantitative data. In addition, given the small number of trainees in the project – twelve – I was presented with an opportunity to avoid sampling the population of PDA users, and to cover their individual experiences in-depth. Some unavoidable effects of AR are the adoption of an idiographic viewpoint of research inquiry, and the acceptance of qualitative data and analysis (Baskerville *op. cit*). I applied data collection techniques that revealed qualitative evidence on issues like social and situated reality, consciousness, shared understandings, and identity perception and formation, which are central to the research problem. Qualitative evidence grounded the understanding of the professionals' use of mobile computers in their social and cultural contexts within which they learn. According to Kaplan and Maxwell (1994), the goal of understanding a phenomenon from the point of view of the participants and its particular social and institutional context is largely lost with the quantification of textual data.

Unit of Analysis

The study focused on the activities of individual PSPs as the units of analysis. Given that organisation culture bears directly on the practices in which the they engaged, my investigation of these PSPs, who all have worked under the NHS before, optimised my interpretation and understanding of their mobile WIL. Organisational actors' cultural orientation give meaning to their perceptions and hence their practices. Besides, the aim to study WIL learning as a process of human development and performance is with reference to professionals' shared meanings towards the development of their innovative capacities. My 'how' question seeks to understand the nature of the uncertainty and complexity of mobile information processing and generation involved in experiential learning; and justifies my focus on the PSPs.

3.3.3 Data Sources

Multiple data collection methods were employed in the process to obtain the qualitative data. The goal was to obtain a rich set of data surrounding the research aim and questions, as well as to capture its contextual complexity (Benbasat *et. al.* 1987). The following data collection methods were used:

Observations

Although my involvement in the project was participatory, I employed direct observation instead of participant observation, and that only proceeded as far as their London-based actions were concerned. It would be fair for one to think that an investigation of mobile computing should entail a significant dosage of direct observation within the context of use. However, this form of observation could not be performed because of official restrictions associated with medical ethics. To perform observations of PSPs' mobile computing within their hospitals, I needed permission from the Ethics Committee of the General Medical Council. Now, the processes and requirements for granting this permission are extremely complicated. At the background of these complications is the fact that the researcher or observer will be observing, in addition, all sorts of extreme scenes of sick patients' conditions in the hospitals. In truth, all the signs were pointing to the fact that I would not be allowed to observe the PSPs' mobile computing in their hospitals. One significant reason was that, as far as the hospitals and the PSPs' surgical teams were concerned, mobile computing was not deemed a very important aspect of the training project. By

implication, my research efforts were not integral either. Therefore, I could not observe their mobile computing-in-action as desired, unfortunately. My only observations of their computing with the PDAs were in situations of their immobility – during my interviews, in the sessions of the London-based modules, and at lunch. Therefore, data on their mobile computing-in-action experiences were obtained from the conversations, sessions and interviews I had with them over the twelve-month period.

Conversations, Interviews and Sessions

Open-ended interviewing was adopted in collecting data. PSPs were asked questions leading to discussions of their mobile computing-in-action, and on how they think the PDAs are shaping and being shaped by their learning. The objective was to induce and entice them to elaborate because when they do so, their languages and social cues reveal attitudes, morals, beliefs, and opinions and feelings (Kendall and Kendall 1993). Furthermore, open-ended interviews are most suitable for gathering information on questions of 'how' because they are explorative in nature. I took advantage of my participatory role and established relationships with the PSPs to obtain further information through informal conversations.

Formal interviews were conducted face-to-face during my visits to the hospitals of the PSPs; and on telephone. Both the face-to-face and telephone interviews were tape-recorded during the process; but, admittedly, not all the telephone interviews could be recorded. I have to say, in addition, that the face-to-face formal interviews were largely interspersed with informal interviews or conversations as part of my problem-solving role in the project. In a typical scenario, information about the PDA's use would be immediately forthcoming from a PSP at the time I make a request on telephone to pay him or her a visit. Then as I arrive at the hospital later on, the very first words of exchange would be either banters or serious remarks about his or her experiences with the use of the PDA. This conversation continues along the corridors and staircases until we finally settle down in the canteen or in his or her office in the hospital for me to pull out my tape-recorder to commence the formal interview. Other instances of informal conversations occurred when they had returned to London for their modules: beside the tea-table, in the classroom before a session, in the canteen, and during the official three-hour "PDA session" of every module.

The official "PDA session" was designed to allow myself and the application designers to interact with the PSPs and solicit their problems and concerns about the PDAs use in their learning activities. These sessions always presented me the opportunity to ask collective questions and to organise workshops with the PSPs. They also presented an environment where their personal experiences were shared among themselves, revealing critical information that could not be discussed in a formal interview. Furthermore, these sessions revealed both collective and idiosyncratic experiences. To ensure the fluency and fluidity of the processes, and to reduce distractions to the minimum, it was not my aim to carry my tape-recorder hand-in-hand with my PDA as I demonstrated solutions to some of their problems and concerns. I therefore tape-recorded these sessions from a fixed location of the recorder, and took notes at the same time because the distribution and local mobility that characterised these sessions ensured that not everything said could be recorded.

There was another three-hour session of every module named as "How things went." This session was always the first of every module; it was designed to solicit feedback and experiences from the PSPs in relation to their learning experiences of the previous six weeks spent in their individual hospitals. "How things went" were always very emotional and presented the PSPs with the official opportunity to pour out their feelings. In the early sessions when nearly all of them were facing resistances from their surgical teams, for instance, it was both interesting and depressing to behold one of them crying at how she had been treated in her hospital; some of them complaining of how they have been turned into errand boys and girls; and some of them not even allowed to follow the surgical teams on their hospital rounds. It was also interesting to witness one of the sessions drift from sharing of learning experiences into one of PDA complaints at the time when one of the applications had proved to be completely unusable. Although it was the project leader himself who moderated the "How things went" sessions, I was present as an observer in all of them and took notes of the proceedings.

In the end, I attended the final evaluation session organised among the key stakeholders of the project – the PSPs, the project authorities, each PSPs surgical team, and other senior NHS officials. Dubbed a "Sharing Event", it was a platform for

each PSP's surgical team to make a presentation of their assessment of the project in general, based on the assessment of their PSP's performance in the team. The chosen venue of this event – the Hilton London Metropole Hotel – was indicative of its importance as far as its justification and the future of the not-yet-accredited PSPs were concerned. These presentations were highly illuminating, and it offered me the opportunity to listen to the views of the surgical teams, particularly the consultants who led these teams.

E-mails and Documents

Over the period, I also exchanged several e-mails with all members of the project. However, most of these e-mails consisted of exchanges with the PSPs on the experiences with technology use. E-mailing was an option I provided them to reach me if I was not available to receive a phone call. It was very helpful in my data collection because it was a medium through which the PSPs were more expressive of their feelings. Besides, the a-contextual nature of e-mail text, its associated asynchronous interaction, and its unobtrusive nature ensured that interaction was convenient for myself and the PSP at any time. Some of their e-mails were additions and confirmations of problems that had been discussed beforehand, serving as a double-check of the data received.

Efforts were made to obtain written materials from sources including formal reports, memoranda, Internet publications and newspaper stories. These secondary sources complemented the other data sources to build some unifying and holistic evidence. More importantly, documented information from such secondary sources were studied to inform the design of some open-ended interview questions. I also sought archival records to complement these documents. These include organisation charts, plans and strategies, and reports.

Meetings

I held several meetings with the project authorities from the project's beginning to its end. Although, these meetings were far fewer in number compared, for example, with my interviews, they were a reliable and rich source of information about the grand scheme of the project. The first ones focused on planning the integration of technology into the project and the assessment of the possible applications that could

be designed into the PDAs. Some subsequent ones focused on the computing problems that had been reported by the PSPs and their possible solutions. Others looked into my assessment of their technology use from my interviews and observations. The final ones concerned the decision to formally abandon the technology as an official part of the training and assessment of the PSPs. It is worth noting that, in addition to these formal meetings, I also had several informal conversations and interviews with the project leader and the application developers. In fact, as part of my facilitative functions, I assisted the application developers in thinking through the possible learning scenarios and the PSPs' corresponding actions as a means of modelling their actions towards the development of the applications. Through this, a great deal of insight was gained into the design of the application and the perceptions of the application developer. Moreover, this insight was immensely helpful in my diagnosis of the PSPs' reported problems and consequent suggestions.

In all several tens of hours were spent – formally and informally, directly and indirectly – in collecting verbal data from the PSPs. I cannot be very precise about the total number of hours spent, but from the accounts I have provided above, and the fact that the project was studied over a period of 12 months; a substantial amount of time was spent in the investigation.

3.3.4 Data Interpretation Techniques

The data that were collected from both primary and secondary sources were characterised by texts, and signs and symbols including voice recordings, transcripts, notes and pictures. To satisfy the central aim of this inquiry, data collection and interpretation were predominantly informed by Philosophical Hermeneutics – a philosophical theory of interpretation developed in the works of Gadamer (1975, 1976); and Social Semiotics – a variant of structural semiotics that concerns social meaning of signs rather than their structural meanings (e.g. Hodge and Kress 1988, Thibault 1997, Jensen 1995).

Hermeneutics is a branch of philosophy concerned with the interpretation of written texts and human understanding. In hermeneutics, texts are perceived as the media that transmit experience, beliefs and judgements from the author to the interpreting

subject. Hence hermeneutics rejects scientific analytical philosophy which seeks meaning from the external referents of texts. According to Taylor (1976),

> "Interpretation, in the sense relevant to hermeneutics, is an attempt to make clear, to make sense of an object of study. This object must, therefore, be a text, or a text-analogue, which in some way is confused, incomplete, cloudy, and seemingly contradictory – in one way or another, unclear. The interpretation aims to bring to light an underlying coherence or sense" (p.153).

According to the tenets of philosophical hermeneutics, the productive grounds of understanding are embedded in the knowledge and experience of the interpreter. Knowledge and experience amount to the *effective history* required in the assimilation of new experiences. This historicity constitutes the interpreter's *prejudices*, derived from his or her tradition and language, which are brought to bear in understanding and interpreting phenomena. It is noteworthy that "prejudices" do not denote negative forms of bias but as "pre-learning" (Scott 2002).

The analysis and interpretation of such texts were tasks partly conducted during the collection process, and partly outside the spatial and temporal context of when others and myself authored them. In what is both spoken and written, "the meaning of what is spoken exists purely for itself, completely detached from all emotional elements of expression and communication" (Gadamer 1975; p.392). I therefore adopted hermeneutical reflections during my data collection and interpretation processes. The two contexts – my own knowledge and experience of IS and technology use, and that of others explicated in the verbal information and texts – represents what Gadamer calls *horizons* that require *fusion* to derive an understanding of the complexity of the process.

Semiotics – pioneered by Ferdinand de Saussure and Charles Sanders Peirce – is the study of 'how' *meanings* are made from signs: as such, being concerned not only with communication but also with the construction and maintenance of reality. It embraces the traditional strands of linguisics – semantics, syntactics and pragmatics. Sausurean and Peircean semiotics have been influenced by structuralism and has acquired the epithet "Structural Semiotics". While structural semiotics concerns itself with the "deep structures" underlying the "surface features" of phenomena (Chandler 1995), contemporary social semiotics offers a comprehensive approach to understanding the ways in which human social meaning is constituted in specific social situations.

Meaning-making practices include linguistic, actional, pictorial and somatic modalities which characterise social discourses (*Ibid.*). The philosophical assumption of social semiotics suggests that no semiotic form, material entity or event, text, or action has meaning in and of itself. Rather, any given community has regular and repeatable patterns of meaning-making which define and distinguish the community from others (Thibault *op. cit.*). Social semiotics therefore represents an invaluable analytical tool that was applied in understanding the qualitative data, particularly the meaning-making practices involved in mobile computing by mobile professionals.

3.4 Conclusion

In this chapter, I have made efforts to outline and detail the methodology used in this research. I have clarified my choice of an interpretive philosophy with justifications founded on the nature of the empirics being studied, and the principles of social science research. The human factor in the study of mobile computing by mobile professionals in a typical distributed activity justifies the interpretative stands taken. This philosophy is further used to justify the Action Research strategy adopted in the fieldwork, leading to the inevitability of collecting qualitative data. Following this, the sources from which the qualitative data were collected and the analytical techniques used for understanding and interpreting the data were also discussed.

Having outlined the *how* or the process used, the next task, in this thesis is to present an overview of the theoretical framework adopted for this study. As hinted in the previous chapter, interpretations of both the empirical and theoretical aspects of the study were founded on the theory of Activity.

Chapter 4: Learning as an Activity

4.1 Introduction

Any study of technology use or of the social impact of technology draws upon sociological and social psychological theories – notable ones in the IS field are Structuration, Actor-Network, theories of social construction of technology, a host of knowledge management and learning theories, and various organisation and cultural theories. Given the objectives of this study, it was imperative to approach the task with a theory of learning as a framework for studying mediated work-integrated learning. Many existing theories of learning have much to offer in terms of understanding the learning process, but they only parochially address the problem of learning based on idealistic principles, reducing mediation of various sorts to secondary phenomena statuses in any learning process. These theories largely centre on phenomena such as the mind, behaviour and/or cognitive development. For example Piaget's cognitive theory of child development is one of the most popular theories of learning; but it does not address learning that occurs within the interactions between people; or within interactions with prosthetic devices (see Vygotsky 1962, Bleuler 1912[17]). Theories of technology mediated communication and interaction were also sought with the aim of gaining an insight into the effects of technology mediation on learning which would be used as a framework of analysis for this study. Technology-mediated theories offer much in terms of the social and cognitive effects of technology mediation, but the insights they offer, while useful, do not particularly focus on the problem of learning (see for example Sproull and Kiesler 1986, Daft and Lengel 1986, Short *et. al.* 1976).

Cultural-Historical Activity Theory (CHAT, hereafter AT) integrates both learning and mediation: its principles treat the combination of learning and mediation as the integral and inseparable components of any conscious human activity and skill development. The philosophical ideas offered by the theory make it a suitable theoretical framework for this study because of the guidance it offers for analysing

[17] In *Autistic Thinking* (1912), Eugen Bleuler's critique of Sigmund Freud's principles of child development also effectively stands as a critique of Piaget's ideas of child "egocentrism" which drew on Freudian principles.

tool-mediation and skills development within the context of work-integrated learning. This chapter presents a review of AT including an explication of how its core principles convincingly suggest its suitability as a framework for studying mobile computer-mediated learning and development.

First, I present a brief overview of the AT in Section 4.2 by discussing the fundamental principles which underpin its development from Vygotsky through Leont'ev to Engeström. Thereafter, the general structure of an activity is reviewed in Section 4.3 through a detailed explanation of its principal elements. In Section 4.4, the activity system is also reviewed in an elucidation of the essence of each of its elements. Next, Section 4.5 presents the psychological underpinnings of the activity structure and system combined. It is in the detailed review of these underpinnings – the key principles of activity – that the suitability of AT for this study is clearly teased out. Thus, Sub-section 4.5.1 focuses on object-orientation, 4.5.2 on internalisation and externalisation, 4.5.3 on consciousness, 4.5.4 on contradictions, and 4.5.5 on prosthesis and mediation. Following these, the ideas of mediation are integrated with the concept of affordances of artefacts based on the psychology of perception in Section 4.6, with the aim of analysing the use of ICTs in learning activities.

4.2 Overview of Cultural-Historical Activity Theory

Cultural-Historical Activity Theory[18] 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 and the world is mediated by his or her activities; that is, his or her interactions with environmental objects.

In his theory of developmental psychology, Vygotsky drew upon the ideas of Karl Marx (e.g. Capital 1909) to initiate his expositions of human activities within which he posited a learning subject and a learning object mediated by tools – physical and

[18] 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.

psychological tools. In these expositions, he challenged existing Piagetian notions of learning as *cognitive development* (Piaget 1970) with his arguments that suggested that learning is inherently social; that is, the origins of thinking are founded on social interaction, and hence learning is a process of *social development* instead of cognitive development. He laid emphasis on the interconnections between people and the cultural context in which they act and interact in shared experiences (Crawford 1996). Essentially, Vygotsky's treatment of the psychology of human development centred on the semiotics of cultural historical ideals of society.

Later, his colleague – Alexei Leont'ev – further developed the activity concept in social development by elucidating its constituent operations-actions-activity levels (Leont'ev 1978, 1982). AT is attributed to the brilliant works of Leont'ev because he did a lot to explain the concept of activity, but he admits that "the idea of analysing activity as a method of scientific human psychology was proposed...in the early works of L. S. Vygotsky. [In those works,] the concept of tooled ("instrumental") operations, the concept of purposes, and later the concept of motive ("motivational sphere of consciousness") were introduced." (Leont'ev 1978, p.62). An activity is the act of satisfying a *need* through the engagement of a subject with the transformation of an object – the object having been perceived to satisfy the need.

Recently, AT has been further explicated in its application to the study of adult learning and of learning-at-work most notably by the educational psychologist Yrjo Engeström (Engeström 1987). AT is a theory of learning that offers a cogent set of postulates on an approach to human development based on the social psychological and physiological implications of human activities. It lays emphasis on the immediacy of human activities and conscious meaning-making of a performing individual, pointing to the importance of engaging learners directly in the practice that transforms the learning object rather than its image (Il'enkov 1974).

Without doubt, AT has had its share of criticisms from other psychologists. Mostly, these criticisms centre on the perceived difference between Leont'ev's tool mediation and Vygotsky's sign mediation. Sergei Rubinstein, for example, attacked Leont'ev for illegitimately identifying "the psychological problem of mastering operations with the social process of the disobjectivation of the social essence of man" (Rubinstein

1960). In his thesis on AT and individual and social transformation, Engeström (1999) pointed out the uncertainty about AT's potency to overcome "individualist and ahistorical biases inherent in the theories of action". He quoted von Cranach's critique of Leont'ev's concept of action illustrated by the primeval collective hunt:

> "History is a concrete process, and it is not enough that one philosophises a bit about the early humans, how they ran after antelopes, and then takes a huge step right to the distinction between capitalism and socialism." (von Cranach 1988, p.155, quoted in Engeström 1999, p.23).

Other critics such as Eric Yudin (1976) and Georgy Shredrovitsky[19] have all accused Leont'ev of substantially deviating from Vygotsky's original developmental psychological formulation.

It is true, that while Leont'ev shared Vygotsky's views on learning through mediation by cultural-historical factors, he took a different view on the form of mediation between the subject and his or her objective world. To Vygotsky, mediation occurs through the learner's social interaction and hence underpinned by the history and culture that have shaped phenomena that interact with the learner – in his experiments, the child. On the other hand, Leont'ev conceptualised mediation as the activity in which the learner is engaged; that is, consciousness is a factor of the relationship developing between the individual and his or her activity. But the essential viewpoint of AT is not the trivial difference between the ideas of Vygotsky and Leont'ev; the essence is in how it offers itself as an instrument for studying how people learn and develop skills. In fact in his discussions of mediated activities, Vygotsky stressed that "tools and signs are mutually linked and yet separate" (1978, p.54). A few lines later, he pointed out that

> "[a] most essential difference between sign and tool, and the basic real divergence of the two lines, is the different ways that they orient human behaviour. The tool's function is to serve as the conductor of human influence on the object of activity; it is *externally* oriented; it must lead to changes in objects. ... The sign, on the other hand, changes nothing in the object of a psychological operation. It is a means of internal activity aimed at mastering oneself; the sign is *internally* oriented." (p.55) (italics original).

Interestingly, both tool and sign mediation are very interlinked, as the mental images and properties of physical tools internalised through appropriation constitute signs.

[19] In *Vygotsky in Context,* his editorial preface to *Thought and Language (1986)*, Alex Kozulin reported Shredrovitsky's critique as follows: "Georgy Shredrovitsky ... addressing a colloquium on Vygotsky in 1979, challenged the myth of succession and suggested that Leont'ev's theory substantially deviated from Vygotsky's programme" (p.liii).

Therefore it is not surprising that Vygotsky followed up the distinction above with how their mutual linkage manifests in the processes of phylo- and ontogenesis.

> "The mastering of nature and the mastering of behaviour are mutually interlinked, just as man's alteration of nature alters man's own nature" (*loc. cit.*).

It is clear that Leont'ev's expositions were built on this understanding, although he took a different viewpoint of activity mediation. In truth, the principles they commonly agree on far outweigh those that are perceived to separate them.

4.3 General Structure of an Activity

> "Activity is a molar, not an additive unit of the life of the physical, material subject. ... activity is not a reaction and not a totality of reactions but a system that has structure, its own internal transitions and transformations, its own development." (Leont'ev 1978, p.50).

When an individual performs an activity, the process of development – of the transformation of the subject and object – is very dynamic and occurs over a prolonged period of time. An activity is directed by a motive: it "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 conscious and goal-oriented *actions* which are also constituted by subconscious *operations* (see Figure 4.1).

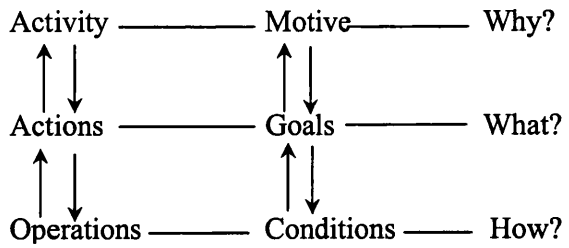


Figure 4.1: General Structure of an Activity
[Adopted from Leont'ev (1978)].

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 that satisfy the motives by which an activity was stimulated. However, in a collective activity that manifests in division of labour among a community performing the activity, the subjective goals of an individual may not be directly related to the motive of the activity. Goals are intermediate and necessarily partial results that are achieved by separate actors in a collective activity. Here, the partial results in themselves cannot satisfy the needs of the actors.

> "Their needs are satisfied not by these 'intermediate' results but by a share of the product of their collective activity, obtained by each of them through forms of the relationship binding them one to another, which develop in the process of work, that is, social relationships" (*Ibid.*, p.63).

Therefore motives are not arbitrary creations but are given in social objective circumstances – they are objective. However, during the performance of the actions related to the given objective goals, the dynamic conditions that underlie those actions may induce a subjectivisation or personalisation of the goals by the subject resulting in subjective goals. Subjective goals represent the personal sense made of the goal-oriented actions, and they may directly correspond to the motives of other activities of the subject. Thus, one action's goal may be serving the motives of different activities; and the different motives of those activities will result in the action having a different, and often contradictory, personal sense to the subject.

> "It follows from it that the aim of one and the same act can be cognised differently, depending on what motive precisely it arises in connection with (...). Depending on

> what activity the action forms a part of, it will have one psychological character or another." (Leont'ev 1982, p.404-405)

The logic in Leont'ev's illumination of activity levels makes it a useful analytical tool for studying learning processes. These levels are not only useful in their reactive sense – for studying learning in order to solve problems of development. They can also be applied proactively in planning and modelling learning activities, as illustrated in the levels of Systems Thinking of Peter Checkland (1999):

> "The idea of levels, or layers is absolutely fundamental to systems thinking. (...) The formal aim of this kind of thinking prior to model building is to ensure that there is clarity of thought about the purposeful activity which is regarded as relevant to the particular problem situation addressed." (p.A23).

Checklands analysis of these activity levels serves as a useful methodological tool for this study because it offers guidelines for analysing the origin or planning stage of a learning activity. The structure activity-actions-operations in Leont'ev is respectively represented as why-what-how in Checkland. An activity's motive answers the question *why*, and the intentional characteristic of goal-oriented actions is a response to *what* must be achieved. Goals are however achieved in specific conditions which present a problem of *how* or by what means. The latter is the operational or methodical aspect of actions "which is determined not by the goal in itself but by the objective conditions of its achievement... I call the methods for accomplishing actions, operations" (Leont'ev 1978, p.65).

All the three levels – activity-actions-operations – are interrelated in the sense that, depending on certain psychic experiences such as emotions and feelings of the subject, one of them can be transformed into the next.

> "Activity may lose the motive that elicited it, whereupon it is converted into an action realizing perhaps an entirely different relation to the world, a different activity; conversely, an action may turn into an independent stimulating force and may become a separate activity; finally, an action may be transformed into a means of achieving a goal, into an operation capable of realizing various actions." (Leont'ev 1978, p.67).

First, an action can be transformed into an activity:

> "The motive of activity, by being shifted, may pass to the object (goal) of the action, with the result that the action is transformed into an activity." (Leont'ev 1982, p.401).

The passage onto the goal of the action inherently changes it into a new motive and hence an activity. The passage usually results when the object suddenly assumes the role of satisfying an identified need of the subject. From another angle an activity can be transformed into an action when its motive ceases to coincide with the subject's needs and becomes subservient towards the achievement of other motives.

Second, conscious actions can develop into subconscious operations through a continuous learning and skill development process. An action is transformed into an operation when the subject has learned how to perform the action so adeptly that it no more subordinates his or her consciousness in performing. Human operations are the targets of automation or, in the terminology of Leont'ev, "technization" by technology. Automation of human operations has been the inspiration of a considerable share of all technology in use (Kuutti 1995).

The collapse of actions into operations exemplifies learning and skill development, and this results in the individual increasing his or her mental capacity to perform more operations. As more of a subject's actions collapse into operations, the greater the skill development of the subject concerned, leading to a fulfilment of the motive of his or her activity. Kuutti (*Ibid.*) calls this the "broadening scope of actions", which means that as more actions collapse into operations, the newly formed operations join the existing set of operations which then form integral sub-parts of actions.

> "The point is that for the subject himself the comprehension and achievement of concrete goals, his mastering of certain modes and operations of action is a way of asserting, fulfilling his life, satisfying and developing his material and spiritual needs, which are reified and transformed in the motives of his activity" (Leont'ev 1978).

Two learning implications can be drawn from this extract: first, the number of actions is reduced for the same activity enabling the individual to perform the reduced actions more efficiently and effectively. On the other hand – and I refer to this as the *broadening range of actions* – those actions, which hitherto could not be performed, are introduced into the frame of 'current' actions aimed at satisfying the subject's other motives. Thus for one activity, as more of its actions are collapsed into operations, the satisfaction of its motives will demand less mental resources (consciousness); this can allow the subject to engage in more actions towards the

achievement of goals that fulfil other motives. This is how learning and development occur: for an activity, as one develops a skill for performing its actions, he or she is able to perform many subconscious operations which were all once actions that demanded total consciousness in performing; it therefore becomes relatively easier to satisfy the motive of that activity allowing for devotion of more physical and mental resources to actions whose goals satisfy other motives.

Granted that an operation is determined by the goal that is given in particular conditions requiring a certain mode of action, operations can also degenerate into actions when the subject encounters adverse conditions in an activity. The movement back-and-forth transformation of actions and operations has direct implications for the analysis of learning and unlearning, especially in technology-mediated learning.

The uses of mediating physical and psychological tools may constitute activities, or may constitute actions and operations of an activity. 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 factors 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 information and communication technologies (ICTs). These instruments contain complex inscriptions of interrelated rules of designers meant for information capture, processing and transmission. Moreover, the ease or clumsiness of their uses are factors of their physical, interface and system design properties; the location, time and context of use; and the motives they have been deployed to help accomplish. These factors have some bearing on the degrees of improvisation and structuration of ICTs by users.

4.4 The Activity System

In his discussion of the *Social Origins of Indirect (Mediated) Memory*, Vygotsky (1978, p.38) distinguished between elementary and higher mental functions in human beings. Elementary functions are completely genetic, founded on perception, and directly related to natural memory; therefore they are unmediated responses to environmental stimuli. However, "[natural] memory is not the only kind...even in the case of non-literate men and women" (*ibid.*, p.39). Human beings are characterised

by higher mental functions that represent development based on their extensions of biological memory.

> "They extend the operation of memory beyond the biological dimensions of the human nervous system and permit it to incorporate artificial, or self-generated stimuli, which we call *signs*. This merger, unique to human beings, signifies an entirely new form of behaviour." (*loc. cit.*).

The new form of behaviour is inherently a reflection of development of higher mental functions. Leont'ev drew upon this idea in his treatment of the essence of mediation in this form of development:

> "Mediated memory, in turn, develops along two lines: (a) along that of a development and perfecting of methods of using aids, which continue to be in the form of stimuli acting from outside, and (b) along the line of a transition from external means to inner ones. Such a memory, based on a highly developed capacity for instrumental use of components of experience that are predominantly internal (inner 'symbolic aids'), constitutes the last and highest stage in its development." (Leont'ev 1982, p.349).

Sign operations of human beings are therefore external phenomena that mediate their elementary stimulus-response functions; Signs are "second order" intermediating stimuli that ensure higher mental functioning (see Figure 4.2).

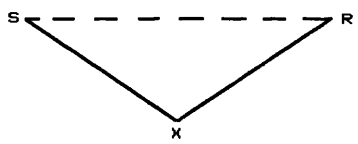


Figure 4.2: The structure of the mediated act: 'S' – Stimulus, 'R' – Response, and 'X' – Mediating Sign.

[Source: Vygotsky (1978)].

It is at this point that Vygotsky emphasises the inseparability of mediating sign and activity: "This intermediate link is a second order stimulus (sign) that is drawn into the operation, here it fulfils a special function;...[the] term 'drawn into' indicates that an individual must be actively engaged in establishing such a link." (Vygotsky 1978, p.39). AT is inspired by this relationship based on artificial or self-generated signs that are reinterpreted as tools and signs: tools referring to physical instruments and signs referring to psychological tools in the form of "language; various systems of counting; mnemonic techniques; algebraic symbol systems, works of art; writing; schemes, diagrams, maps and mechanical drawings; all sorts of conventional signs; etc." (Vygotsky 1981, p.137). Engeström (1987) makes a distinction between physical instruments and psychological signs: "the primary level of mediation by tools and

gestures *dissociated from one another*...and the secondary level of mediation by tools *combined with* corresponding signs or other psychological tools." To him, it is in the secondary level of mediation where optimum results are attained.

In AT, Vygotsky's idea of stimulus-sign-response relationship is transformed into a subject-tool-object relationship by Engeström (1987) – the subject's *responses* to external object *stimuli* are mediated by psychological tools and *signs*. In any conscious human activity, there is a *subject* who pursues an *object* with a motive to transform the subject and object into an *outcome*, a product (see Figure 4.3). It is the transformation of the object that motivates the existence of the activity. In learning terms, the outcome is not just a transformation of the object but a transformation of both the subject and object. Object transformations are reflected in Engeström's Marxist interpretation of human production and consumption: "Production is always also consumption of the individual's abilities and of the means of production. Correspondingly, consumption is also production of the human beings themselves" (Engeström 1987). The continuous performance of an activity by the subject is inherently a cyclical internalisation-externalisation process of assimilation by the subject of the properties of the object as it is being transformed.

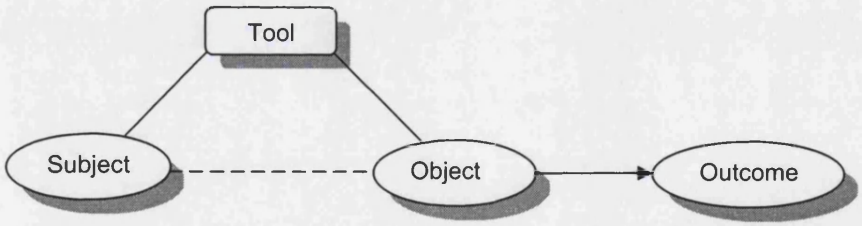


Figure 4.3: Basic Structure of an Activity at Individual Level.
[Source: Engeström 1987]

At the social level – where the individual performs an activity in collaboration with other people – an activity is more complex because of its collective nature. Based on Marx's *Capital* (1909), Leont'ev laid emphasis on a collective motive that manifests in the *division of labour* in the performance of an activity. He elaborated the collective and cooperative nature of the performance of an activity, citing the infamous example of the primitive hunt (1978), but he did not tell us much about the intrinsic concepts of *community* and its *rules*.

AT, popularly attributed to Leont'ev, draws on the cultural-historical psychological works of Vygotsky; but the activity system or triangle is a result of an elaboration of Vygotsky's basic structure by Engeström, a contemporary champion of AT. In his theory of Expansive Learning (1987), he draws on Marx's (1909, 1969, 1971, 1976) and Zinchenko's (1983) knowledge of the economics of human labour to remodel the subject-tool-object structure to reflect the collective nature of an activity, and hence the social nature of learning. Engeström's well-known activity system incorporates the community-based elements of human activity (see Figure 4.4).

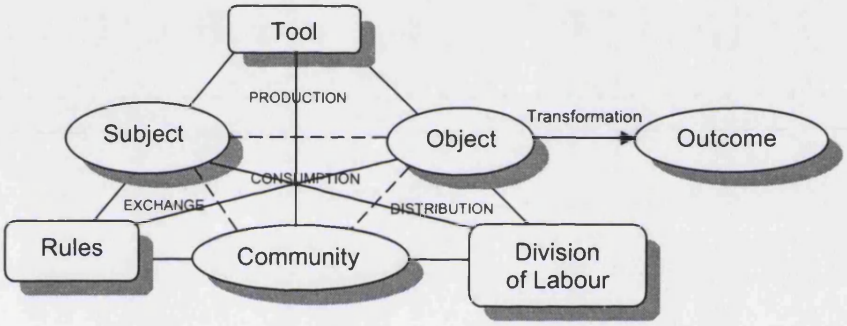


Figure 4.4: An Activity System
[Source: Adopted from Engeström (1987)].

In this system, the relationship between the subject and the object are mediated by tools in addition to interactions with community members and the rules governing the division of labour among community members. Engeström's conceptualisations suggest that all the elements of the structure are interconnected and they shape each other based on a transition from human adaptation to consumption. Drawing on Marx's *Grundrissse* (1976), he depicted how an individual subject's consumption subordinates his or her activity to production, distribution and exchange (communication). Marx wrote:

> "Production creates the objects which correspond to the given needs; distribution divides them up according to social laws; exchange further parcels out the already divided shares in accord with individual needs; and finally, in consumption, the product steps outside this social movement and becomes a direct object and servant of individual need, and satisfies it in being consumed. Thus production appears to be the point of departure, consumption as the conclusion, distribution and exchange as the middle..." (*Ibid.*, p.89).

Through his analysis of production, distribution, exchange and consumption, Marx amplifies the social or collective nature of objects – a property that implies that, to the subject, the sense of his or her involvement in the actions that lead to the transformation of the object is always two-fold: that is, in its objective sense and personal sense. Engeström deduced from Marx and Leont'ev to elucidate the fact that each of production, distribution, exchange and consumption, while representing integral actions that realise the holistic motive of society, is an activity in itself.

> "In other words, each sub-triangle...is potentially an activity of its own. (...) In a more complex and differentiated society, there exist a multitude of relatively independent activities, representing all the sub-triangles. But within any such relatively independent activity system, we find *the same internal structure* as depicted in [the activity system]... This has the important implication that *there is no activity without the component of production...*" (Engeström *op. cit.*).

Kuutti (1995) makes a slightly different interpretation of the interrelationships between the elements of the activity triangle. This is depicted by the different geometric shapes of the elements. He establishes relationships between the elements through mediation: the relationship between the subject and the community is mediated by the implicit and explicit rules shaping the community; and further, the relationship between the community and the object is mediated by the division of labour among members of the community (mediators in rounded rectangles). Based on Vygotsky's ideas, the activity system suggests that all the elements of the activity system, apart from the subject, object and outcome, constitute signs and tools which mediate an activity.

The interrelations of elements of the activity structure are useful for describing and analysing the interrelated parts of any learning system. Leont'ev's activity structure addressed the issue of context within changing *conditions* – and hence within the activity. But Engeström's triangles – founded on multiple activity systems – takes care of the external context or environment of an activity. For example he has focused more of his arguments on the contradictions within elements of an activity, and more importantly between that activity and what he calls "neighbour activities" (see Section 4.5.4).

In a collective activity, the subject's management of the rules as well as the division of labour and social interactions within the community are all actions that demand

conscious planning, modelling and execution. In other words, the mediators of the relationship between the subject and object are such that their effective utilisation in the transformation process initially constitutes actions. Learning or skill development occurs when the magnitude of mental resources (degree of consciousness) that these mediators demand continuously diminish towards subconsciousness, allowing the learner to transform the object more efficiently and effectively by broadening his or her range of actions and/or scope of actions.

Behind the structure and system of activity, AT is built on a set of psychological principles which depict the dynamics of the developmental process that occur in the transformative or developmental relationship between an individual and the objects which he or she acts on. The next section is devoted to a detailed discussion of each of the principles of object-orientation, consciousness, internalisation, contradictions, mediation and development.

4.5 Principles of Activity

4.5.1 Object-orientation

When a conscious activity is being performed, it is always aimed at an object. In an external activity – in human labour – the subject is confronted with elements of the external environment, of reality. The nature of objects can be deemed as either ontological or epistemological, and they can represent either subjective or objective phenomena depending on the perception of the subject (see Searle 1995). The inherent objectivity of an activity stems from the externality of objects that exist in social conditions, and which subordinate human actions to them. Essentially, it is these social conditions that "carry in themselves motives and goals of [the individual's] activity, his means and methods..." (Leont'ev 1978, p.51). This understanding of the objective and social sense of objects and activities is demonstrated in Il'enkov's (1977) analysis of the concept of the *ideal*. The ideal, according to him, is independent of the consciousness and will of the individual subject; it is a sign or symbol historically and culturally built collectively by society for society which mediates activities in the sense of Vygotsky's psychological signs (1978). 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 cultural-historical origin built through collective sense-making of people. The essence of an object lies in its satisfaction of the motives of human labour; it is the entity that shapes the will and consciousness of the individual as he or she seeks to survive in society through his or her labour (activities). Within the external environment, a plethora of objects can be pursued by individual subjects. By virtue of a combination of the biological and environmental *needs* of a subject, an object – or a transformation of the object – is pursued in an activity. Leont'ev's psychology of needs suggests that a need in itself does not have an inherent capacity to direct an activity: its latency as a condition only becomes transformed into a driving force when it "meets" the particular object, which, it perceives, will satisfy it. This is the point where a need becomes objectivised; that is, transformed into a motive. To illustrate, the biological need will instigate the want for food in the subject, but the environmental need, based on the ideal, will direct the subject's activity to particular kinds of food.

Several activities can be performed by a subject at the same time, but one activity is differentiated from another by its object. "It is exactly the object of an activity that gives it a determined direction." (Leont'ev 1978). Primarily, an activity implies objectivity as the performance of an activity is inherently the pursuit of an object. Thus the essence of an activity lies in the transformation of an object as a means by which the individual satisfies his or her needs. Objects therefore direct activities. Leont'ev explained:

> "Being, the life of each individual, is made up of the sum-total...of successive activities. (...) Activity is a non-additive unit of the corporeal, material life of the material subject. (...) The basic, constituent feature of activity is that it has an object. In fact, the very concept of activity (doing) implies the concept of the object of activity. ...the object of activity appears in two forms: first, in its independent existence, commanding the activity of the subject, and second, as the mental image of the object, as the product of the subject's "detection" of its properties, which is effected by the activity of the subject and cannot be effected otherwise." (1978).

Objects are inherently external and environmental. An activity is objective because society or the environment appears as a superstructure in the mind of the subject, and he or she is forced to adopt and survive in this superstructure. This does not imply that the subject exists in opposition to society, rather the superstructure contains his or her motives and goals. In the expression of Leont'ev, "society produces the activity of the individuals forming it" (*ibid.*). Society is objective in nature because of cultural-historical development of the interrelationships between its human species. Phylogenetic development ensures a communal survival within which ontogenesis dictates to the individual subject to adapt within the community. The interrelationships between individuals built on production and exchange, and on language and communication leads to the objectification of society: all items of communication – names, signs, symbols, commodities and gestures – have collectively, socially defined meanings and not individual and subjective meanings.

To this end, the principle of object-orientation offers an insightful appreciation that guides this study in identifying the motives that underlie the actions of work-integrated learners. It also enhances an understanding of the ideal phenomena in any learning activity. Particularly, it offers pointers for the investigation of the nature and ideality of mediating instruments in learning. Furthermore, given that there are multiple activities competing for learners' attention at any one time (Engeström 1987), object-orientation is highly instrumental as an analytical and methodological tool in clearly identifying and differentiating the various objects and associated motives in relation to the learners' actions and operations. This serves as a foundation for analysing the interdependencies between interrelated activities, and for ascertaining the causes and effects of the movement of mediating tools between the statuses of tools and objects in learning activity.

4.5.2 Externalisation and Internalisation

Object transformation is not just an external activity: it is an intertwined dualism of external objective physical activity and internal mental activity. Once the subject identifies an external object that he or she perceives to satisfy his or her needs, an external activity – directed at the object – is initiated by the subject in pursuit of a transformation of the object. The relationship that is established initially between the subject and object is an appreciation by the subject of the properties of the object that

he or she seeks to transform. During the performance of the external activity, there is a corresponding psychological process in which the subject generates mental representations of the properties of the object and how he or she intends to surmount the problems associated with those properties. This mental reflection of the objective world is not merely a wholesale process of assimilation of the external object; rather, this reflection is mediated by the processes in which the subject comes into practical contact with the external object and makes personal sense of the problem associated with it.

Therefore, mental images are not objective properties of the objective world: they are rather subjective properties shaped by the subject's interpretation of the independent properties, connections, and relations of the objective world (Leont'ev 1978). The process of formation of mental representations of the objective world is what Leont'ev labels as "interiorisation":

> "a transition that results in processes external in form, with external material objects, being transformed into processes that take place on the mental plane, on the plane of consciousness; here they undergo a specific transformation – they are generalized, verbalized, condensed, and most important, they become capable of further development which exceeds the boundaries of the possibilities of external activity" (*Ibid.*).

This is a succinct expression of his "psychological reflection of reality" in which personal subjective meanings are formulated from objective external meanings. During this process, the subject can perform an internal transformation of mental subjective properties of the external object to an extent that even transcends the bounds allowable in physical transformation. These internal processes are later externalised by the subject physically to ensure a material transformation of the object; and it immediately initiates another interiorisation process.

Thus, externalisation and internalisation do not represent a linear process but a cyclical one. The community of external and internal activity, mediating the interrelations of the subject with his or her objective world, is fundamental to the understanding of learning. We are interested in the developmental study of learning processes and their external manifestations. In other words, the understanding of learning must transcend phenotypic (descriptive) analysis into genotypic (explanatory) analysis (Lewin 1935, Vygotsky 1978). The essence of the principles of internalisation and externalisation is in its usefulness for describing the external,

phenotypic aspects of an activity in relation to explanations of its internal genotypic aspects. In reality

> "two types of activity can have the same external manifestation, whether in origin or essence, their nature may differ most profoundly. [Therefore] special means of scientific analysis are necessary in order to lay bare internal differences that are hidden by external similarities." (Vygotsky 1978, p.63).

Based on internalisation and externalisation, the explanations of the impact of the properties of external objects on work-integrated learners can be enhanced. It makes possible an examination of the relationship between the deployed support tools in any learning process and the resulting transformed external actions of the learners. This form of analysis enhances an apposite judgement of the efficacy of learning support tools.

The most critical aspect of the relationship between external and internal activity is that internal activity derives from external activity and not the other way round. "The genetically initial and *fundamental* form of human activity is external activity, practical activity" (Leont'ev 1978). This principle is in harmony with Vygotsky's argument that an individual's thought derives first from his or her interactions with the external world (Vygotsky 1962). In an activity, the psychological process of internalisation of an object's properties is not merely external action transformed into a pre-existing internal "plan of consciousness"; it is the process in which this internal plan is formed (Leont'ev 1978). This plan formation process is essentially conscious.

4.5.3 Consciousness

A central feature of an activity is its productive character – its orientation to transform an object into a static product. According to Leont'ev, an activity is terminal, that is, it is "extinguished" at some point where the product absorbing the activity is realised. This phenomenon is a reflection of Marx's interpretation of human labour: "a transition of static activity into a static product." (Marx 1909). Given that the product of an activity does not yet exist at the beginning or during the performance of the activity, the transformation proceeds only by virtue of an idealisation of the product of activity – the creation of a mental representation of the material properties of the outcome by the subject. These mental representations are conscious creations of conscious reflection.

> "... the mental image of the product as a goal must exist for the subject in such a way that he can *act* with this image — modify it according to the conditions at hand. Such images are conscious images, conscious notions or, in other words, the phenomena of consciousness." (Leont'ev 1978).

The notion of consciousness which postulates an extraction of mental representations from external reality challenges the idea that mental images are original and genetic images of individuals that are projected into the world (*Ibid.*). Vygotsky's theory of child learning espoused in agreement with Leont'ev and in challenging Piaget (1970), postulated that the child's first thoughts revolve around images and speech that are derived or extracted from its external environment, and not the other way round. Il'enkov (1977), also used his knowledge of the *ideal* to corroborate this actuality: "...both will and consciousness are determined by this ideal form, and the thing that it expresses, 'represents' is a definite social relationship between people...". Consciousness in activity, therefore, implies internal conscious reflection of external activity as the origin of thinking and not external activity emanating from internal thought processes. Of course from the beginning, the subject is conscious of the objects of his surrounding environment, but this is what Leont'ev calls *image-consciousness*, which is related to direct visual perception. However, consciousness is not a matter of the subject's formation of mental images of static or passive objects; rather, consciousness implies continuous imaging of an activity: the subject's imaging of his or her interaction with and transformation of the object. Here, activity also becomes an object of consciousness: consciousness becomes *activity-consciousness*. This notion is significant in understanding the process of human development or learning inherent in an activity. It implies that learning is inherently social, and hence appropriate external support can lead to better learning and development.

It is through consciousness that an activity is sustained, by availing to the subject an idealised image of the material product of activity. This idealisation of activity through imaging and language presents an opportunity for the subject to perform mental transformations of the object to an extent far greater than what would be possible in external activity. Through activity-consciousness, "man becomes aware of the actions of other men and, through them, of his own actions. They are now communicable by gestures or oral speech. This is the precondition for the generation

of internal actions and operations that take place in the mind, on the 'plane of consciousness'" (Leont'ev 1978).

Meaning has a dual existence on the individual plane of consciousness – personal subjective sense and objective meaning. Personal senses are not independent phenomena; they are meanings formed from objective meanings. Objective meanings are culturally- and historically-evolved idealisations that are assimilated from early stages of ontogenesis. The knowledge of objective meanings is drawn from Vygotsky's theory of child learning – the child's assimilation of "'ready-made', historically evolved meanings [that] takes place in the child's activity during its intercourse with the people around it" (Vygotsky 1978). Objective meanings derive from the development of language, and obey the socio-historical laws and inner logic of their development. Language is "the product and means of communication of people taking part in production. [It] carries in its meanings (concepts) a certain objective content, but content completely liberated from its materiality." (*Ibid.*). It is the combination of activity-consciousness and the use of language that underpin the learning and development of the human subject. They are the original basis of cognition of the learning individual as he or she engages in social interaction and conscious actions. They "express the movement of science and its means of cognition, and also the ideological notions of society – religious, philosophical and political" (*Ibid.*).

However, the personal demands of individuals as they engage in conscious actions embodied in activities lead to the individualisation and subjectivisation, but not the destruction, of objective meanings. Regardless of whether the individual is conscious or unconscious of the motive of an activity, there is a conscious personal evaluation of the immediate objective circumstances, leading to the development of personal senses. Thus personal senses become refractions of objective meanings by means of the individual's unique characteristics such as needs, emotions, previous and current experience, temperament and personal principles.

Personal senses vary from objective social meanings by degree. The greater the degree of refraction, the more confrontational or 'controversial' the individual becomes; and if the individual persists in the objectivisation of his or her personal

senses through external activity, the process can result in alienation and/or an innovative outcome. Learning and innovation are thus factors of the forms of personal senses that subjects make of the objective meanings during the performance of conscious actions.

The development of the personal senses by work-integrated learners out of the objective social meanings underlying the motive of the learning activity makes the principle of consciousness very resourceful in this study. It is a methodological tool which augments an understanding and interpretation of the interview responses and observations made in the study, as well as an analysis of the impact of external instruments in the learning process. Stated differently, the concept of personal sense serves as the underpinning for the evaluation of the social semiotics of the empirical data which will be sourced from the WIL subjects.

The personal and objective senses of goals of actions generate contradictions because, in a capitalist society, the personal sense of goals is oriented towards personal "leading" motives always opposes the objective sense of those goals that orient towards the motives of employees, or capital owners for that matter.

4.5.4 Contradictions

An activity is inherently dynamic due to the fact that objects are characterised by dual existence in the individual consciousness of the subject. The dualistic property of an object incorporated in its *individual* and *social* characters pulls the subject from opposite sides and causes him or her to remain ever dynamic in terms of the sense-making of goal-oriented actions. Herein lays the contradictoriness in the activity of the subject: that is, the dialectic in the consciousness of the subject between independence of individualistic, personal production on the one hand, and the subordination to social, collective production on the other hand. Engeström (1987) uses the term "object-activity" to portray the non-static and complex nature of objects, highlighting typical complex objects such as other human beings or capitalist markets. The contradictions naturally imply continuous dynamics in the behaviour of the elements of an activity.

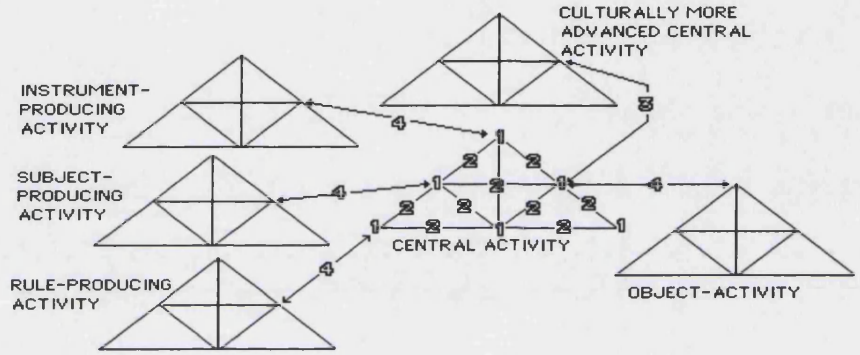
This fundamental contradiction in activity is traceable to the analysis of the "division of labour in society" by Marx in *Capital* (1909). Marx's conceptualisations are richly expressed in the origins of division of labour in human activities which were oriented towards production of *products*, and subsequently, the intrinsic transformation of products into *commodities*. On the one hand, there was an initial natural division of labour as a product of familial, tribal or communal bonds shaped by differences in physiological factors such as age and sex: this was the first stage of subjugation of the individual by social forces. On the other hand, there was a subsequent division of labour as a result of differences between communities or tribes or families in terms of environment, means of production, subsistence, modes of living, and products.

At the interface of two communities, "it is the spontaneously developed differences which...calls forth the mutual exchange of products, and the consequent gradual conversion of those products into commodities" (*Ibid.*). Interdependencies between societies are thus created through commoditisation of products and exchange; moreover, products assume an objectivised social character. The essence of Marx's description of the division of labour is the exposition of the contradiction inherent in the nature of the product of activity – product as product versus product as commodity. As a product, it has a primary *use value* – valuable in its utility by the producer. As a commodity, it has acquired a social *exchange value* in addition to its primary use value; these values co-exist in the consciousness of the subject as personal sense and objective meaning. To Engeström, "the essential contradiction is the mutual exclusion and simultaneous mutual dependency of use value and exchange value in each commodity" (1987).

Marx's analogy of the contradictory nature of products of activity is a telling revelation of the sociality of 'individual' activities. There is always some form of contradiction within each of the elements of an activity system expressed as a reflection of an inner conflict between product-as-utility (use value) and product-as-value (exchange value) of the subject's perception. It represents a summary of Engeström's (*Ibid.*) first of four levels of contradiction (see Figure 4.5). The contradiction at the product- or outcome-end naturally results in contradictions within each of the elements of the activity system. For example, a school pupil can be caught in-between seeing himself or herself as achieving grades and as a sense-maker. His

contradictory perceptions will also apply to the instruments, rules, community and division of labour that mediate his or her learning.

Engeström's theory of Expansive Learning is based on the contradictoriness in human activities; it elucidates the understanding of learning as a factor of managing and overcoming contradictions within the elements of one activity, and those between one "central activity" and other "neighbour activities".



Level 1: Primary inner contradiction (double nature) *within* each constituent component of the central activity.
Level 2: Secondary contradictions *between* the constituents of the central activity.
Level 3: Tertiary contradiction *between* the object/motive of the dominant form of the central activity and the object/motive of a culturally more advanced form of the central activity.
Level 4: Quaternary contradictions *between* the central activity *and* its neighbour activities.

Figure 4.5: Four levels of contradictions within the human activity system

[Source: Engeström (1987)].

> "The 'neighbour activities' include *first* of all the activities where the immediately appearing objects and outcomes of the central activity are embedded (let's call them object-activities). *Secondly,* they include the activities that produce the key instruments for the central activity (instrument-producing activities), the most general representatives being science and art. *Thirdly,* they include activities like education and schooling of the subjects of the central activity (subject-producing activities). *Fourthly,* they include activities like administration and legislation (rule-producing activities). Naturally the 'neighbour activities' also include central activities which are in some other way, for a longer or shorter period, connected or related to the given central activity, potentially hybridizing each other through their exchanges" (Engeström 1987).

The coexistence of contradictions within elements of the activity system in the consciousness of the subject (first level) is an elaboration of Leont'ev's conceptualisation of objective social meanings and their subsequent subjectivisation

into personal senses by a subject. The most outstanding contribution made by Engeström's levels of contradictions is found in his conceptualisation of the relationship between an activity and other activities – a phenomenon which is not much discussed in the works of Leont'ev. In it, a foundation is laid to aid the analysis of an activity in relation to "neighbour" activities, of an understanding of the nature of contradictions pertaining to an activity, and of the problem of learning and human development within multiple interrelated activities in terms of subordination of the subject by which type of activity.

4.5.5 Mediation and Prosthesis

The object transformation process is mediated by physical and psychological *tools* resulting in a triangulation of the process – subject-tool-object (see Figure 4.2). Here, mediation departs significantly from "augmentation" (Kaptelinin and Kuutti 1999) in which artefacts merely enhance limited and "native" human capabilities for the solution of more difficult problems. Mediation engenders "re-mediation", that is, it breeds new varieties of mediation (*op. cit.*).

The objective properties of physical tools symbolize shared cultural-historical understandings that inform the subject. Bruner (1986) calls them 'prosthetic devices' which man uses in accomplishing tasks – in performing activities. Physical tools are material in nature, with enabling and limiting properties into which are crystallised methods and operations (Leont'ev 1978); however, it is during the *operationalisation* of the tool that the particular limiting and enabling properties are realised. When an individual performs an activity, his or her relationship with the object is mediated mainly by physical tools and the history and culture that has shaped his or her understanding and interpretation of the properties of the tool and object.

Between both Leont'ev and Vygotsky, there is concurrence in the fact that human learning is always mediated, that there is always some form of mediation of the relationship between individual subjects and their objects. For Vygotsky, physical tools and psychological tools – such as language and culture – mediate the relationship. To emphasise the significance of tools in child learning, Vygotsky drew on Bacon's aphorism: "Neither the naked hand nor the understanding left to itself can effect much. It is by instruments and helps that the work is done, which are as much

wanted for the understanding as for the hand."[20] He argued strongly against the understanding of learning founded on a polarisation, rather than a combination, of idealism or materialism in favour of an understanding of learning based on a combination of both. The hallmark of his popular thesis was an explication of some ever-present environmental mediating factors between a learning subject and object; and which represent the original source of conscious thought and higher psychological functioning of the subject.

Leont'ev followed up the development of the idea of mediation on a slightly different basis of understanding: to him, it is the relationship developed or developing between the subject and object – the form of the subject's development of a personal sense of the relationship with the external object – which mediates the subject and his or her world. Thus what Vygotsky may see as a mediating tool may be seen as an object by Leont'ev.

The essential idea to be gained from Vygotsky and Leont'ev, in terms of the understanding of tool-mediated conscious human activities and learning, is that both the tool and 'object' are all objects in the external world; the necessary implication is how mediation assists the subject in his or her development during the performance of an activity. An important question related to the subject-tool-object discussion will be *how, when, and under what circumstances does a mediating tool become an object of an activity and vice versa?* In other words, what we draw from this review is an understanding of an activity as a process which is fundamentally mediated by physical and psychological tools, and which, further mediates the subject and his world. For the purposes of this study, the properties of physical tools, including their ease of use and perceived ease of use, and how, during the activity, these properties influence the movement of the perception of the object between a tool and an object is central. An instrument's properties and how they can affect its perception as an object or tool by the user in an activity is a function of combined perception and action, which is the cornerstone of the concept of *affordance* (Gibson 1966, 1979, Gaver 1991, Norman

[20] "The New Organon Or True Directions Concerning the Interpretation of Nature" (Bacon 1620).

1988). It is the analysis of the affordance of tools in activity and their movement between the status of 'tool' and 'object' that unearths an understanding of the skills development of the subject in addition to the factors that cause those movements. This is the focus of deliberations of the next section.

4.6 ICT Tools in Learning Activity

ICTs are physical mediating technology tools used in various human activities including pre-determined learning activities. Their information processing, transmission and capturing capacities have been identified as potential enhancers of learning and skills development leading to the evolution of areas of study such as technology-mediated learning (TML) and knowledge management. The most essential ingredient of these studies is information – how its capture, processing and transmission with the ICT artefact mediate learning. Human activities have always been mediated by physical tools since the stone-age man began to use rudimentary artefacts to mediate his hunting activities.

Over the years till this day, scientific advancement has ensured the continuous development of more complex artefacts which represent an increasingly significant departure from original rudimentary tools of the stone-age. Therefore the study of tool mediation is also increasingly becoming a complex task in which an analysis of human *activities*, alone, without a consideration of the complex dynamic properties of mediating tools cannot yield effective outcomes. This is one visible weakness of Activity Theory: neither Leont'ev nor Vygotsky discussed the possible complex and dynamic nature of mediating tools and their effects on human activities in their works. Of course it is in the operationalisation of the tool that its limiting and enabling properties are realised (Leont'ev 1978); but what is the specific nature of these limiting and enabling characteristics, and how do they affect the achievement of an activity's motive?

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. Social construction, however, is initiated by individuals' reconstruction of technology based on their teleological "assignment – or imposition – of function" to the artefact (Searle 1995, p.14). It is the accumulation or individual reconstructions that evolve into a socially shared understanding, and is then seen as a social construction (cf. Searle 1995, Berger and Luckmann 1967). It is reasonable to say that, truly, the user's activity and context of use of technology induces a flexible interpretation and social construction of the technology's properties which reflects age-old extensive criticisms of rationalism. For example, Bijker (2001) 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). However, it is also reasonable to say, at the same time, that an overemphasis of interpretive flexibility can be misleading because 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).

In a sense, one cannot understand any learning and human development process that is mediated by ICTs by adopting only an activity perspective reflected in the interpretive flexibility of technology arguments: a concomitant substantive analysis of their design properties based on the determining capacities that affect their manipulation for information capture, processing and transmission must also be undertaken.

4.6.1 ICT Affordances in Learning Activity

The concept of affordance, pioneered by James Gibson in the 1960s, was originally an illumination concerning the direct relationship between an organism and its environment. The crux of his idea is 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" (Gibson 1979, p.127). Affordances point to both the environment and the observer, and are mostly realised in the interaction between organisms and environmental objects. A point worth noting here is that Gibsont idea of affordance and the principles of activity differ from a dualistic notion of a separation between actor and environment.

> "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).

Where Gibsonian affordance departs from Activity Theory is the belief in the possible existence of affordances "independently of the individual organism in the sense that as long as the possibility of a particular activity exists for a particular species in an environment, then the affordance can be said to exist." (Bærentsen and Trettvik 2002, p.52-53). Gaver (1991) argued similarly that "[affordances] per se are independent of perception. They exist whether the perceiver cares about them or not, whether they are perceived or not, and even whether there is perceptual information for them or not" (p.80). Activity theorists would argue that affordance cannot achieve independent existence; rather, an affordance is always inherent in the personal sense made of an environmental object by an actor during the performance of an activity. It is the motive driving an activity, the goals of its actions being performed, and the changing conditions during the operationalisation of the tool on the object which determine, in the consciousness of the subject, whether the object affords anything at all.

Gibson's notion of perceptible affordance has been challenged, notably, by Gaver (*Ibid.*) and Norman (1988, 1999). Their challenging ideas were inspired by the fact that some environmental objects such as modern ICTs exhibit sufficient complexity, and therefore, compared with simplified objects, perception by the actor alone does not offer adequate perceptual information needed to appreciate the other "hidden

affordances" of the artefact (Gaver *op. cit.*). Gibson's idea of absolute reliance on immediate perceptual information to determine the affordances of objects breaks down when applied to ICTs. For any given ICT tool, given its artificial nature, its affordances are determined through social-cultural factors and through the activity which it is mediating. "Affordances are not passively perceived, but explored" during an action with the tool on an object (*Ibid.*). Based on this assertion, Gaver made a distinction between affordances of a tool and its perceptible information, and used the dichotomy to suggest four possible forms of affordances that are useful for understanding its ease of use (see Figure 4.6).

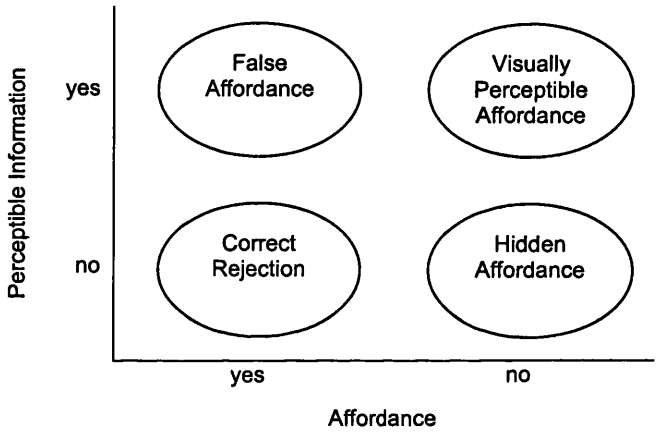


Figure 4.6: Separating affordances from the information available about them.
[Source: Amended from Gaver (1991)]

First, *perceptible affordance* is a result of availability of perceptible information for an existing affordance. This is typical of simple tools which easily present to the sense organs of an actor their utility. Second, when there is no perceptible information available on an affordance, it is deemed as a *hidden affordance* and must be inferred through evidence from elsewhere; that is, through other means. Most contemporary ICTs exhibit hidden affordances which cannot be determined through immediate visual perception. Normally the determination of their affordances is achieved through prior cultural-historical knowledge, training and exploration-in-action. This verity is also expressed by Norman (*op. cit.*): "...affordances result from the mental interpretation of things based on our past knowledge and experience applied to our perception of things about us" (p.219). Third, when perceptible information seems to

suggest an otherwise non-existent affordance, the resultant affordance is *false*. The determination of a false affordance of an object is however dependent on the particular action the object is being used for. The personal sense made of the goal of that action by the actor will tell him or her whether the affordance of the tool he or she is using in that action is 'true' or false. In other words, perceptual information is a factor of the goal-oriented action that the tool is being used to perform. Finally, a tool which suggests neither perceptible information nor affordance normally leads people to *correctly reject* it for a given action.

For ICTs which have numerous hidden affordances for information capture, processing and transmission, their ease of use is very much dependent on perceived ease of use. Therefore, "[m]aking affordances perceptible is one approach to designing easily-used systems" (Gaver 1991, cf. Draper 1986). The perceived ease of use has to be derived from a revelation of the hidden affordances of the artefact through inferences from other sources and through its use to perform an action. Gaver uses the term *inter-referential* to describe perceptible affordances and to illuminate the fact that "attributes of the [tool] relevant for action are available for perception" (p.81). In contrast, hidden affordances of ICTs lack inter-referential properties because their attributes do not avail themselves for immediate perception: their affordances are revealed in a process that is mediated by perceptible affordances and other representations exemplified by screen icons, user-guides, instructions, experience, culture and goals.

ICTs are information systems of cultural-historical origin which comprise complex assortments of technological components. Their cultural-historical value is manifested in the "objective meanings" inherent in their semiotic properties built and accumulated over time by previous generations of human users and contained in language and symbols. Thus, ICTs offer sufficient affordances of their information capturing, processing and transmission capacities beyond perceptible affordances; but even then, aspects of these seemingly sufficient affordances could prove to be false or hidden or correctly rejectable depending on the features of the activity systems they mediate.

4.7 Conclusion

In work-integrated learning (WIL), the practice orientation of the learning process easily suggests that a physical activity directed at a learning object and mediated by a physical instrument is performed by the learner. The philosophical expositions of AT, drawn mostly from the ideas of Vygotsky, Leont'ev and Engeström, bestow a holistic framework with which to analyse mobile computing within the context of WIL. But AT as a framework is not exempt from the general problems associated with frameworks: their likelihood to enslave their users. Therefore, while AT makes a significant contribution towards a holistic understanding of WIL, the study also draws on a host of other theories and concepts which guides an understanding of the key themes which confronts this study. For instance, it has been imperative to integrate the mobility of WIL and of its learning objects and tools, as well as the theories that espouse, in sufficient details, the complex nature of computing artefacts and their affordances. Based on the theoretical review undertaken in this chapter, it is a matter of critical necessity that the analysis of the efficacy of the use of the PDA – the physical mediating tool in WIL – incorporates an analysis of its affordances based on its complex physical, interface and systemic properties. These properties impact significantly on its perception as a supporting tool or object of activity in the learning process.

Chapter 5: Mobile Computing in the Training of the PSP

5.1 Introduction

The phenomenon of learning mediated by desktop ICTs has received fairly sufficient IS research coverage; but the same cannot be said of contemporary portable ICTs. Perhaps this can be explained by the infancy of mobility as a research field in IS. To enhance the understanding of mobility and distribution as a dominant feature in contemporary society, more research endeavours in this direction are required. The objectives of this study, as set out in Chapter One, orient towards the achievement of this requirement. The task demands a re-conceptualisation of the whole idea of distribution of activities based on an empirical study of the situational and contextual use of mobile computers in remotely mobile and distributed learning settings.

The focus of this chapter is a detailed presentation of the empirical work done in this direction. Although idiographic, the case presented is an epitome of the numerous cases of the deployment and adoption of portable ICTs to support remotely mobile and distributed activities in modern society. Based on an action research strategy adopted in this empirical study, I gained an immediate and close appreciation of the dynamics of mobile computing in the training of a group of professionals for a new professional role. This chapter is organised as follows:

Section 5.2 presents a background of the case with particular focus on the key drivers that stimulated the mobile learning activity. This is followed by the outline of the learning project which sets out the key outcomes, pedagogic framework and implementation in Section 5.3. Section 5.4 narrows down to tackle the information management aspect of the learning project leading to a detailed account of the implementation and use of PDAs. Next, Section 5.5 presents the key findings of the empirical study which sets the grounds for subsequent analysis and discussion. Section 5.6 concludes the chapter with a summary of the study and findings.

5.2 Background

The PSP – Perioperative Specialist Practitioner – represents a new medical professional role in surgery which was instituted to take over some of the functions that were preformed by junior doctors in the NHS[21]. The establishment of the new role translated into a comprehensive and distributed work-integrated learning pilot project. This project constitutes the empirical case in focus in this study.

The key driver of this learning activity was the European Union Working Time Directive (EUWTD) which required junior doctors to work a maximum of 58 hours per week – in fact, the maximum number of hours would further drop to 48 hours by August 2005. At the time, junior doctors worked for more than the number of hours per week allowed under the directive. As of January 2003 until August 2004, the legislation was not being enforced; its full enforcement was expected from August 2004. The EUWTD placed pressure on arrangements for medical cover within UK hospitals. Since the production of junior doctors in UK was suffering at the time, and even training of many more of them was expected to take more than a few years to complete, pressure was mounting on the NHS to fill the impending vacancies with a new category of professionals.

As a measure to tackle this looming crisis, the NHS Changing Workforce Programme at the Department of Health (DoH) established 19 pilot projects to address the mandatory reduction in the workload of junior doctors to 58 hours a week by August 2004. One of these, the PSP, was a new professional role that aimed to expand hospital surgical teams by providing patients with integrated care before and after an operation. The goal of integrated care was to provide patients with a stable relationship by being affiliated with a single PSP throughout their stay in hospital, rather than a fragmented series of contacts with different healthcare workers. The role was also aimed specifically at perioperative management for elective and emergency surgical care which included a range of diagnostic and procedural skills. PSPs would assume many of the diagnostic and procedural responsibilities carried out by junior doctors.

[21] National Health Service of United Kingdom

The role encompassed many of the responsibilities that were carried out by Pre-registration House Officers (PRHOs) and Senior House Officers (SHOs) at the time. It was expected that the new role would use operational flexibility to provide a constructive response to the EUWTD, coupled with significant improvements in the educational component of the SHO post. The pilot training project took an activity-oriented approach which was driven by clinical needs and underpinned by accountable assessment of competence. These included pre-operative clinical assessment, routine post-operative monitoring and care, identification and management of post-operative complications, and determining fitness for discharge from hospital.

To operationalise this project, twelve health professionals with different background specialities were selected through rigorous interviews. All of them were mature professionals with many years experience of working in the NHS. Before leaving their old occupations to become PSP trainees, nine of the participants were nurses, two were operating department practitioners and one was a physiotherapist.

5.3 Project Outline

The aim of the project was to develop new professionals – PSPs – to undertake pre- and post-operative care of surgical patients. This aim relied on the achievement of the following key outcomes:

- The development of a permanent new role within hospital surgical units, allowing a more efficient performance of clinical duties and improved continuity of care within surgical teams.
- The provision of adequate clinical cover for perioperative patients at all times, in line with the EUWTD requirements. This would include surgical tasks and the provision of postoperative care.
- The development of an educational template for rolling out the new role nationally if it proved to be successful. This would allow its application to small hospitals and Diagnostic and Treatment Centres (DTCs) across the country.
- The opportunity to redesign the current SHO role, maximising the educational opportunities of the post in line with learning needs of junior doctors.

Initially the PSP was conceived as an extended nursing role. However a broader view was later adopted and it was recognised that the crucial outcome should be a competent practitioner whose skills are accurately aligned with service requirements. It was thought, for example, that staff within the professions allied to medicine (PAM), such as physiotherapy, might wish to move into this new field. The key components of the operationalisation of project were:

- Effective training, irrespective of professional background;
- Accoutable assessment of competence;
- Close alignment between service needs and training provision; and
- Professional support throughout training.

The pilot's planned trajectory progressed logically from definition of the state of practice at the beginning, through the design of a training programme for the new role, to provision of appropriate training and application, to supervised clinical practice. Formal evaluation was envisioned to form the backbone of the entire process. At the completion of each stage, deliverable outcomes would be generated and assessed.

It was believed that the potential impact of this project would extend far beyond the single surgical units within which much of the learning would take place. It was also believed that, if successful, the pilot could produce a blueprint for a more efficient approach to the provision of surgical care at the national level. This was especially relevant for small hospitals and for the emerging Diagnositic and Treatment Centres, where no provision of 24 hour medical cover existed at the beginning of the project.

The pilot was engineered to have a significant impact on the role of the SHO. At the time, the published Chief Medical Officer's report entitled "Unfinished Business – Proposals for Reform of the SHO Grade"[22] highlighted the need for a modernised SHO grade which would provide time-limited, managed basic specialist training programmes.

[22] The report can be found at http://www.publications.doh.gov.uk/shoconsult/shoreport.pdf.

5.3.1 Team Structure

The PSP project was run by a team at Imperial College London and consisted of a manager (or leader), an administrative assistant, an educational consultant and a consultant from the Department of Health. A learning technologist was appointed 6 months after the project began. PDA software was developed in collaboration with The Department of Information Systems at the London School of Economics (LSE). The LSE team consists of a departmental head, a PhD student (myself) and 2 MSc students. They provided technical assistance and advice but were removed from the day-to-day running of the programme.

5.3.2 Pedagogic Framework

The training project was a full-time learning activity and lasted for one year from April 2003 to April 2004. It consisted of two components: intensive one-week training modules at Imperial College London alternating with longer periods (mostly six weeks) of supervised clinical practice within the surgical team at each participant's hospital across the country. This arrangement allowed the classroom-based skills learnt during training sessions in London to be consolidated and extended in the workplace. These skills included:

- Pre-operative assessment and investigation
- Understanding of normal and abnormal states relating to surgical procedures
- Identifying and treating common and important complications
- Carrying out clinical procedures including taking patient histories, ordering tests, taking blood and putting up intravenous infusions.

The classroom-based one-week modules used a range of teaching styles: didactic lectures, scenario-based learning, skills training and computer simulations of surgical procedures. Technical, professional and communications skills were taught on an integrated basis. For example, a PSP could learn techniques for taking blood while simultaneously answering questions from an actor playing the role of a patient. This method was deigned to recreate the process of healthcare skills deployment in practice in the hospital ward.

A flexible pedagogic approach was also adopted, with continual revision and restructuring of training modules. Ongoing evaluation allowed an assessment of the changing educational needs of the PSPs. Interviews at the end of every training module were conducted by an independent, professionally accredited psychologist who encouraged negative (critical) as well as positive (commendatory) feedback. Group interviews and evaluation forms were also used to provide an in-depth critique of the course as it developed over the period.

5.3.3 Implementation

The project was implemented to allow each PSP to gain a raft of relevant skills within a clear educational framework. Clinical practice and training or professional development were intimately linked to every structure of the training implementation. The most crucial of these arrangements were:

- *Structured training* with a progression from isolated procedural skills (using existing benchtop models at the St. Mary's Hospital Skills Centre in London) and clinical training (using the Harvey Cardiovascular Mannequin) to more complex issues of diagnosis, clinical judgement and teamwork (using the project team's expertise in simulation technology to create a Virtual Surgical Environment). This aspect was built on the Virtual Operating Theatre at St. Mary's and its associated Black Box recording technology and included realistic pre- and post-operative scenarios.
- *Ongoing performance monitoring.* This aspect used a portfolio approach for comprehensive simulator and clinical data capture. Objective measures of clinical competence were combined with personal mentoring and extensive use of feedback. Reflective self-assessment was also incorporated to encourage professional growth.
- *Portable information and communication technology* was integrated to provide ready access to clinical information and decision-making support, and to collect and analyse performance data. Handheld computers (PDAs) were deployed to play a key role in integrating clinical and theoretical medical information. Protocols for common clinical management pathways were also established.

A dynamic interplay between service and educational needs was also implemented to ensure that PSPs received continuing support even after initial training. Besides, continuous audit of clinical practice highlighted areas for continuing skills development and these were fed back into the educational framework.

5.4 Information Management

Monitoring clinical activities: It was believed that interviews and written feedback are extremely valuable but they would only give the training centre in London indirect evidence of each participant's clinical activity being performed in his or her own hospital. In order to identify possible gaps in training, there was a requirement for a method of remote monitoring and control of the professional duties performed by the PSPs with the aim of ensuring the adequacy of opportunities to practise the clinical and motor skills they have been taught.

Creating a Portfolio of evidence: Each PSP was encouraged to keep a portfolio of evidence that would act as a 'map' of their training. The portfolio was thought to be fundamental for any future accreditation of PSP training and acceptance of the profession, so it was important that it was built comprehensively and accurately. In order to withstand external scrutiny and maximise learning, the portfolio was incorporated to provide detailed evidence of clinical activities, learning competencies, course materials and certificates. The critical aspect of this portfolio creation was that records of each PSP's clinical activity were to be made contemporaneously while fresh in their memory, and a regular backup was meant to be made by each PSP in case of loss or theft.

Written reflections-on-action: It was also realised that learning journals are both a way to collect evidence of professional activity and an educational tool to help make experiences explicit by reflecting upon them. Learning journals help to consolidate learning and play an important part in the transition from one professional role to another. Each PSP was therefore encouraged to keep a learning journal to allow a consolidation of the skills and knowledge learnt during formal training with work-based skills acquired in their own hospitals.

Access to learning resources: Each participant was also encouraged to have access to learning resources on the internet by means of a Virtual Learning Environment (VLE) such as WebCT or Blackboard. Participants would be able to access material on a standard desktop computer or by using a Personal Digital Assistant (PDA).

5.4.1 Architecture of Mobile Computing Support

Without doubt, the PSP training project was characterised by distribution and mobility – of the PSPs, of the learning activity, of the PDAs, and of information. It entailed both local mobility within the hospital and remote mobility to and from the training centre in London. For example, a PSP's typical schedule of a day at work involved physically joining the surgical team as they made their visits to the surgical wards to examine patients. Sometimes, these visits could take up more than half of the total shift period of the PSP. As one of the PSPs reported in an e-mail when I asked about her availability to receive a phone call from me, her response was that her "work is so MOBILE ...." In the parlance of Kristoffersen and Ljungberg (2000), these forms of mobility are respectively conceptualised as wandering and visiting (see Figure 5.1).

The deployment of the PDAs was meant to provide computational support for these forms of mobility. Particularly, the highly critical issues of monitoring and remote control of the PSPs activities in their hospitals and the development of learning portfolios were the targets of the computing support.

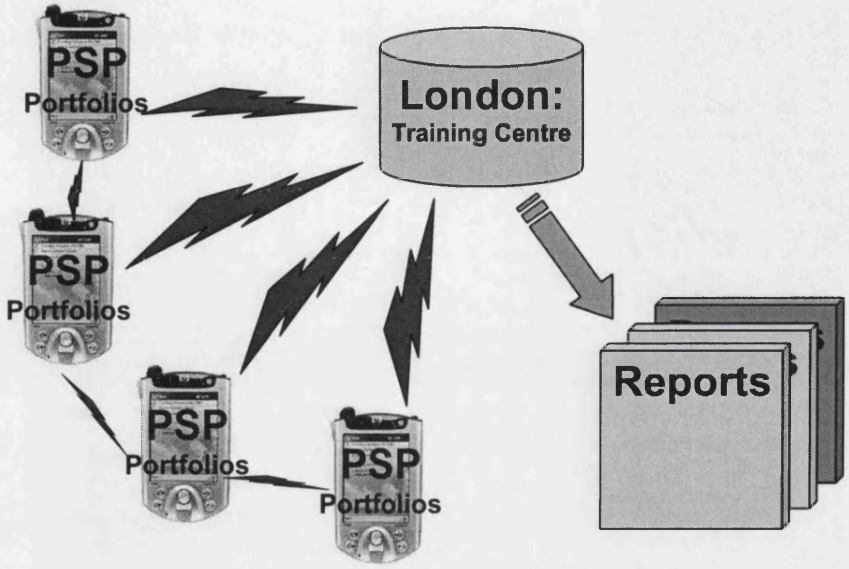


Figure 5.1: Architecture of the Mobile Computing Support.

Activities monitoring and control, and portfolios of evidence of the learning activities undertaken are 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 PSPs 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 PSPs in the instance where anyone doubted their relevance.

5.4.1.1 Access to Learning Resources

It was envisaged that the PDAs would provide learning support to the PSPs through the accumulation of relevant learning resources – medical literature, drug calculators and formulary[23] – which could be available to the PSPs anywhere during their learning manoeuvres. Although access to learning resources was implemented six

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

months into the project, it eventually became the key factor that sustained any hope which the PSPs 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 activities.

These are issues whose whole successes depend on timely information capture, storage and transmission, and it was envisioned initially that the PDAs could offer computational support in these respects.

5.4.2 Mobile Computing: Integration of PDAs

It was realised at the beginning that not all PSPs would have easy access to desktop or laptop computers, therefore handheld computers (PDAs) were acquired and deployed to support these information management tasks. The iPAQ handheld computer is a miniature version of a desktop or laptop computer. For the PSP learning project, the iPAQ H3970/H5450 model (see Figure 5.2) was the model adopted.

a b c

a: PDA-in-cradle with synchronisation cable
b: PDA and folded keyboard
c: PDA mounted on opened keyboard

Figure 5.2: The Compaq/HP iPAQ H5450/H3970 Handheld Computer and Foldable Keyboard.

Each PSP was provided with a Compaq iPAQ H3970 model PDA which was running a Pocket PC 2002 operating system. Each trainee was also given a foldable keyboard to facilitate their input of written reflections 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®.

5.4.2.1 Rationale

The adoption and deployment of the PDAs were premised on the following functional and instrumental advantages: A PDA's functionality affords mobile interaction and digital information processing, and its portability makes it usable almost anywhere and anytime. It has a capacity to store digital information, which equivalent in paper records will amount to several kilograms in weight. It can fit conveniently into an average adult human palm, can be carried around and be slotted easily into anyone's pocket. It is a lightweight device of about 206 grams, and possesses a range of inbuilt functionalities to support mobile computing. PDAs combine the portability of paper forms with the technological advantages of personal computers. Furthermore, they are increasingly being used in UK healthcare and are even more common in hospitals in the United States.

The following critical issues also influenced the adoption and deployment of the PDA: In terms of mobility, PDAs can be carried at all times and were thought to provide guaranteed and continuous computer support for the mobile PSP. In terms of connectivity, GPRS jackets[24] could be purchased for each PSP to allow them to connect their PDAs to the internet from any location and at anytime. In terms of continuous monitoring of training activities, captured data could be transmitted via the internet to the training centre in London to build up a cumulative database of the PSPs' activities. In terms of security, PDAs have inbuilt biometric fingerprint readers and strong alphanumeric authentication systems that can be activated to prevent unauthorised access in case of loss or theft; and a backup of data is created every time the PDA is synchronised with a PC. In terms of customisation, some programmes can be written into PDAs to suit the particular tasks they were deployed for. In terms of

[24] General Packet Radio Service (GPRS) enabled networks offer 'always-on', higher capacity, Internet-based content and packet-based data services. This enables services such as colour Internet browsing, e-mail on the move, powerful visual communications, multimedia messages and location-based services. Production of the Compaq iPAQ GPRS Modem Jacket had been discontinued. Visit http://www.mobiledatadirect.co.uk/product_info.php?cPath=24&products_id=239 for more information.

the politics of technology use, since the access to IT facilities vary within each hospital and NHS Trust, the use of PDAs could be independent of any hospital's IT infrastructure. And in terms of the accuracy of captured data and rigour of the training process, PDAs could ensure the immediate and contemporaneous entry of information. Relatively, paper based logs have the benefit of simplicity but are hard to share with others, they may be filled incorrectly, they become bulky and can be easily lost.

The argument was that desktop computers are confined to specific locations and may not be readily available within a clinical setting. Laptop computers are more portable but they are more expensive and too cumbersome to be used in the hospital ward.

These perceived advantages notwithstanding, PDAs are deficient in terms of their systemic functionalities. For example their processors and memories are far lower and less powerful. Therefore for most commands issued, they take more than a few seconds to respond. Under such circumstances, their uses can prove very irritating and disruptive in the activities which they are meant to support.

5.4.2.2 Data Capture

Activity Logging Database: The Activity Logging database was developed to hold recorded details of patient encounters on the wards. Clinical activities were 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 performed 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.

Reflective Journal: The learning Reflective Journal 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 that would allow the PSPs to frame the answers as they wished. Answers to these questions were to be typed at the end of each learning day using the foldable keyboard.

5.4.2.3 Data Transmission

The most crucial aspect of the continuous monitoring of PSPs' clinical activities from the remotely located monitoring centre in London was the daily and continuous transmission of clinical activity logs and written reflections via e-mail to the motoring centre. The transmitted data would serve as the input of a comprehensive database of the PSPs' learning experiences that would be used to generate reports at the end of the project period (see Figure 5.1).

Thus the PDAs were deployed to support this transmission process; and there were two possibilities. First, it was thought that the PSPs would e-mail their data to the training centre daily when they synchronised their PDAs with their internet-enabled computers. However, it was realised that not all of the PSPs had PCs let alone internet connections. Therefore the second, but more expensive, option of acquiring GPRS jackets to ensure the PDAs internet connectivity was thought of. This also could not be implemented because of two reasons: on the one hand, the cost of the jackets would not be financed by the project financiers; and on the other hand, the phobia among UK medical doctors and hospital administrators of wirelessly-connected mobile devices interfering with medical equipment did not make the GPRS jackets a worthy option.

Eventually, the issue of connectivity was abandoned altogether. And throughout the project, none of the PSPs e-mailed clinical data back to the training centre. The project manager was resigned to monitor the PSPs clinical activities through their individual Activity Logging databases and Reflective Journals, or their paper-based leaning portfolios. Monitoring was done during the times when the PSPs returned to the training centre; there, they would be asked to submit their PDAs or portfolios which would then be reviewed by the project leader.

5.4.3 Implementation and Use

The PDAs were introduced at the very beginning of the project. Generally, there were three aspects of usage of the PDA: first, there were the generic, standard or pre-packaged applications such as Calendar, Contacts, and Task Scheduler that did not have direct bearings on the learning task; second, there were the custom-built applications – abcDB and HanDBase – that were designed specifically to satisfy the

training and learning objectives of the project; and third, there were uploaded or installed clinical resources directly relevant to the task which PSPs were to draw upon during their learning.

The PSPs' experiences of the use of their PDAs over the project period can be categorised into three stages. The first stage was the period of the project where Pocket Word® and Excel® were the applications used for reflections writing and Activity Logging respectively. Stage two begins at the point when abcDB – a custom application – was developed for reflections writing and Activity Logging and ends when the application was officially abandoned. Stage three begins from the point when abcDB was officially abandoned and a learning technologist appointed to develop a new application – HanDBase. It ends at the point when this application was also officially abandoned.

5.4.3.1 Stage One

Each PSP was given his or her package – PDA, foldable keyboard, Microsoft® ActiveSync® software, users manual, charger and cradle – in the first module. Assisted by the LSE team, they were given a three-hour training and induction session to familiarise with the PDA and learn to use its basic functions. Initially, when the custom applications had not yet been developed, the framework of the Reflective Journals and logging sheet were transformed from the pre-designed desktop Word® and Excel® files into a Pocket Word® and Excel® files via synchronisation with ActiveSync®. Subsequently, all the PDAs were synchronised as guest clients with a desktop computer at the training centre to upload the Pocket Word® Reflective Journal files (see Figure 5.3).

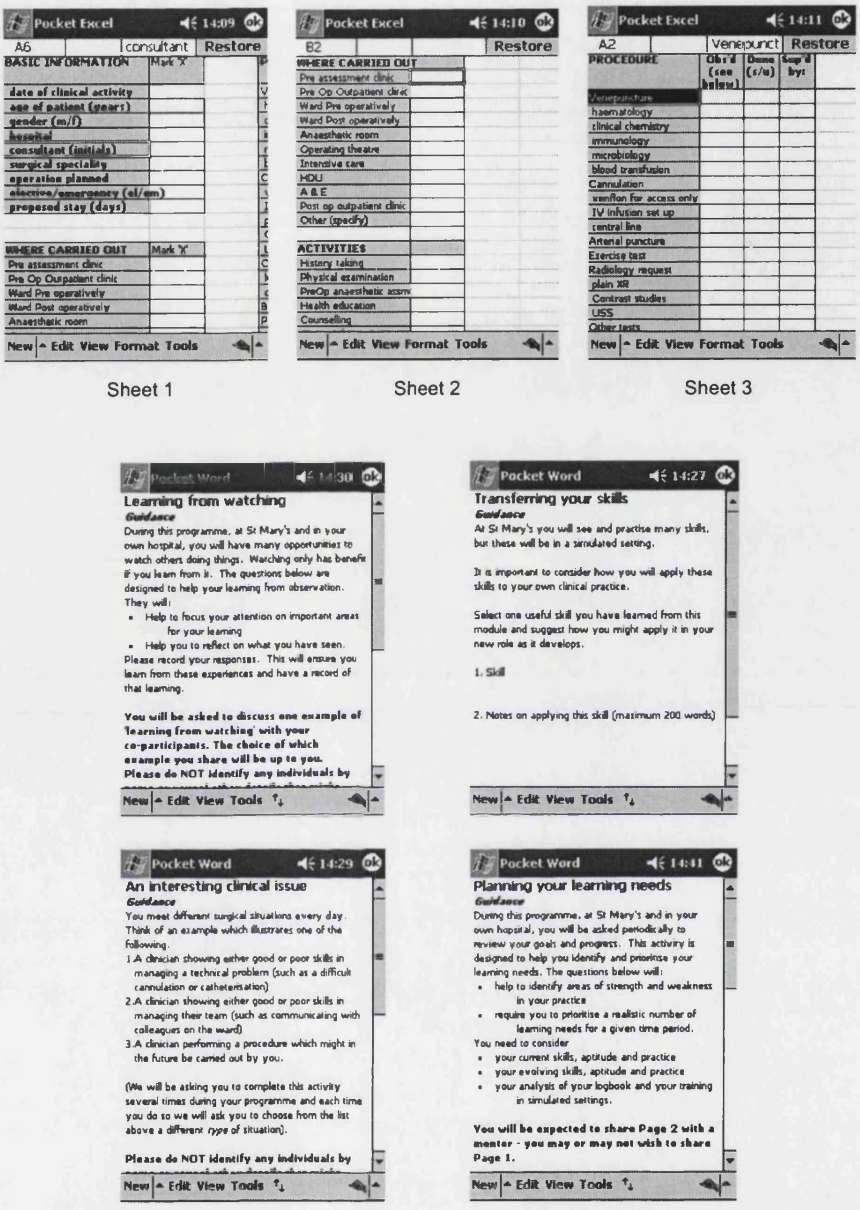


Figure 5.3: Selected screen dumps of the Pocket Excel and Word applications.

The PSPs were unfamiliar with PDAs, except for one of the trainees who owned a Palm Pilot® and required minimal instruction. They were first taken through an induction session on how to use the standard applications of the PDA – calendar, task scheduler, contacts, notepad, Bluetooth™ and infrared. Next, they were taken through a short tutorial about the use of the files for Activity Logging and reflections documentation. Each was given a manual with explanations on how to use the clinical

activity database. They were also given instructions on how to email clinical activity data back to the training centre.

The PSPs found the standardised applications very useful. They marvelled and were fascinated by the usefulness of the standardised applications of the PDA. In terms of these, the PDA was a wonderful technology.

"One day I forgot it at home and throughout the day I found myself completely lost" – Mary.

"It's like a lung. I thought I can't get to work without it, I need it." – Ruth.

"I've found it very useful. I've started using it more and more." – Claudia.

However, the Reflective Journal Word® document and the Activity Logging Excel® spreadsheet that were more important to the project objectives proved more difficult to fill in. These applications were problematic from the beginning: the pocket Word® application supported very limited formatting and therefore the matrices and boxes accompanying the desktop versions were removed when converted into pocket versions. The matrices, for example, were redesigned into long pages which extended the reading length of the file. Moreover, the PSPs were supposed to create copies of the original file each time they wanted to write their daily reflections or log their activities. The problem with the pocket Excel® file was worse. Due to the small screen size of the PDA, the desktop version of the file which had all the data on one sheet had to be redesigned into three sheets (see Figure 5.3). Next, the screen size also ensured that access to extreme columns and rows of the spreadsheet had to be achieved through left-right and up-down scrolling of the scroll-bars on each sheet.

Because it was obvious that these problems would render writing reflections and logging activities difficult processes, the PSPs were given the option to write paper-based reflections and activities. They were assured that a better application was being developed by the LSE team to replace these Microsoft-based files. At the same time, they were encouraged to use the PDA-based versions as a means of getting used to their PDAs. It was therefore not surprising when the PSPs reported their discomfiture

with the use of those PDA files for writing reflections and logging activities. It was almost impossible for them to log activities during history taking exercises with real patients. It was also nearly impractical to log observed activities during their rounds in the hospital wards. They further complained of how irritating it was when they scrolled the Activity Logging spreadsheet left-right and up-down. They preferred to use the paper-based logging spreadsheet because of this problem.

"It's very difficult to see where you are. I mean I have to use the stylus to know where I was because if you go to Sheet 1, right, now that's not too bad and you can put in the mark. But as you go down the sheet...I don't know what that is. To be able to enter that activity, I've got to go back to find out what it is. You see what I mean...you've got to physically visualise what you're actually filling in." – Comfort.

They also reported that they felt so tired after each day that for most of the time they went home to write their reflections instead of writing immediately after each day's training. On the occasions when they were able to type their reflections before going home, they found the Pocket Word® file simple to use. There were not much problems with their writing of reflections after their daily activities.

During this period, two members of the LSE team had been contracted to develop a better custom application to overcome the problems associated with the Word® and Excel® files. This was supposed to be a Java-based application which incorporated, mostly, radio boxes, text boxes and dropdown menus to facilitate logging or ticking and writing. The application had to have the capacity to be synchronised with a desktop version and to clearly depict the daily build-up of the database of reflections and clinical activities.

5.4.3.2 Stage Two

Two and half months into the project, a new application – abcDB – was developed and introduced by two members of the LSE team (see Figure 5.4). Unlike applications such as Microsoft® pocket Word® and pocket Excel®, there was no pocket version of a database application such as Microsoft® Access® at the time. Microsoft had not yet developed a pocket version of its Access® database application. Therefore the developers had to do an internet search for a pocket database application, and hence

the discovery of PocketSoft's abcDB which was eventually selected and purchased (see Figure 5.4).

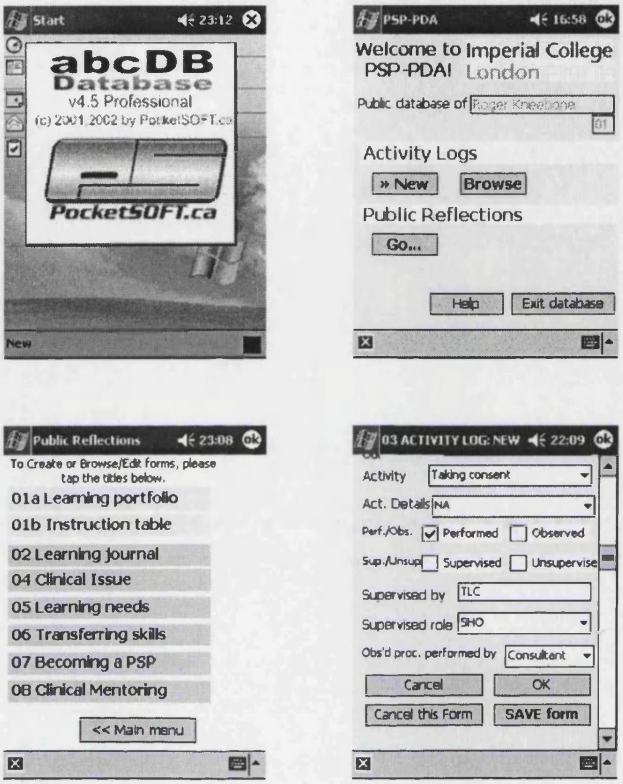


Figure 5.4: Selected screen dumps of the abcDB application.

The aesthetically pleasing abcDB application was installed on each PSP's PDA, and the PSPs were taken through a three-hour orientation session where a step-by-step process of using the application was demonstrated by the developers. In addition, each of them was given a detailed user-guide as a supplement. The orientation session proceeded quite smoothly with very few questions from the PSPs. They all seemed to have understood the instructor and could navigate through the pages of the application and perform their writing and logging tasks without any perceived difficulty.

On their return to their various hospitals, reports of severe problems with the application began pouring in.

"I have been having more than a few problems with my PDA ... as this new database is not workable especially when it is busy. I have tried to use it as much as possible but do not really trust that my work will be retrievable on paper.

Also each time I have tried to put the added work I have done into my computer, it tells me that the sync is complete but some of the documents have not been added to the database as the PDA will not let this happen. I also tried to print out some of this database but the format is too wide to do so, even the reflections are not in the same format as they were before.

There are some other things wrong with this system which I have put in a report I am compiling for you all to look at. I do not know how the other PSPs are getting on with their PDAs as the last thing I heard was that they were having trouble with syncing the database." – Comfort.

"As you would expect, I am finding the new system even worse than the old...I do not use my PDA AT ALL!! I rely on paper and to be honest I find it much easier and quicker. You can have it back if you would prefer." – Naomi.

"It's not complicated, it's just too time-consuming. I just can't use it. If I could use it per patient, then that would be fine, but per activity, it's out of question. It's too time-consuming so I'm just not going to use it. To do each patient, I reckon it would take something like half-an-hour to input the data which would be mad. It's just not feasible to do it like that." – Ruth.

"Assuming I have to deal with 5 patients, the slowness of the application's response implies that I have to spend about 10 minutes with each patient ... it's not realistic in a clinical setting" – David.

In the end, abcDB was virtually unusable in the mobile clinical learning setting and had become extremely problematic due to the following: First, there was a basic design flaw in which the users had to input one patient's personal details anytime a different action was to be performed by the PSP on a patient. The PSPs views had not been sought in the design of the application and therefore their particular practical

needs were not incorporated into its design. The application's design was not reflecting the clinical reality in which the PSPs found themselves working and learning daily.

Second, there was a systemic problem with the application which manifested in its slow running. The purposes of the PDA demanded the use of a database application that would allow an accumulation of PSP clinical activities as they are logged in daily. While the generic applications such as contacts and calendar responded very quickly to commands, it took an average of eight seconds for a command in the application to execute on the PDA. Incidentally, this database software ran too slowly on the PDAs – and this was not detected beforehand. Perhaps the trial versions of other alternatives should have been tested before a choice was made. This also made the use of abcDB very problematic because, again, it was too time-consuming and not practical in the clinical setting to wait for eight seconds for every command to execute. Quite simply, the use of a slow responding application which contained too many pages was a burdensome process which was disrupting the actual learning activities of the PSPs.

Third, PocketSoft at the time constrained developers to only seven dropdown menus per PDA page of any application developed with its software. Therefore, given the wide range of items which the application had to be developed to cover, the design of abcDB consisted of many pages. There were too many interfaces that the user had to navigate when using abcDB to log in their actions and type reflections. There was too much duplication of the key resources such as text boxes and buttons across the numerous pages of the application. Apparently, little care was taken to ensure that as few as practicable pages were built to simplify its use.

Fourth, the reflections file format was strange and unprintable because their print sizes were far greater than an A4 sheet. As such, they could not print daily reflections from the application for their portfolios. What most of them did therefore was retype the same reflections on their desktop computers in Word® format to make them easily printable on A4 sheets.

Fifth, there was also a problem with transfer of data from the PDA onto their computers through synchronisation. After logging clinical activities, synchronisation attempts failed to send the PDA recorded activities to their computers.

These problems together made the use of the application very unwieldy and clumsy since its use was not simplified enough to stay as an action alongside the skills learning clinical actions being performed.

The magnitude of problems associated with abcDB was alarming. The developers were informed of these reported problems but they could not fashion out an immediate solution – either because they did not consider the technology-response time factor in their design or they could not rigorously test the application before releasing it for use. Feedback on the efficacy of the application was expected to be sought from the PSPs when they returned to London for the next module; but the frequency of complains from the PSPs and the strength in their dismissal of the application did not make that possible. The project manager was compelled to immediately employ a learning technologist approximately three weeks after the introduction of abcDB to develop a new and better application to replace abcDB.

5.4.3.3 Stage Three

When the PSPs returned to London for the next module, abcDB was officially abandoned and removed from their PDAs. The learning technologist gathered the feedback on the PSPs' experiences with abcDB use as an input into his new design. Unlike the developers of abcDB, the learning technologist engaged the PSPs in a three-hour consultation about the critical aspects of their clinical activities which would influence his design decisions. The PSPs contributed significantly in this regard and presented a picture of the nature of their clinical activities upon which a better application would be premised.

In the development of the new application – HanDBase – it was agreed by all members of the project that reflections writing would thenceforth be officially paper-based. But PSPs were still given the option to type their reflections in the earlier Pocket Word® templates if they found that more convenient. Thus HanDBase was an

application to be developed solely for clinical Activity Logging purposes (see Figure 5.5).

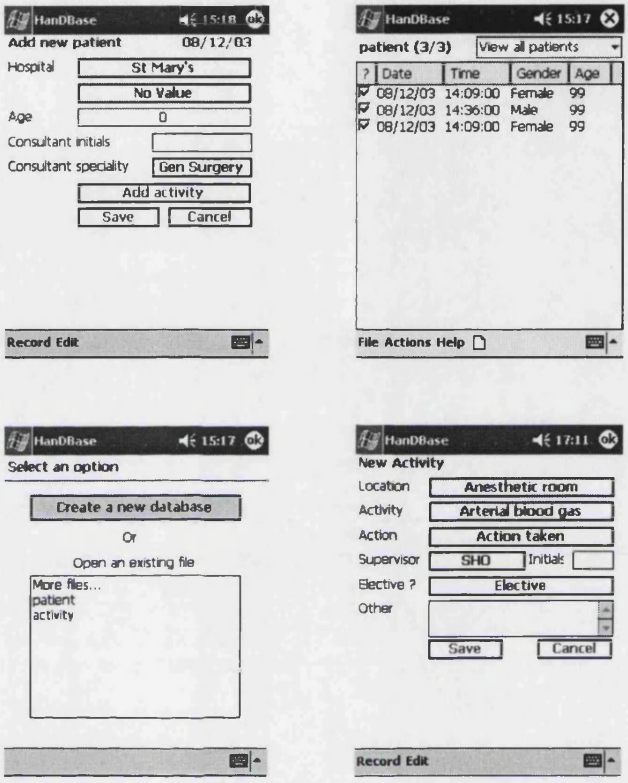


Figure 5.5: Selected Screen Dumps of the HandBase application.

The development process took more time than it took to develop abcDB. The learning technologist had to design the new application to surmount the problems which the abcDB presented. Apart from the lengthy consultation of PSPs for their views on how the new application should look, the development of the new application also included its beta-testing in the clinical setting by three PSPs. The feedback from the testing was encouraging: the application was easier to navigate because of its fewer pages, it was many times faster than abcDB, and it reflected the nature and structure of their clinical activities. To them, the redesign was much better.

As an accompaniment to HanDBase, the electronic version of the Oxford Handbook of Clinical Medicine and the Archimedes drugs calculator were acquired by the project manager to be installed on each PSP's PDA. This handbook contains rich medical literature and was envisaged to provide learning support for the PSPs.

However, during the beta-test, there was still the lurking problem of Activity Logging on-the-move or during history taking – realistic use in the clinical setting. The testing PSPs reported that they did not have time to enter data contemporaneously. They rather logged their clinical activities at the end of the day in contravention of the contemporaneous activity logging rule. While one of them indicated that he could potentially enter data contemporaneously in the future, the general impression was that using the application was "another thing to do" in addition to their usual clinical activities round their hospitals.

The few rough edges of the application identified by the PSPs during the testing period were dealt with and the application was ready to be rolled out to all the twelve PSPs. The first step was another three-hour orientation session that was notably facilitated by the three PSPs who had earlier undertaken the testing. Their support, in addition to the PSPs' improved familiarity with the PDAs, and the fewer pages of the new application in totality ensured that the PSPs were more properly trained to use the application for Activity Logging. They therefore left the training centre in London for their hospitals with the expectation that they could effectively use the PDA to log their clinical activities when they were being done.

During the evaluation of the application six weeks later, it was agreed by all the PSPs that the new application and the installed software represented a significant improvement in the use of the PDA compared to the days of abcDB. The application was many times faster than abcDB, but it was still not usable contemporaneously with the performance of clinical activities and with history taking. But this problem was comparatively minor because the PSPs could log in their activities at the end of each one of their activities. The more perilous problem manifested in losses of logged activities as a result of synchronisation of PDAs with desktop or laptop computers. PSPs started complaining that the synchronisation process caused a corruption of the activity file, and as a result the PDA continuously lost activity data. Furthermore, the synchronisation problem frequently caused the PDA to crash. Here again, this problem represented a kind of a mystery to the learning technologist because it was completely unexpected and, worst of all, he had no immediate solution to it. Based on this, it was decided by mutual consent that the PDA be officially abandoned for the

second time. And the HanDBase was removed from all the PDAs. From that period, all information management tasks reverted to the use of pen and paper. Although the PSPs still had the option to use the Word® and Excel® files for reflections writing or activities logging or both, the official output of the portfolio was the huge files which were supposed to be replaced by the PDAs.

5.5 Learning Outcomes

In terms of the project outcomes, the evaluation at the end of 12 months revealed that the training had achieved some significant objectives that could further facilitate the overall aim. It has to be said, however, that the achievement of the aim to "develop a permanent new role" could not be assessed at the end of one year. Whether the PSP will eventually be established as a permanent medical professional role can only be determined after several years of its development or the lack of it.

The accounts of the PSPs and their surgical team members confirmed that the expected transformation of the twelve healthcare professionals into functional PSPs was achieved. Peri-operative care skills, which represented the most important aspect of the project, had been satisfactorily acquired; and for most of them, their consultants thought they could confidently rely on PSPs for surgical tasks that were previously performed by SHOs. In the eyes of their team members, the PSPs had become indispensable to their teams.

It emerged at the evaluation that amid all the positive and negative experiences which the PSPs underwent in their hospitals during the project implementation, their role had had positive impacts in terms of the reduction of junior doctors' hours in their hospitals. Most significantly, the PSPs provided effective cover for absentee junior doctors and sometimes offered doctors the opportunity to attend theatres and clinics. In most instances, the reduction was estimated to be twelve hours per week.

There were some encouraging revelations in terms of the ultimate acceptance of the PSP role among medical professionals: the resistance by and territorial disputes with members of their surgical teams that dominated the PSPs' training in their hospitals had significantly subsided towards the end of the project. The PSPs reported that one

of the key positive outcomes was their improved relationships with these professionals.

Two of them who trained in the same hospital had conducted a survey among their surgical patients to enquire about their experiences. They reported that the patients claimed that the PSPs eased the stress of going for surgery; and they were more confident coming into hospital.

5.6 Key Findings

Although peri-operative skills acquisition was paramount in the project, it only formed a microcosmic portion of the development of the entire professional role. The politics that belie the evolution of new professional roles are not only concerned with the end product of a role. In fact, as demonstrated in the development of other professions such as Engineering, Town Planning, and Medicine itself, the skills content and the process of acquisition of those skills have proved to be crucial for the survival of professions in the job market. Therefore, merely producing PSPs equipped with peri-operative skills may not be sufficient in terms of the survival requirements of the role; critically required is evidence of the skills contents, and the process and duration of their acquisition. Furthermore, since the pedagogic framework of learning in this project deviated from traditional classroom-based models, the necessity for monitoring and control of the PSPs' learning activities from a distance was also fundamental in the role's survival requirements.

To this end, the management of the information generated by the project, and hence the deployment of PDAs for these purposes, were extremely important. At the final evaluation of the entire project, the deployment of the PDA in the project was lauded by the PSPs. Although the PDAs failed in terms of the particular purposes for which they were deployed, most of the PSPs claimed that it would have been a brilliant means of learning support if HanDBase was not blighted by the data loss and crashing problems. They admitted that, taking a retrospective look from the introduction of the PDAs to their abandonment, the technology was always getting better by the day. In other words, they held the belief that a better application devoid of the problems which afflicted the PDA's application would have served the Activity Logging and reflections writing tasks effectively. In view of these perceptions and facts, important

questions which come into mind are: why did the technology fail? How did the learners perceive the technology? Taking an Activity-theoretical perspective, the key findings of this study will offer us some insights about this problem.

5.6.1 Problematic Learning Conditions

So far, what has been clarified are the systemic problems associated with the various applications which were designed into the PDAs for the project. It is true that the earlier designs were poor and contributed on their own towards the technology failure. However, the accounts of the PSPs also pointed to considerable interpersonal problems in their hospitals which were directly confrontational as far as their computing actions were concerned.

Each PSP worked and learned in the surgical team of his or her hospital. These surgical teams comprised of a consultant head, junior doctors and nurses of various levels in the hierarchy of the profession. In their learning, each PSP was supposed to integrate into their surgical team and develop their pre- and post-operative care skills. According to prior agreements with the project team, the consultants, the leaders of the surgical teams, were supposed to facilitate the integration of the PSPs into their teams and ensure that they achieved optimum learning experiences. However, the PSPs reported of serious encounters of resistance and non-acceptance by their surgical team members. This was not too surprising given the volatility and novelty of the new role; it was also not too surprising given the natural uneasiness on the part of the surgical team members as they comprehended PSPs who would end up higher in the ranks above most of them.

Resistances manifested in the PSPs over-acting or under-acting in the performance of their clinical routines in their hospitals. On the one hand, some of the PSPs reported that they could perceive overt and covert tactics of rejection and resistance on the part of surgical team members which stifled their participation in patients care. On the other hand, in instances where their participation were not stifled, they were overloaded with tasks by their team members. For example three PSPs complained bitterly, not once but in three consecutive 'how things went' sessions, that in much of the time spent with their teams, their roles were reduced to running errands which

constituted total aberrations as far as their learning objectives and actions were concerned.

More implicitly, the nature of work-integrated learning which this project exemplified entails elements of pragmatism which coerce learning participants to concentrate more on the work. In healthcare, the pragmatic demands of patient care overrides and overwhelms any other concerns, and therefore it was not surprising to hear PSPs reporting that the clinical demands of patient care did not make possible the manipulation of portable computers.

All these forms of conditional problems were attributable to the immediate control exerted on the actions of the PSPs by their team members. While the project leader instituted some measures to exercise remote control over their actions, this was siginificantly supplanted by the immediate control of the surgical team. The distant project leader's aim was the skill development of the PSPs which contrasted with the surgical teams' leaders' aim of efficient and effective healthcare delivery for their patients. Since mobile computing was instituted as part of the project leader's controlling measures, and since the surgical teams were less concerned with mobile computing and even largely opposed to it, it was always going to be difficult for the PSPs to compute on-the-move during their clinical duties. The balance of control between the surgical and project teams, therefore, played a dominant role in the inability of the PSPs to use their PDAs as desired by the project team.

5.6.2 Marginalisation of Technology

According to the accounts of the project leader, the pilot project consisted of three phases – preparation, training and evaluation. The project preparation started one year before the training or implementation phase. There were so many resources committed to the preparation phase that manifested in the definition of the role, designing the training and consultation and involvement of key stakeholders. Interestingly, the planning of technology integration to assist in continuous monitoring of distance learning activities and portfolio development was only incorporated towards the very end of the preparation phase.

It is very clear from the key learning outcomes of the project (see Section 5.5) that technology had been neglected. Information management with PDAs was incorporated into the project to support the process and not the product. Thus, while the preparation phase began in April 2002, the planning of technology integration only began in February 2003 when the project leader consulted a senior lecturer of the IS Department of LSE to be advised on integrating mobile technology into the pilot project. When it was decided that the Pocket PC be adopted for the development of a custom application, the project leader decided to contract two students of the IS Department of LSE to design the application. Incidentally, these students were seriously preparing for the final examinations of their master's degree which were scheduled for May 2003. So it was mutually agreed that the development of the custom application be postponed till the end of the students' examinations in June. This is the reason why at the beginning of the training phase, the PSPs were made to use pocket Word® and Excel® files to write reflections and log activities.

During the training phase, the time resources that were allocated for the PDA were relatively insignificant. Only three hours out of an average modular period of about thirty-five hours were used to officially discuss the problems of the technology usage with the PSPs. Given the magnitude of the problems encountered by the PSPs, in addition to the fact that the use of PDAs was an entirely new experience to 11 of the PSPs, one would have expected a greater devotion of resources to the technology integration.

At the end of the project, its total evaluation was organised into two parts. There was one which was designed along the lines of the 'How things went' session of the modules and held at St. Mary's hospital – the participants were the project authorities and the PSPs. The second one – held a day after the first one in Hilton London Metropole Hotel – was labelled as the "PSP Sharing Event." This was the ultimate meeting of all stakeholders of the project, including the members of each PSPs surgical team they had worked with. During this function, the entire pilot project was put into perspective to outlay its achievements, relevance, potentials and problems: the most significant aspect was the individual PowerPoint® presentations by the surgical teams in which the PSPs had worked. While the first evaluation covered the PDA's use over the period, the experiences of use, problems and potentials of the

PDA as a learning support tool were conspicuously absent from the entire exchanges of the second evaluation – not in the project leader's speech nor in any of the team's presentations.

This training project was characterised by a high degree of mobility, and therefore the attempt to integrate portable technologies such as a PDA for those purposes was not a bad idea in itself. The introduction of technology to support any human activity requires effective planning and monitoring to ensure its successful use. Since the trend of technology use in this country points to the likelihood that similar distributed and mobile learning projects will integrate portable technologies in future, a comprehensive and in-depth evaluation of the PDA use as an integral component of the entire project in the presence of all the key stakeholders would have prompted fruitful discussions and useful lessons for the future.

From preparation through training to evaluation, the PDA seemed to be a peripheral item in the eyes of the project authorities; and therefore, it remained at the fringes of the project from the beginning to the end. Although one cannot conclude simplistically that this marginalization of the PDA totally accounts for the failure of the technology, one cannot also rule out the positive impact which a proper integration of the technology would have made in the project. Just as it was emphasised throughout the Sharing Event that the success of the PSP role critically requires essentials such as champions, clear plans, and effective support, so did the successful integration of learning support technology for such a project require those essential attributes.

5.7 Conclusion

In this chapter, a detailed account of the empirical study conducted to ground the understanding of mobile technology use in support of mobile activities has been presented. The presentation covered the introduction of a new professional medical role in which PDAs were deployed to facilitate information management tasks. The results have shown that after three stages of uses each involving a different application, the technology was eventually abandoned because it could not fulfil the required tasks. Based on this, the apparent causes of this failure were sought leading to the identification of the key findings – the marginalisation of the technology and

the problematic conditions which undermined the computing actions of the learners. The study presented in this chapter and the theoretical foundations developed in earlier chapters set the grounds for exhaustive analysis and discussion of the findings. These are the focuses of the following two chapters.

Chapter 6: Mobility of Computing and Work-Integrated Learning

6.1 Introduction

The purpose of this chapter is to analyse the findings of the WIL empirical study presented in Chapter 5. Against the background of the literature on portable ICTs and mobility, on learning and technology mediation, and on Activity Theory (Leont'ev 1978, 1982, Engeström 1987) in other previous chapters, the aim is to unearth the salient interrelationships between components that characterise the mobility of computing and WIL. AT is a developmental-psychological theory of human development whose principles combine learning and tool mediation as inseparable components of any conscious human activity and skill development. It offers a cogent set of postulates on an approach to human development based on the cultural-historical, social psychological and physiological implications of human activities. In this regard, it provides relevant guidelines for analysing tool mediation and skills development within the context of WIL. This framework is applied in analysing and synthesising the findings of the empirical study, and serves as the underpinning for theory development in the next chapter.

In accordance with the research aim and question, the analysis and synthesis of mobile computing and WIL is undertaken to contribute to an understanding of the mutual shaping between mobile computing, and mobile and distributed learning. Within these deliberations, the key issues outlined in Chapter 1 which confronted this research are taken up and elucidated in sufficient details.

I begin in Section 6.2 with activity-theoretical explanations of the WIL that point to the conditions and modalities of human mobility it entailed. Under this, Sub-section 6.2.1 examines the contradictions within the WIL activity and other neighbour activities to outlay the problematic nature of the WIL process. Sub-section 6.2.2 takes the analysis further to show the significance of distance, distribution and mobility in the activity. Under Section 6.3, Subsection 6.3.1 examines the design properties of portable computers and the degree to which human sensuous perception of these

properties generate affordances of mobile computing. Subsection 6.3.2 follows with an analysis of the conflict of needs and motives which caused the non-usability of the PDAs. This section culminates in Subsection 6.3.3 with an analysis of the political games and degree of control exerted over the PSPs which influenced their mobile computing during the activity: it ends with a flexible computing model that shows the relationship between mobility and flexibility of computing. Next, Section 6.4 takes a step from the product feature of the PDA to its service delivery aspect. In Subsection 6.4.1, mobile information services, derived from the use of the PDA are analysed from an interpretive flexibility or reconstruction perspective. This culminates in the proposition of a conceptual framework for the determination of flexible computing from the mobility of humans and ICTs in Section 6.5. This framework further depicts a paradox between mobility of computers and flexible computing. Finally, the key arguments of the chapter are summarised in Section 6.6.

6.2 Conditions, Modalities and Sense-Making of WIL

6.2.1 WIL as Contradiction

The set up of the WIL project reflected a collective human activity system (see Figure 6.1). The PSP was the learning subject who was motivated primarily by the transformation of external and intangible pre- and post-surgical care skills – the object – into internal knowledge. This transformation was mediated, on the one hand, by physical tools such as portable computers, paper-based learning portfolios, surgical instruments and simulation technologies; and, on the other hand, by psychological tools in the form of the surgical cultural-historical ideals – the jargons, concepts, mannerisms, etiquette and procedures that identify the surgical role. Consistent with every collective human activity, this transformation was undertaken within a community of other PSPs, medical professionals and the entire network of hospitals and institutions that had a stake in the project. The relationship between the PSP and this community was mediated by the learning rules – instructive, constructive and experiential learning. These rules produced the remote, mobile and distributed conditions within which the actions of the activity were performed. Furthermore, the relationship between the community and the object was mediated by the distribution of the activity's tasks – division of labour – among the community members. These relationships defined the WIL activity system.

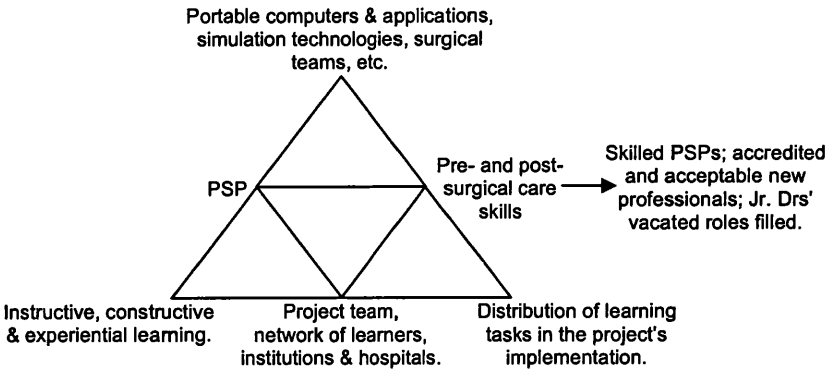


Figure 6.1: The Central/WIL Activity System of a PSP.

The system represents, in Engeström's (1987) parlance, the *central* activity of the PSPs which is the unit of analysis in this dissertation; central because it constituted the system in which the PSP was the subject using a portable computer to support the transformation of the object. The outcome of the central activity was their transformation into accredited and acceptable new medical professionals equipped with pre- and post-surgical care skills to assume junior doctors' vacated roles. It is worth noting, however, that the motive behind this transformation was not necessarily generated by the PSPs; it was rather introduced by representatives of the cultural underpinning – the project team – as was palpable in the project proposal. This motive was "only understandable" (Leont'ev 1982) from the point of view of the PSPs.

The project team, as subjects of a "culturally more *advanced* central activity"[25] (advanced activity hereafter), were motivated by the cognitive transformation of the PSPs. On the other hand, the PSPs, in responding to their personal and professional needs, adopted this "understandable" motive at the beginning of the project to share the same outcome. This adoption illustrates the harmony that characterised the formative stages of the project; and it ensured that the central activity was entwined with the advanced activity of the project team. In these formative stages, the outcome appeared to satisfy the motives of the two activities. Indeed, it was not merely the outcome and motives of the advanced activity which were shared or adopted by the

[25] According to Engeström, the more advanced motive is induced by representatives of culture by some means (e.g. rewards), and assumes an encompassing role to subordinate or conflict with the central activity.

PSP; its tools, rules, community, division of labour, and associated actions were all shared with the central activity at the beginning (see Figure 6.2).

What were not shared from the outset were their subjects and objects, and this was not trivial. These activities were significantly different in the sense that while the central activity had the PSP as its subject and the intangible and external peri-surgical skills as its object, the advanced activity had the project team as its subject with the PSPs themselves as its objects. Given that one activity is distinguished from another by its object which gives it a "determined direction" (Leont'ev 1978), the different objects gave the two activities different directions and orientations in the consciousness of the PSP.

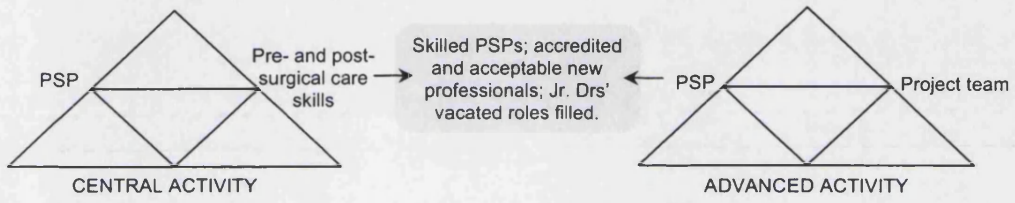


Figure 6.2: Interaction between the central activity and culturally more advanced central activity depicting the shared outcome.

The designed actions of the advanced activity, conceptualised in anticipation of the conditional problems within their execution, incorporated objective meanings of cultural-historical origin, which reflected the culturally more advanced motive. On this plane, the PSPs' concern of where they would end up after the project was predominant, leading to their adoption of the motives of the advanced activity. However, the demands imposed by the empirics and pragmatics of the conditions in which they engaged in the performance of the designed learning actions were overwhelming and largely unexpected. For example, the resistances and uncooperative attitudes of other surgical team members; the perception of the PSPs by other surgical staff as threats to their roles; the territorial disputes; the mobile nature of the learning process; the life-and-death criticality of dealing with real surgical patients as part of the learning process; and the design properties of the portable technology, were all daily challenges which conditioned and stimulated their personal evaluations of the learning actions. Their instinctive reaction to these challenges was subjectivisation or personalisation of the pre-conceptualised objective goals of their

actions: this manifested in a demonstration of their utility to win over the sceptics, cynics and resisting agents in their surgical teams. In other words, the complexities intrinsic in these conditions, which underpinned the execution of the learning actions, guided a metamorphosing of the goals of the actions of the central activity to contradict those of the advanced activity. In short, beyond the seemingly harmonious inauguration of the project, the practicalities and realities of the learning conditions that subsequently confronted the PSPs caused a reshaping of the entire central activity.

Therefore, at a superficial level of analysis, the motive of skills acquisition, common to both activities, makes the parts of the outcome appear mutually supportive. However, beyond skills acquisition, the subjective and objective meanings spawned two supplementary but contradictory motives: respectively, the demonstration of their personal utility to their surgical teams and hospitals; and national accreditation and countrywide acceptability of the role by, most notably, other medical professionals. The former, corresponding to the central activity, is a reflection of the skilled PSPs as products of use-value, while the latter, which corresponds to the advanced activity, reflects the skilled PSPs as commodities of exchange-value in the wider society. This "double nature" (Engeström 1987) was a result of a dialectic of perceptions embedded in the consciousness of the PSP between their individualistic subject-production in the central activity on the one hand, and subordination to the advanced activity's collective object-production on the other hand. The personal sense made of the WIL conditions, and hence actions, contradicted the objective sense of the advanced activity. The origin of sense-making by the PSPs was therefore directly related to this first contradiction: the conflict between the PSPs' central and the project team's advanced motives.

Sense-making by the PSPs was a function of the direct relationship between their learning actions and the conditions or environment within which their actions were performed. It is the conditions that determine whether a conscious action deteriorates into an activity or develops into a subconscious operation. In the WIL project, the conditions within which the PSPs conducted their actions were consequences of other interrelated activities that impacted on the central activity. Engeström calls them "neighbour activities" – object-activities, instrument-producing activities, subject-

producing activities and rule-producing activities (Engeström *Ibid.*, see also Figure 4.5). Naturally and inevitably, very human activity, which assumes a central or leading position at any point in time, interrelates with these neighbour activities in varying degrees of relational emphases.

The actual and routine surgical practice in the PSPs' hospitals represented the object-activity within which the peri-surgical skills – the object of the central activity – were embedded. Disciplines such as information technology, software engineering and computer science, which gave birth to the PDA and its applications, constitute the instrument producing activities. The subject-producing activities comprise the previous medical training, which had shaped the PSPs into nurses and operating department practitioners, and therefore ensured their eligibility to enrol in the project. The EWTD, the administrative arrangements of the project, hospital formal and informal regulations, and accreditation requirements are some of the key rule-producing activities that influenced the training of the PSPs.

To be sure, the central WIL activity was in constant interaction with representations and reifications of these neighbour activities. In conjunction with the advanced activity, they make up the external environment of the central activity; but their occurrence was serial rather than parallel. In other words, the primary sense made of the relationship between the central and advanced activities influences the subsequent sense made of the relationship between the central and each neighbour activity. Thus, it is the contradiction at the outcome end that effected inner contradictions in all the other elements of the PSP's central activity system (see Figure 6.3).

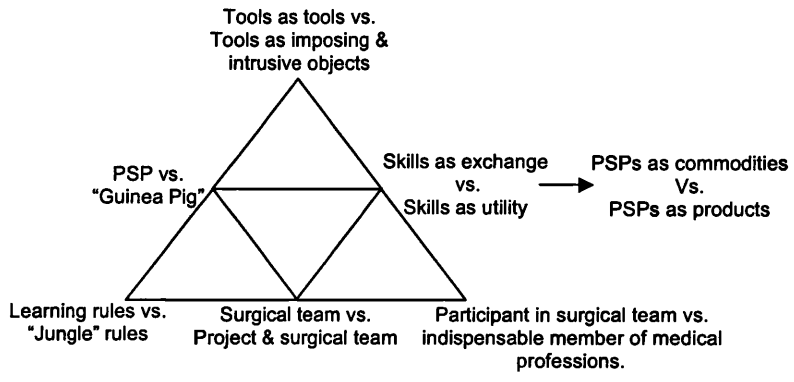


Figure 6.3: Inner contradictions within the elements of the central activity.

These inner contradictions are results of the internalisation efforts of the PSPs through continuous sense-making of their actions. Internalisation is a conscious mental reflection of the objective world in which subjective representations of the objective world are formed in the internal "plan of consciousness" (Leont'ev 1978). What was internalised by the PSPs at the institution of the project was an image of the shared outcome – PSP as commodity. But that was mere "image-consciousness" (*Ibid.*) corresponding to fantasy and hapless flight of imagination. Later, their "activity-consciousness", which derived from the actual learning experience, and which generated the motive of the central activity, resulted in the internalisation of a contradictory personal outcome – PSP as product. This internalisation process symbolised an inter-psychological facet between the central activity and the advanced activities.

Intra-psychologically, activity-consciousness resulted in the search for an identity: necessarily about how the PSPs perceived themselves against how others saw them. Indeed, the aims of the project were clearly explained to the PSPs at the beginning; but the fact that accreditation of the role was not promised at the beginning nor at the final evaluation was sufficient for the PSPs to see themselves as "Guinea Pigs" of the pilot project rather than new surgical professionals. Therefore as subjects of the central activity, they made sense of their actions amid an inner identity contradiction between PSPs and Guinea Pigs.

They also made sense of the peri-surgical skills as an object of utility or object of exchange, but this sense-making transcended the object level to the object-activity level. Based on the product-commodity contradiction, the PSP's sense of the object-activity was founded in contradiction between first, a parochial discernment of the peri-surgical skills as objects of utility whose transformation would lead to the skilled PSP as a product; and, second, a holistic viewpoint of those skills as exchange objects whose transformation would result in the skilled PSP as a commodity. As the motive of the central activity dictated, it was the sense of object as utility that pervaded.

The actions and operations, which constituted the actual learning experience, were performed with the support of the physical and psychological tools. However, the

utilisation of these tools was subject to the impact of rule-producing and instrument-producing activities. The relevant outcome of the rule-producing activities manifested in the instructive, constructive and experiential learning principles; these further underpinned the development of the custom applications of the PDA. The learning rules dictated the remote mobility and distribution of the PSPs and their learning – distance and distributed learning – leading to the critical need for remote monitoring. The direct outcome was the deployment of the PDAs, and to this end, they were expected to be supportive tools whose performance would constitute actions of the central activity, at least. However, their actual learning experiences were rather dominated by informal ("Jungle") rules and norms of their surgical teams – of the object-activity – which challenged the pre-designed learning rules from the very beginning. For example, the jungle rules dictated the local mobility and actions of the PSPs that did not allow the desired contemporaneous use of the PDA. Thus, against the background of the contradictions with the advanced activity, the PSPs perceived the PDAs as imposing and intruding objects that were at odds with the supportive tools notion promulgated by the project team. The case has shown that, had it not been abandoned, it would have generated another activity altogether.

Consequently, the learning community of stakeholder hospitals and institutions, which corresponds to the advanced activity, and which represented the embodiment within which the PSPs would identify themselves as professional participants, could not manifest. Rather, their surgical teams represented their narrow community within which their actions found their meaning and were directed. As a corollary, the division of labour was also affected: there was a contradiction between the planned PSP as an indispensable medical professional and the resultant PSP as a mere participant in his or her surgical team.

6.2.2 Sense-Making of Distance, Distribution and Mobility

The central activity was pervaded and influenced by complexities inherent in the political and pragmatic conditional problems such as the resistance by other surgical team members, the need to satisfy and be accepted by their surgical consultants, and the high-degree of wandering – local mobility – around the hospital environment. On the other hand, the advanced activity was influenced by conditions and needs which represented an extension of those of the central activity – the remoteness and

distribution of the PSPs around the country, the remote mobility between London and the PSPs hospitals, and the need to continuously monitor and scaffold the PSPs learning from London. In short, the whole WIL activity was premised on a combination of distance learning, remote distribution and mobility of the PSPs.

The distance between instructors and learners introduces problems of monitoring and coordination of learners' activities. Instructors need to ensure that learners follow objective instructions to achieve desired learning outcomes, while learners need to reciprocate by availing their learning activities and outcomes to instructors for assessment. Furthermore, instructors have a responsibility to support knowledge construction and cognitive development of learners through coordination efforts. Indeed, "distance matters" (Olson and Olson 2000) in learning because it compounds monitoring and coordination problems between instructors and learners.

When it comes to skills acquisition, especially towards health services delivery in general and surgery in particular, there is very little allowance for constructive learning. Specific learning instructions, aimed at addressing the identified problem of a looming skills shortage in the NHS, therefore constituted the guidelines for action in the WIL project. Although the immersion of the PSPs in the context – surgical practice – suggests some constructivism and experiential learning, the strength of the project manager's instructions was indicative of the emphasis on content and process (see Pettigrew 1985b, 1987). In this respect, the distance between the skills contents instructions and the process of assimilation becomes crucial. In the project, the issuance of instructions occurred in one location under one instructor – the project manager – while the process of assimilation occurred under another instructor – the surgical consultant. These instructors had contradictory objects and motives: The PSPs represented tools of the surgical consultant's object-activity which motive was a transformation of patients through surgery; in this respect the PSPs were useful in the performance of the actions of the object-activity. On the other hand, the project manager was more interested in the cognitive aspect of the PSPs skills development (see Figure 6.4). Indeed, the motive of the advanced activity was a mere goal of the object-activity.

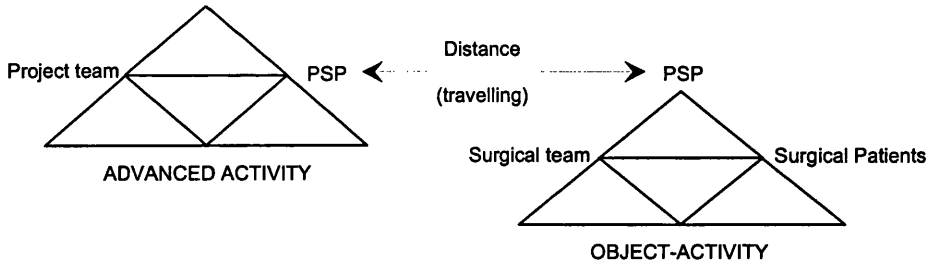


Figure 6.4: The changing role of the PSP as a factor of distance.

The WIL case presented was not only characterised by distance; there were also problems relating to the distribution of the learners and their extreme local mobility within hospitals. To the project team, although the practical or contextual aspect of the learning was important, the extreme local mobility which this entailed, as well as the distance and distribution of the PSPs represented an unstable facet of the project. Besides, the PSPs' attachment to surgical teams headed by consultants implies that they were directly confronted with immediate instructions other than those of the project manager. In other words, their actions were subject to instructions of both the project manager and the resident consultant of their training hospitals. Instability in this sense was implicitly bearing on the outcome of the advanced activity: the outcome was as important as the process but, due to distance and distribution, the project team had very little direct control over the process from which the outcome would manifest.

The inertia to change within an age-old discipline such as medicine, the life-and-death criticality of dealing with surgical patients, and the threat that existing medical professionals would feel about a new role, were some other key factors which induced caution in the project manager. He could not be assured that the PSPs would survive in these surgical teams without resistances from other medical professionals. Sørensen and Pica (2004) rightly point to this problem in their analysis of "trust and flexibility", based on portable technology-induced mobilisation of human activities. Flexibility and control are the bipolar parameters within which they placed the management of mobile work. To address the problem of mistrust and instability, the project manager instituted control measures including the one-week modules, the PDAs, the learning portfolios and support from the consultants – the leaders of the surgical teams – to stabilise the process.

The distribution of the PSPs necessitated the institution of coordination and monitoring measures to ensure that the distributed learners went through similar, if not the same, learning experiences. These measures manifested in the one-week London modules during which the PSPs converged to share their experiences after every six weeks were spent in their hospitals. These modules were critical means of levelling up the learning field for the PSPs because they attended classroom-based tutorials sometimes with simulated technology aids. Thus if there were any significant disparities between the learning experiences of the PSPs in their various hospitals, the weekly modules always addressed the differences to ensure some considerable degrees of uniformity in the process. In terms of monitoring their cognitive development, given the failure of the PDA to provide continuous information about the PSPs learning activities, the weekly modules served as surrogates: their activities were monitored through their paper-based activity logs and written reflections in their learning portfolios.

This implies that the distribution of the learners was a key factor in the design of the London modules, which introduced remote mobility or "travelling" (Kristoffersen and Ljungberg 2000) into the WIL structure. In other words, travelling was a critical necessity as a leveller, a stabilising measure, a controlling strategy, and a "coordination mechanism" (Schmidt and Simone 1996) to tackle the discrepancies in the distributed learning experiences of the PSPs.

In sum, the following arguments can be drawn from these explanations. In WIL, the distribution of and distance between learners and instructors enhances the flexibility of the process. However, flexibility simultaneously signified instability from the point of view of the project manager, which manifested in the learners' vulnerability to conditions enforced by the politics and control – the "jungle" rules – of the object-activity. These conditions can potentially destabilise the learners' central activities, necessitating the need for the advanced activity to affirm its control through extra mobility – travelling to and from London – and through information technology. To this end, travelling – remote mobility of humans – and mobile computing were decisive measures for controlling and stabilising distance and distributed learning.

6.3 Portable Computers and Problems of Mobile Computing

6.3.1 Design Properties and Affordances of PDAs

The expositions in the previous sections have proven that mobile computing failures in the central activity were factors of the contradictions between the motives of the central and advanced activities as well as the instrument-producing activities. The instrument-producing activities consisted of the activities of the original designers of the hardware and software properties of the PDA as well as the activities of those who built the custom applications (see Figure 6.5). Thus, the PDA consisted of two sets of design properties: the hardware and software of the original developers, and the subsequent custom applications sanctioned by the project team.

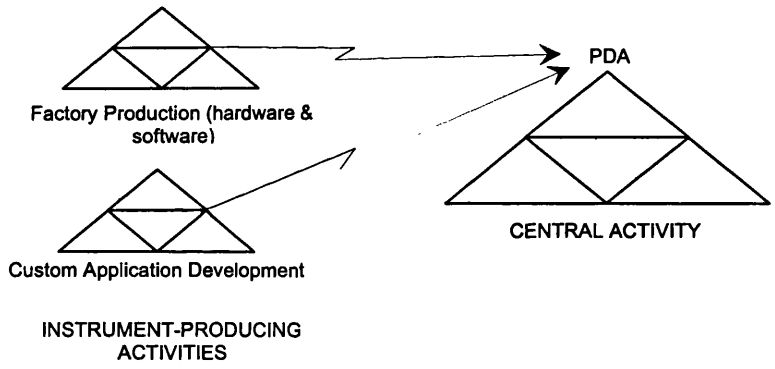


Figure 6.5: Relationship between Instrument-Producing Activities and the Central Activity.

The activities of the original designers produced three fundamental and essential design properties of the PDA that impacted on their use in learning activity – *physical, systemic* and *interfacial.* These design properties, in various degrees of proportional dominance, embody potential affordances that have bearings on the adaptability of users and the efficacy of the instrument's usage in any learning activity. Adaptability and efficacy in activity are factors that determine whether the PDA afforded the flexibility of mobile computing. In a typical computer-mediated activity epitomised by WIL, adaptability and efficacy reflect the problems of complexity in information capture and processing that are associated with the sense made of the goals of the actions that constitute the central activity. Since the personal sense of goals relates directly to the conditions vis-à-vis the subject's consciousness,

the degree of affordance that a PDA exhibits is a measure of the amount and variety of sensory information it presents to the perceiver, the subject.

Analysis of mobile computing therefore begins with an assessment of the technological-deterministic properties of a PDA which, as Kallinikos (2004) puts it, "invites [human] participation along specific paths of action" (p.150). In other words, it is imperative to analyse the role of the PDA's design properties on the range of sensuous information perceived by the user-in-action. This range is further derived from the number of human senses an individual deploys to source information relating to the design properties of the portable artefact. Our aim here is to appreciate the limiting design properties which, in combination with the activity-related parameters, determined the flexibility of computing in the WIL project.

The physical design properties of a PDA mimic an ordinary or simplified tool; and for analysis sake, its internal functionalities are temporarily deliberately overlooked. Thus, at the physical level, the determination of its mobile computing affordances is largely dependent on its isolated external properties that doubtless offer a variety of sensuous information to the perceiving subject. The eyes perceive and receive *visual* information about the size or portability of the PDA and of its few shortcut buttons. For the finger that perceives by feeling those buttons, it receives *tactile* information about their springing properties. The human palm can also perceive and receive tactile information about its portability. Sensuous information about the physical properties of portable computers is mostly visual and tactile; and together they inform the perceiver about the mobility affordances of a portable computer. Thus, it is well known that visually and tangibly, a desktop computer does afford very limited object mobility, but a PDA, due to its relatively small size and weight affords sufficient mobility of object (cf. Urry 2000a). Visual perception informs on the size of the PDA while tactile perception informs on both size and weight.

The internal functionalities of a PDA and the user who performs manipulations of those functionalities are separated by a graphical user interface (GUI) – the images on the computer screen. The GUI is also a consciously designed component of a portable computer, and it comprises of changing texts and images in dynamic proportions and combinations. A PDA's GUI items – such as icons, images, buttons, text, text boxes,

hyperlinks and other animated features – are designed as symbols of semiotic significance necessary for its manipulation and for understanding its output through a variety of possible actions. In their design, these interface items are moulded as much as possible to ease their perceptible affordances, usually through a combination of visual and aural sensuous information. PDAs are designed to allow direct manipulation of their interface items through screen taps with a finger, stylus or any other pointed device. They thus possess information that is perceptible visually and aurally. However, these GUI symbols offer very limited, if any, immediate perceptible affordances. To the uninitiated person, a screen icon or button in itself says very little about its depressible affordance. Usually, these affordances are hidden and false until revealed; first, through the perceptibly afforded action of a stylus, mouse pointer or cursor; then secondly by socio-cultural information, training, previous knowledge and experience.

The third set, the systemic design properties of the PDA – e.g. hardware, software and applications, processors, memory and operating systems – proved to be the most critical and influential of the three design properties in the training project. Compared with desktop or laptop computers, PDAs are characterised by systemic deficiencies such as low processing power, low RAM[26], low memory, low battery power and limited input mechanisms. These deficiencies contributed significantly to the difficulty in the PDA's use for mobile computing in the WIL project. These systemic properties constituted the substrate upon which the custom applications were built, and, together with the strong inscriptions of the project manager which underpinned the custom applications, they contributed significantly to the difficulty of use of the PDAs. For example, it was apparent that the operating system – Microsoft Pocket CE® – disallowed a smooth interoperation with the abcDB and HandBase applications.

Thus while there may have been design errors as well as the imposing demands of WIL conditions that made the use of the PDA difficult, the problem of system interoperability was also directly responsible for the slowness of abcDB, and for the data losing and crashing experiences with HandBase. This means that the systemic

[26] Random Access Memory: The RAM of each of the PDAs deployed in the PSP training project was 64Mb.

properties of the PDA also contribute to the determination of their mobile computing affordances; that is, mobile computing affordances are a function of the ease or difficulty of the mobile device's use depending on its design properties.

It was also evident in the use of the PDA that all of its three design properties require visual, tactile and aural perception to determine its affordances. However, visual perception emerged as the most dominant and pervasive mode of determining the mobile computing affordances of the PDA. The eyes were required to spot and tap the GUI items and to view request results. During the performance of WIL actions, these same eyes were required for peri-operative skills acquisition from their clinical activities. Given that consciousness in the performance of WIL actions and in manipulating a portable computer is a direct function of the engagement of these human senses, the conditions represented by design properties of the PDA, the modalities of human mobility and the strict requirements of the WIL actions resulted in the distribution of the subjects' consciousness between WIL and mobile computing motives. As far as the aims of the WIL project were concerned, these two activities could not co-exist contemporaneously.

From the explanations above, it is clear that transformation of mental images of an artefact's design properties based on direct action and perception – visual, aural or tangible – into affordances was mediated by the consciousness induced in the user through the utilisation of the artefact to support an activity. This mediation occured because, fundamentally, the predominant and pervasive source of direct perception, the eye, is the same sensory organ which is required to manipulate a portable computer and perform actions of an activity simultaneously. Under such conditions, the distribution of the concentration or focus of the eyes between the portable computer and the activity's actions is crucial for determining the affordances of the artefact. In the instance epitomised by the case, where the artefact's systemic properties – interoperability problems, slow applications, many pages to navigate – demanded quite an extensive use of the eyes, the distribution of their concentration would have drifted from the tasks, the actions of the learning activity, towards the artefact.

This problem becomes more acute when the activity demands human mobility because, apart from blind persons, human mobility itself obliges the use of the eyes for manoeuvring around perceived obstacles, even when other actions are being performed. Comparably, manipulating a handheld computer while travelling in a train or bus, or operating a desktop computer is easier because at least one of the factors – mobility – which demand the use of the eyes is removed: a train or bus passenger does not need his or her eyes to move, and desktop computing does not even require human and object mobility.

It is argued, therefore, that the affordance or ease of use of an artefact in an activity is dependent on the number and relative dominance of the conditions that demand the use of the user's eyes. In the WIL case, these conditions were inherent in a combination of the physical, interfacial and systemic design properties of their PDAs, their local mobility, and the strict control over their work or learning actions.

To conclude, any mediating tool, as long as it has a physical presence, will also engage some of the sensory organs of the subject. In activity theoretical parlance, if the use of the tool will serve in achieving learning outcomes, then as much as possible, it has to constitute an operation and not an action nor the activity itself – it has to represent a mediating tool rather than the object of activity. As a mediating tool, its manipulation, due to an appreciation of its affordances that translates into ease of use, will represent a subconscious operation. And the operation will consume a minimal amount of sensory resources, the rest of which can be devoted to the performance of actions. The evidence of the case points to the fact that the problems with the custom applications vis-à-vis the PDAs systemic properties ensured conflicts in actions of the WIL and computing. Let us explore these conflicts in detail.

6.3.2 The Conflicts of Needs and Motives

While the PDA's design affordances contributed significantly towards the difficulty in use in the clinical setting, it never represented the sole factor in that regard. For example, I have argued that there was a split in visual focus between the actions of the central activity and those of computing, in which the focus on computing was finally traded off. The underlying reasons that engendered this trade-off can be traced to the needs and motives of the various activities in which the PSP was involved.

With the generic applications of the PDA, it was not too long before they were mastered. The planning and orientation phase of the use of such generic applications paled significantly. About halfway through the project, those actions were much more fluent and nearly subconscious; and could be deemed to have collapsed into routine operations. The rather quick acquisition of the fluent skill of using the PDA's generic applications is attributable to their desire to fulfil personal needs. These were a group of 12 individual health professionals who, apart from only one who already had a Palm® handheld computer, were complete novices to the overwhelming instrumental functionalities of new handheld and pocket computers. Their first reactions to the PDAs showed their strong enthusiasm to explore and know what it had to offer. Why they never bothered to find out how specifically the PDAs were going to support their learning at the beginning, how they responded to the tutorial about the PDAs generic usage, and how satisfied they had immediately become with the whole project itself reflected their enthusiasm and appetite.

One does not show enthusiasm about any phenomenon unless there has been a hidden *need* for that particular phenomenon that has to be satisfied. Clearly, the PSPs were also aware of contemporary technological advancement and its concomitant manifestations such as powerful desktop computers, the internet and handheld computers, which utilisation represented some of their hidden needs. To them, it was clear that this project had presented a welcome opportunity for them to connect, actively, their needs with these *objects* that satisfy them. At that point the whole fervour to master the use of the PDA's generic functions, based on the tutorials and their previous awareness, constituted an independent stimulating force to direct a new and separate activity. Geisler's (2003) analysis of the relationship between tasks, "task management" and "personal management" attests to the evolution of new personal activities based on the use of Palm Technologies

Why was it an activity? There was the object of some inscribed fascinating functionalities inscribed into the PDA that this activity was directed in order to satisfy their needs. There was a newly developed *motive* to transform the external properties of the PDA into internal knowledge, which co-existed with the motive to acquire pre- and post-surgical care skills. This motive was carried beyond the tutorial: the flurry of

e-mail queries, the degree at which some PSPs had, through their own initiatives, explored and experimented with other applications on the device, and the number of questions I had to answer on these generic applications bear testimony. But gradually, as the skills were being developed and this need was being satisfied, the sharpness of the need and motive was diminishing to assume parity with other goals of the central activity. This activity was relatively very short-lived.

The erstwhile activity had collapsed into conscious actions, guided by goals, and characterised by careful planning and execution. This is the phase where goals such as building contacts lists of work and learning colleagues, scheduling skills learning tasks, sharing typed-in clinical notes via the PDA's infra-red port, and masterfully documenting impending appointments were pursued. During this phase, the goals of the skills learning activity were being integrated with the new goals of using the PDA's generic applications in preparation for more skills learning-oriented purposes (cf. Geisler 2003). This is a demonstration of the *broadening range of actions* of a particular activity.

Later on, most of those consciously planned actions whose problems caused my occasional call-in also collapsed into operations; that is, they became subconscious mastered routines that were executed in response to changing environmental conditions of their skills learning. For instance, while the PSPs exercised some care in inputting contacts, schedules or appointments, and therefore demonstrated some degree of consciousness in the process, the ease and rapidity with which they input text, scrolled pages, and moved in-between different interfaces – tasks that erstwhile required their total attention and were slowly performed – suggested some significant levels of subconscious usage.

When abcDB was designed, its use was expected to represent actions performed in conjunction with other actions within the skills learning activity. Interestingly however, these actions were threatening to degenerate into an activity to co-exist with the other activities. Trying to input a patient's personal details for every action performed on him or her, navigating between the numerous interfaces, and the time-demands that accompanied the slowly running application were threatening to reduce these supposedly simple screen-tapping operations into activities. Unsurprisingly, the

application was rejected and hence those actions – even if they had briefly become dominant activities at some point – could not be sustained. As computing actions strived to degenerate into an activity, they began to compete for the PSP's very motivational resources that drove his or her central activity. When this happened, the focus of attention on the central activity started dividing to accommodate a focus of attention on computing.

When an action degenerates to compete with the very activity that it was meant to constitute, there are two possible outcomes. The subject will, on the one hand, try to accommodate the newly-formed activity with the existing one if both objects serve his or her needs and hence motives; on the other hand, if he or she perceives the object of the new activity as one that will not serve his or her needs, then he or she will do his or her possible best to shirk that activity. The custom applications were manifestations of the needs of the project team's advanced activity while the generic applications directly served the needs of the PSPs. Consequently, the slightest difficulty faced in using the custom applications generated series of complaints from PSPs. Sometimes, one could easily decipher these to see dissatisfied and frustrated PSPs.

From the beginning of the project, the PDAs' deployment symbolised a kind of an unwanted and imposed 'gift' in the eyes of the PSP. The project manager's explanation of why the PDAs were acquired and deployed for the project did not include any empathetic objectives of how the PDA was going to support the PSPs learning. His interests were represented in his one-sided rationale for the PDAs: monitoring, control, coordination and system independence as documented in the project proposal. He admitted the fact that they did not "effectively communicate the long-term training benefits of the PDAs to the PSPs", and therefore the "PSPs did not perceive any direct professional advantages from using PDAs."

PSPs' responses revealed that it was clearly evident they did not know why the PDAs were offered them apart from the association of a new training project with the novelty of modern sophisticated handheld computers. The need for monitoring to give credit to their learning, their qualification and the new professional role were explained to them. While this rationale seemed to have been accepted as quite reasonable for the PDAs deployment, how the PDA was supporting their learning was

not fully grasped. A few of them talked about inputting textual medical information for easy sharing and referencing later. Unfortunately, they neither were able to reference such information on-the-move in their learning nor satisfied that those reasons were sufficient justification for investing in these expensive PDAs.

The conflicting needs of the PSPs and the project team explain why the PSPs reverted to paper-based and Pocket Word-based logging actions – to concentrate their energies on the actions of their central activityies. An object – pre- and post-surgical care skills – clearly answered their needs and their methods of satisfaction, and these needs aroused and directed their central activities. Apparently, to each PSP, there was not an equal need and motive to learn to log actions into a PDA – and therefore no perceived vague object to satisfy the need, no motive, and no activity.

6.3.3 Control and the Politics of Technology Use

Information technology resources and their uses are matters characterised by extreme complexity. IT infrastructure are expensive and their lifeblood – information, its capture, transmission and processing – is no less a complex phenomenon. Although the paperless office, since it was predicted about fifty years ago, has so far proven to be an illusion, it has to be said that ICTs have great potentials for "automating," "informating" and "transformating" phenomena (Zuboff 1988). Modern ICTs have become so pervasive in human activities that the difference between access and non-access is no more trifling. Thus, accessibility to IT resources has grown into a political gaming tool wielded by organisational authorities; and stereotypically, hospital ICT infrastructure are drawn into such acute political games. In most instances, information and computer security constitute the key undertones of the politics of technology use by hospital staff.

For the purposes of ensuring sustained monitoring, control and stability in the distant and distributed learning activities of the PSPs, they were provided with portable computing support. One would have thought that since these PSPs were workers in the same hospitals as the ones in which they trained, the provision of ICT support by their hospitals would be easily and readily forthcoming. On the contrary, and as it was rightly foreseen by the project manager, prevention of access to hospital ICT infrastructure would be one of the surest means by which the project could be

sabotaged. It was envisioned by the project manager – possibly based on his own experience in the medical profession – that hospital ICT infrastructure, based on flimsy security reasons, would be used as political tools to undermine the project's effective monitoring, control and stability, as well as the PSPs' learning efforts. Therefore the portable computers – PDAs – were purported to provide computing support independent of hospital infrastructures; to provide computing support on the move so that critical learning information could be contemporaneously captured; to immediately avail relevant theoretical medical information to the PSPs wherever they would be required; and to manage the huge information that would be generated over the entire learning period.

Nevertheless, most of these aims could not materialise because of several encumbrances within the hospitals in general and the learning process intricacies in particular. The first encumbrance concerned security surrounding wireless connectivity in UK hospital environments. Quite mysteriously, and without any credible scientific evidence, hospital administrators and doctors alike all seem to have settled on the fact that wirelessly connected equipment such as GPRS-activated PDAs, laptops, as well as mobile phones will interfere with biomedical equipment in hospitals. Therefore, even when the project manager was prepared to seek for funds to purchase GPRS jackets for each PDA so that captured information could be e-mailed to the London training centre everyday, he was prevented by this notion. Second, the failure of the technology was directly related to the flexibility and mobility of the learning process itself. As I have explained in the previous section, as far as the surgical practice – the object-activity – was concerned, the surgical team exercised authority and immediate control over the PSPs actions. Therefore, in taking a patient's history or following the team around the wards for instance, the PSP was obliged to follow typical, real actions and not simulated procedures.

Thus, the performance of a typical clinical action such as taking a surgical patient's history could not happen contemporaneously with activity logging. Nor could the PSP, 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 activities. 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.

To be sure, these expositions reveal an irony: the mobility of humans and learning actions were not suitable for the flexibility of computing. In other words, the mobility of humans and the control of their actions did not afford flexible computing. Drawing from this irony, we can also argue that mobility of humans and computers do not necessarily imply flexibility of computing. Based on this, it is imperative for a distinction to be made between purposeful mobility of humans and flexibility of computing. In fact, a 'visitor' is not as mobile as wanderer, thus the 'visitor' can search for a suitable platform and location to manipulate a portable computer: such a scenario allows for greater flexible computing. On the other hand, a wanderer, although highly mobile, does not have the resources to find a suitable platform to compute flexibly.

In terms of the degree of immediate control of the activities which computing is meant to support, a lower degree of immediate control is likely to guarantee the actor a greater degree of flexible computing compared with the scenario characterised by a high degree of immediate control (see Figure 6.5).

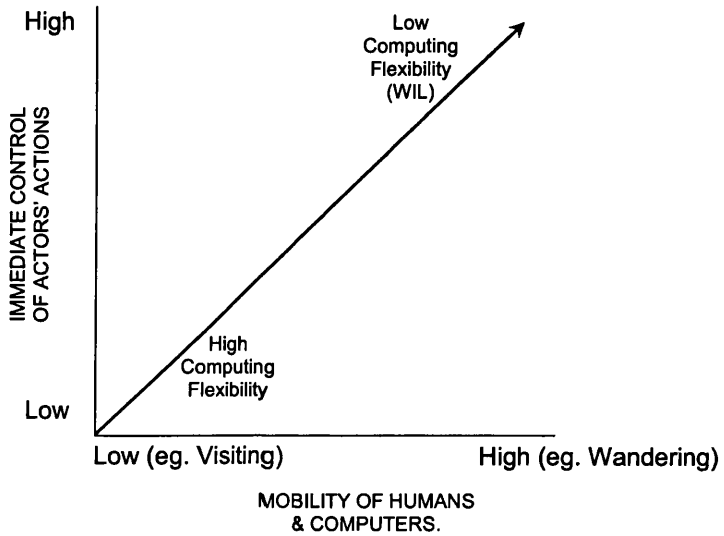


Figure 6.6: Flexibility of computing as a factor of the human mobility and immediate control of actions.

From the model above, mobility, control and flexibility emerge as the most salient parameters surrounding mobile computing in work and learning activities. Flexibility of computing depends on the mobility of humans and objects on the one hand, and the magnitude of immediate control exerted over the actions that computing is meant to support on the other. Stated differently, the more human actions become flexible, the less flexible mobile computing becomes. In short, as far as computing is concerned, mobility of computing does not suggest automatic flexibility of computing; furthermore, it is worth noting, from Figure 6.5 above, that mobility of computing can be flexible or inflexible depending on the magnitude of immediate control exerted on the actions of actors.

An important revelation, therefore, is that the politics of technology and technology use in WIL is not only confined to direct prevention of IT use based on reasons such as security and signal interference; the amount of control wielded by the subjects of the object-activity – of which individual IT users are its "tools" – can be also be used to sabotage flexible computing. Thus, the efforts of the distant project team to control the PSPs' distance learning through flexible computing were easily thwarted by the strong immediate control wielded by members of the surgical team. Thwarting may be advertent or inadvertent: in the sense that immediate authorities may be merely responding to the motivational demands of their activities; at the same time, these actions may be negatively perceived to be stifling the remote control measures of distant authorities. To wit, the 'work' aspect of WIL bore significantly on the 'learning' aspect by introducing a greater level of risk compared with ordinary distance learning. It was the work, the actions of the WIL, which dictated the mobility of the PSPs; and it was the excessive control exerted over the PSPs' actions to work which debilitated flexible mobile computing.

6.4 Mobility of Computing Services

If affordances of mobile computing were lacking in the WIL project, what kind of mobile information services did the PDAs offer? I have argued in this thesis 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. 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 contexts and needs of people induce them to switch motives. Although it has earlier been stressed in this chapter that the design properties of the PDAs offered few affordances, and that mobile computing was inflexible and a failure, it is noteworthy that the PSPs 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.

6.4.1 Ideality and Reconstruction of the PDA

The trajectory of use of the PDA was situated within the PSPs 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 neighbour activity existing alongside the central 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 PSPs 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 ttechnologies. 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 WIL 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 within the use conditions engendered processes of re-construction 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 (cf. Christensen and Bardram 2002). 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 PSPs. Its non-utility in the clinical setting, software problems and data losses together caused its eventual formal rejection in the project. As far as the central activity was concerned, the ideal PDA proved to be false in all three stages of its use. However, the uses of its generic or standard applications 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 PSPs 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 WIL project, this strive for flexibility on the part of PSPs was obvious; and circumstances of low computing flexibility, 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 6.7).

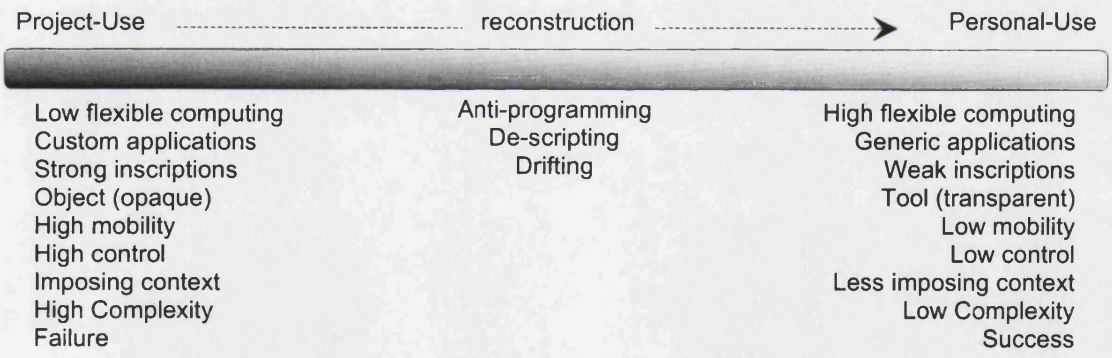


Figure 6.7: Reconstruction of the PDA.

Furthermore, given that these expensive PDAs were acquired purposefully to support the skills acquisition and monitoring aims of the project, and not necessarily to help the trainees manage their contacts, diaries nor schedule tasks, the eventual success-

and-failure of the device is a result of the activity- or context-based interpretation of its design properties.

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 activities 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 peri-operative care skills acquisition towards the assumption of junior doctors' functions, and the aim to satisfy accreditation and acceptability requirements, the pedagogical principle underlying the activities 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 PSPs. 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 activity, the PSPs, on realising the clinical impracticality of such an action, 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 PSPs 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 three different 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 PSPs 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 PSPs' motive to transform it was implicit in its reconstruction into a tool; and its tool perception reflects highly flexible computing which, in the PSPs' 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 PSPs contrary to the originally purported tool function of the WIL activity. To wit, at the collective level of the twelve PSPs, it was clear that the PDA had been socially constructed – personalised at the individual level – into a useful and successful tool.

It is therefore argued that flexible mobile computing correlates directly with the delivery of mobile computing services, and is therefore a resultant of the degrees of *immediate control of actions* and *human mobility* forces that shape an activity. Based on this, the set of conditions of an activity, which determine the flexibility of mobile

computing, must further be the focal point of determining whether an artefact offers any mobile information 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.

6.5 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 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, is properly dissected to depict its constituent levels and their interrelationships between these levels (see Figure 6.8).

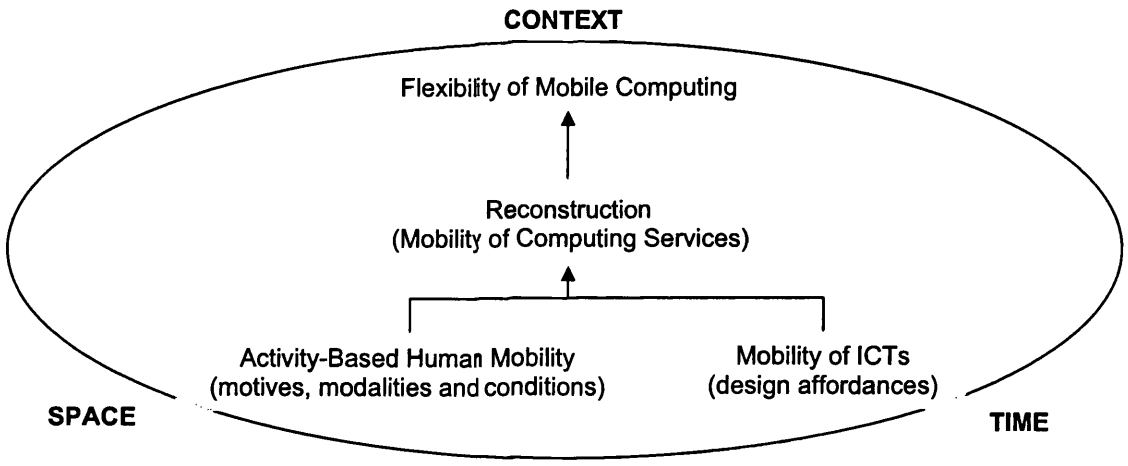


Figure 6.8: Conceptual Framework for the determination of Flexible Computing from Mobility of Humans Activities and ICTs.

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 6.8.

It has already been explained (see Part I of Chapter 2) that human mobility is most fundamental due to the 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 information 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 information 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 information services. Mobile humans carry portable

ICTs to draw on their information 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 objects for supporting mobile activities varies 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 information services that can be obtained from portable ICTs, the flexibility of mobile computing can be deciphered. In the WIL 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 information 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.

Therefore, for the purposes of analysing the utility of portable ICTs in purposeful human activities, the mobility levels presented in the model (Figure 6.8) is valuable. It places the analysis of mobile information services and reconstruction in a pivotal position, brings the complexities and complications associated with portable ICT use

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. It is in the analysis of the mobile computing services – 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 flexible mobile computing. This is the most effective way of informing the design of portable ICTs for mobilising human activities.

6.5.1 Conclusion: A Paradox?

In contemporary times, the traditional modes and ways of living and working have experienced considerable degrees of mobilization and distribution. This is not merely a resultant of the emergence of portable ICTs: in addition, the revolutionary advancement in ICTs – including their miniaturization – and the demands of the new knowledge economy have spawned significant increases in the movement of humans and hence their activities (Urry 2000a, 2000b). Mobility has therefore assumed a household-name status recently. At this level, although it is a popular catchphrase, it is still regarded as a generic phenomenon – as demonstrated in its definition by terms such as state, ability and quality of being mobile. The problem with such a definition or such vocabulary is that they isolate mobile phenomena for description, as exemplified by phrases such as object mobility, mobility of symbols, interaction mobility and human mobility. However, it is well known that mobility of phenomena – for example, humans, objects, symbols, information and activities – cannot be cheaply isolated from one another if we want to analyse properly and extend our knowledge of the concept. In almost all instances, the mobility of some of them depends on the mobility of others; as purposeful mobile computing depends on the mobility of activities, computers, symbols, and humans. In short, mobility is a more encompassing issue comprising an interwoven, interdependent and interacting set of mobile phenomena.

To this end, the fact that not much research attention has been paid to the finer details or degrees of mobility of ICTs is strange. Strange that problems about the mobility of humans, their activities and ICTs are approached mostly from an oversimplified

viewpoint of mobility as granted. Strange that nearly all mobility research attempts overlook the significant differences between various degrees of human mobility (a notable exception is Kristoffersen and Ljungberg 2000). Strange that even at this level, mobile computing is also often superficially and simplistically isolated from human activities and the degrees of mobility they entail.

As far as human motives and activities are concerned, we cannot simply presume that mobility of humans equates computing flexibility. As far as portable computers are concerned, while the understanding of their mobility is hinged on ability, state and quality of movement, the understanding of their computing flexibility is founded on efficacy in satisfying human motives and positively transforming the corresponding activities. The analysis in this chapter has proven that human mobility and computing flexibility are paradoxical in the sense that a high degree of mobility of humans and computers as a result of motives effectively reduces the flexibility of mobile computing, and vice versa. Stated differently, increasing human mobility reverses computing flexibility.

By these arguments, I am not implying a limitless interpretive flexibility of portable computers or a complete rejection of their determining design properties. I have argued in this chapter that mobile computing affordances of PDAs, for example, are largely determined by their imposing design properties. However, it has to be stressed that within the bounds of these imposing design properties, interpretive flexibility prevails along a continuum that ranges from high to low flexible mobile computing. Flexible computing in this sense is not a direct derivative of the determining design properties of the artefact; rather, it is directly related to the conditions of human activities most notably human mobility and the magnitude of immediate control exerted over users' actions. Stated differently, it is true that a poorly designed customised application on a PDA can result in or determine users' inflexible computing even in less mobile and less imposing conditions; however, just as the "good" standard applications proved in the project, their use required less imposing and less mobile conditions.

In short, portable ICTs and the mobilisation of activities render mobile computing an extremely complex issue; complex because it entails an interplay of decisive

parameters such as mobility, distance, control, monitoring, trust and power among stakeholders who have different dominant motives. Its analysis therefore has to integrate such parameters, first, as a viable means to properly plan the adoption and deployment of portable computers to support distant activities; second, as a means of identifying emerging problems confronting users of these computers; and third, as a means of ascertaining the requirements for custom applications development in such computers.

6.6 Chapter Summary

The analysis of the WIL empirical study in this chapter has been an attempt to explicate the intricacies that characterise contemporary mobility of humans, activities and computers. First the central/WIL activity was examined in relation to other stakeholders' activities pointing to the contradictory motives and outcomes which impacted on the central activity. Within this, the significance of distance, mobility and distribution of learners was also analysed. This led to the identification of the political forces and conditions which affected both technology use and the very actions of the WIL activity. The design properties of PDAs were also scrutinised to lay out their determining properties and the levels of computing affordances they exhibit. Based on these, the kind of computing services which were derived from the PDA were examined as a means of portraying the reconstruction and interpretive flexible efforts of the users.

Based on these, vis-à-vis the purposes of this study, it became necessary to reconceptualise portable ICTs within the context of mobility leading to the proposition of a conceptual model depicting the relationship between mobility of human activities and flexibility of mobile computing. The result has been a delineation of conceptual model of three analytical levels of mobility within which the impact or utility of portable ICTs can be appropriately analysed. The model argues that the evaluation of portable ICTs in mobile activities must not be isolated; evaluation must rather be informed by an insight into the portable ICTs' design affordances, the motives that engender their uses, and the modalities of mobility exhibited by users.

The analysis concludes with discussions on the paradoxical relationships between human mobility and flexible computing.

Together, the analysis has teased out the key challenges confronting this research endeavour – mobility, distance, distribution, learning, monitoring, power, control, motives and mobile computing. The amalgamation of these issues in one activity exemplifies and reflects the changing nature of how we live and work in contemporary times. In other words, activities are continuously being mobilised and distributed, and the challenge to build upon existing activity theoretical models to match contemporary portable ICT-mediated activities is imperative. This challenge is the preoccupation of discussions in the next chapter.

Chapter 7: Problems of a Remotely-Distributed Activity

7.1 The Problem

The analysis of the case in the previous chapter elucidated the interrelationships between components that characterise the relationship between mobility of computing and WIL, leading to arguments which provide answers to problems concerning mobile computing. The understanding of these interrelationships was sought from an activity-theoretical perspective, a perspective which proffers principles underlying the psychology of human development. To this end, much of the arguments forwarded in the previous chapters have concentrated on the narrative and the concrete – on the particular case study presented in Chapter 5. Within this narrative, the following key parameters – mobility, distance, distribution, learning, work, control and mobile computing – have emerged as phenomena which reflect the changing nature of contemporary work and learning.

One key conclusion that emerged from the analysis was the fact that flexible computing is dependent on two key factors: the degree of immediate control wielded by authorities over individuals' actions on the one hand, and the degree of local mobility exhibited by these individuals on the other. While this conclusion enlightens us on the reasons why computing failed in the WIL activity, it spawns further questions about how controlling powers are achieved and wielded by authorities, how the control of individuals' actions can stifle flexible computing, and crucially, how the distribution of the learning activity influenced the distribution of control over learners' actions between the two motives associated with the two locations. These questions about distribution have not yet been addressed in the literature: In short, the impact of the distribution of an activity in relation to the problem of technology use is, so far, a formidable problem yet to be surmounted satisfactorily.

There have been many attempts to tackle this overwhelming problem of distribution of activities. The most notable attempt is conspicuously witnessed in the popular phrase of Olson and Olson (2000) – "Distance Matters". In their critique of Frances

Cairncross's "The Death of Distance" (1997), they rightly argued that indeed distance does matter, it "is not only alive and well, it is in several essential respects immortal" (Olson and Olson 2000, p.141). They proceeded to substantiate their critique with evidence of cooperation, coordination and collaboration problems of communication induced by groupware-assisted distribution of activities. Other CSCW[27] researchers have made similar attempts, however, just like Olson and Olson, their efforts have been concentrated on the same communication problems without deeply looking into the dynamics of technology use in distributed activities.

Another attempt is also witnessed in Wiberg and Ljungerg's (2001) critique of Kleinrock's (1996) "anytime anywhere" notion of mobile computing. Using time and place as the dimensions and "same" and "different" as the parameters under each of these dimensions, Wiberg and Ljungberg described four scenarios of interaction and used them to conclude that computing can occur anytime, anywhere but not necessarily "everytime everywhere". Although their conclusion related to computing, their arguments were founded on remote interactions with portable ICTs. In other words, their arguments only provided superficial expositions of computing in "different places", similar to many other publications on portable ICTs.

Engeström's (1987) thesis on "expansive learning" comes close to tackling the problems of distribution. His explications of contradictions in related activities – "neighbour activities" – of a central activity shows the rich interrelationships which shape the consciousness of the individual. Indeed contradictions were the premises upon which he developed his thesis on "developmental research". He went beyond Leont'ev's static model of activity to richly espouse the potential relationship between an individual's central activity and other associated activities. Moreover, he placed human activities within the context of other interrelated activities, and further argued that the problems in human activities must be sought within the contradictions between these interrelated activities (see Figure 4.5). However, while his expositions put activities into context, their inadequacy lie in his lack of differentiation between localised and distributed activities. Such an omission undermines any meaningful efforts to study the contradictions inherent in contemporary remotely-distributed

[27] Computer-Supported Cooperative Work.

activities, especially given current technological advancements that have immensely reduced, but not eliminated, distance and time barriers in communication, collaboration and coordination. In this respect, it is necessary to transcend existing conceptualisations of contradictions in localised activities to tease out the nature of contradictions in distributed activities.

To this end, the problem of the impact of remote distribution on the actions of an activity cannot be considered satisfactorily resolved, despite several illuminating attempts. The problem is as contemporary as it is challenging, in the sense that its technological deterministic facet has been recently empowered by current technological advancements. The problem is not only here to stay, it is indeed likely to unfurl into multiple complex variations.

This state of affairs translates into a considerable challenge to build upon the existing principles of activity theory to enhance our understanding of remotely-distributed activities. There is a craving for new knowledge and understanding on the relationship between distributed activities and portable technology use. Moreover, in terms of the aim of this dissertation, there is a need to proceed from narrative to paradigmatic arguments, from concrete to abstract deliberations, and from particular to general submissions about distributed activities and computing. This challenge is the foundation for the theoretical discussions in this chapter.

I begin in Section 7.2 with a comparative discussion of localised and remotely-distributed activities to outlay the uniqueness and significance of distance and distribution in an activity. These discussions remain grounded in the established principles of Activity Theory (Leont'ev 1978, 1982, Engeström 1987) that are used to depict the significance of a distributed activity. In these discussions, the key distinction between localised and distributed activities that emerges is contradictions between the motives of advanced and central activities, which in the instance of distributed activities, are remotely separated. In Section 7.3, the strength of these contradictions are analysed in relation to the extent to which the distant authority may be co-present in his or her exertion of control. This analysis results in a control framework which shows four possible control environments under which individual workers or learners can find themselves performing actions. Next, in Section 7.4,

these control environments are further analysed in relation to the flexible computing model to portray the key implications for flexible computing in a distributed activity. This eventually leads to the examination of the possibility of flexible mobile computing in Section 7.5., and concludes with key suggestions for analysis of computing in a distributed activity. Finally, Section 7.6 presents a summary of the key arguments and propositions.

7.2 The Significance of Distance and Distribution in Activity

First and foremost, I want to emphasise and draw readers' attention to the fact that the trajectory of any individual's development is replete with his or her multiple activities and associated motives in varying degrees of contradictions and relationships. What becomes the "leading motive" (Leont'ev 1982) for an individual is dependent on several conditions which cause his or her multiple motives to drift. Leont'ev's explanations of contradictions rendered the concept a fundamental trait of consciousness:

> "... a closer examination of the general picture of man's life in a capitalist society brings out not only its dual character but also its inner contradictoriness. (...) [they] are usually called contradictions of consciousness and sometimes, more expressively, torments of consciousness." (*Ibid.*, p.258).

Engeström built upon Leont'ev's idea and concluded that "internal contradictions find their outward expressions in external ones" (Engeström 1987). To Engeström, both internal and external contradictions are fundamental in human activities; and they are even more pronounced in sanctioned activities such as work and learning. Inspired by Bateson's (1972) concept of "double bind", he coined the phrase "double nature" to refer to the inner-contradiction that manifests in contradictions of each element of the central activity. He called this the primary contradiction that implies that it is the first form of contradiction that leads to other forms; that is, the secondary, tertiary and quaternary contradictions that follow.

However, based on my analysis of the WIL case, I have argued otherwise: I have contended that the contradictions between the motives of the central (or leading) and neighbour activities, and hence between individual subjects and their authorities – instructors, bosses, organisations, and society – are rather primary. Primary contradictions lead to the 'double nature', inner-contradictions that signify the intra-

psychological or consciousness facet of an activity. This distinction or clarification is important because it directly relates to the age-old psychological problem of the origin of consciousness that dominated arguments between Vygotsky and Piaget in the 1930s. The activity-based understanding of the origin of consciousness, based on Vygotsky's and Leont'ev's expositions, suggest that

> "consciousness owes its origin to the identification in the course of labour of actions whose cognitive results are abstracted from the living whole of human activity and idealised in the form of linguistic meanings. As they are communicated, they become part of the consciousness of individuals." (Leont'ev 1978).

"Interiorisation" is the term which Leont'ev used to describe the process of consciousness generation in an individual. Upon this, it is important to note that contradictions implicitly concern the persistent struggle between individuals and society[28]: its origins are found in the conflict between the motives of learner's/worker's central activity and those of the instructor's/authority's advanced activity. This inter-contradiction further and necessarily generates the intra-contradictions – inner contradictions – within the individual's central activity or cognitive frame. By implication, the individual is eventually defined by a double identity in production. In learning, he or she is a subject of his or her central activity and an object of the advanced activity of the instructor; in work, he or she is a subject of his or her central activity and a tool of the object activity.

As I have already explained in Chapter 4, contradictions are direct resultants of the personal sense-making of objective meanings in the consciousness of the individual subject. These objective meanings are associated with the goals of actions, but it is the conditions within which these actions are performed that engender personal sense-making or subjectivisation of objective meanings on the plane of consciousness. In effect, it is the conditions surrounding an activity and their dynamics which engender both inner and outer contradictions. These conditions are defined by their "social variables" (Bijker 2001); in this regard, contradictions owe their existence to a high magnitude of social determinism (cf. Leont'ev 1982). Since the remote distribution of an activity is inherently an essential condition, its significance can be found on its impact on contradictions, among other principles and parameters, within activities –

[28] In this context, I use 'society' to refer to entities such as instructors, bosses, authorities, managers who champion the motives of advanced activities within which individual subjects' actions are subordinated.

work and learning activities in particular. Furthermore, since the social variables characteristic of localised activities are significantly different from those of distributed activities, we must expect the nature of contradictions generated in distributed activities to differ.

Our first obligation, therefore, is to explore the differences in contradictory characteristics between localised and distributed activities. It calls for a spelling out of the critical differences between the motives and contradictions which shape the actions of a localised activity and those which shape the actions of a distributed activity. Localised activities are performed in a contained or defined area where distance between individual subjects is insignificant, and where the instructor or authority is co-present within the area. Examples can be found in traditional classroom and office settings. Conversely, in distributed activities, the subjects are distributed in diverse and remote locations and, in most instances, the distribution is defined in relation to one particular location where the subjects converge or report to account to an authority (see a typical example in Wiberg and Ljungberg 2001).

7.2.1 The Contradictory Nature of a Localised Activity

Both localised work and learning are characterised by the proximity of individual subjects in production in a localised area, but their uniqueness lie in the relationship between the central, advanced and object activities. In the sense of this relationship, there are considerable differences between work and learning, which reflects in the kind of contradictions dominant in these activities.

In learning activity, the dominant motive is subject production – the cognitive transformation of the learners. It is characterised mainly by a contradiction between the central motives of the learners and the advanced motives of the instructors. These motives may be entirely different and even conflicting: for example, in the classroom, the learner whose motive of school-going is to meet with friends to play will always be in conflict with the instructor whose culturally advanced motive is the cognitive transformation of the learner. To be fair, this form of contradiction is a feature of the early stages of human ontogenesis, when the child's mind is predominated by play. In later stages, when adulthood is reached, studying replaces playing and learners tend to understand the culturally advanced motive as acceptable (Engeström 1987) or "only

understandable" (Leont'ev 1982). The WIL case exemplifies this understanding that resulted in the adoption of the motives of the advanced activity by the learners. It has to be said, however, that in the typical learning setting, the essential inner-contradiction is a direct attribute of the identity of the learner: the learner identifies him- or herself as the subject of learning while the instructor identifies him- or her as a part of the objects to be transformed. This follows from the fact that while both parties potentially share the same outcome, their objects and motives may be entirely different or, at worst, conflicting (see Figure 7.1).

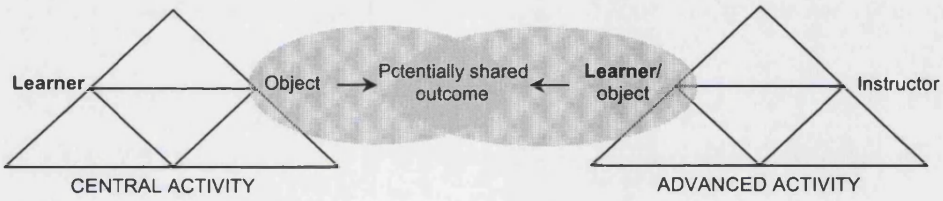


Figure 7.1: Learning Activity depicting the differences in motives and the dual identity of the learner.

The potentially shared outcome contains the "double nature" (Engeström 1987) contradiction of the value of the outcome. For example, is the outcome – the skilled individual – conceived to be an instrument or success demanded by the object activity or an instrument of learning content mastery? An instrument of content mastery signifies a product of primary use-value, while an instrument of success signifies a commodity of exchange-value in addition to the primary use-value. This double nature of the outcome or product of learning activity constitutes the consciously reflected image which must "exist for the subject in such a way that he can act with this image – modify it according to the conditions at hand" (Leont'ev 1978). In other words, the image of the outcome, including its double nature, determines the will, consciousness and the personal-sense made of the transformative learning actions.

In this form of localised learning, there are two possible scenarios: On the one hand, both the learner and instructor are immersed in the object activity within which the learning object is embedded, as typified in workplace learning or on-the-job learning. On the other hand, the object activity may be removed from the localised setting leaving the learner to learn with either a mental image of the real object or its representation (see Il'enkov 1974). The latter scenario is exemplified in learning

through experiments and simulations. In the instance where all three activities feature co-presently in the learning activity, the object and advanced activities are almost merged into one: the instructor remains the subject, and the learner and the learning object are his objects. The only difference here is that the erstwhile learning image or object representation becomes the real object. The significance of this merger of object and advanced activities is in the fact that the learner remains under the tutelage of the same instructor, and this is important as far as the control of learning actions is concerned.

In localised work, the relationship is rather dominated by a contradiction between the motives of the central activities of workers and the advanced activities of the authorities of the organisation. Unlike learning activities in which the cognitive transformation of learners reigns as paramount, work activities are oriented towards object production. For example, the instructor in a learning activity is motivated by transforming his or her objects, the learners, into skilled products. His work, however, obtains its objective basis in the wider context of his or her institution or on the principles of the discipline that his or her instructions are founded. The economics of human labour (e.g. Marx 1909) suggest that human labour is fundamentally a subsidiary aspect of the entire societal production; it is aimed at exchange, distribution and consumption in society. Societal production is objective because outcomes of activities are ultimately aimed at exchange, distribution and consumption necessarily by society and not by the producers. In collective work, for instance, the owners of the work capital are motivated by societal production that fulfils their capital accumulation needs, and also represents an advanced motive compared with the central motives of the workers. Stated differently, human labour or activities are always subordinated to the motives of an advanced motive.

The actions of a worker, although subordinated to others' advanced motives, are also ultimately aimed at satisfying his or her immediate needs; this is where the motives of his or her central activity are directed; and this constitutes the fundamental contradiction of motives in work. Leont"ev's famous illustration of the primitive hunt elucidates this fundamental contradiction:

> "A beater, for example, taking part in a primeval collective hunt, was stimulated by a need for food or, perhaps, by a need for clothing, which the skin of the dead animal

would meet for him. At what, however, was his activity directly aimed? It may have been directed, for example, at frightening a herd of animals and sending them toward other hunters, hiding in ambush. That, properly speaking, is what should be the result of the activity of this man. And the activity of this individual member of the hunt ends with that. The rest is completed by the other members. This result, i.e., the frightening of game, etc., understandably does not in itself, and may not, lead to satisfaction of the beater's need for food, or the skin of the animal. What the processes of his activity were directed to did not, consequently, coincide with what stimulated them, i.e., did not coincide with the motive of his activity; the two were divided from one another in this instance." (1982, p.210).

This division portrays the fundamental contradiction in work – contradiction between the individual worker's central motive and the advanced motive of the authorities of the organisation which employs him or her. Again, the most extreme form of this contradiction reflects in the identity of the worker – a subject of his central activity and a tool of the imposing advanced activity. In a typical work setting, since the worker is directly involved in the object activity, his central and the object activity systems possess the same elements, although the motives of object transformation may also be contradictory (see Figure 7.2).

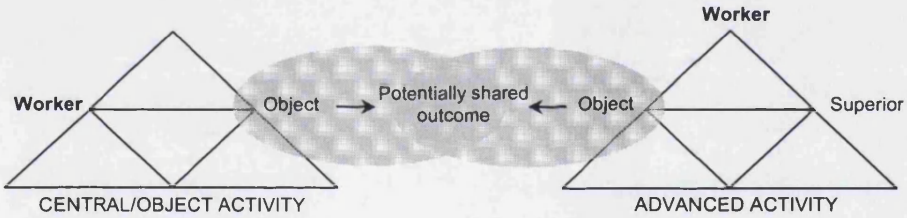


Figure 7.2: Work Activity depicting the differences in motives and the dual identity of the worker.

The significance of these clarifications lies in the fact that localised activities are always characterised by "double nature" contradictions. The actor's – learner or worker – central motive potentially conflicts with or is subordinated by an advanced motive. Therefore, the localisation of activities is necessarily characterised by the actor's disposition between individual motives and the immediate organisational motives represented by the advanced motive. This translates into a direct unmediated relationship between primary (external contradictions) and inner contradictions (see Figure 7.3a). This unmediated relationship directly bears on the "double" sense-making of actions of workers or learners.

7.2.2 The Metacontradictory Nature of a Distributed Activity

Compared with localised activities, a distributed activity is one which is performed in at least two remotely separated locations, and in which the worker/learner typically acts in one location away from authorities or instructors in the other. The distance between these the worker/learner and the instructor introduce new problems of remote control, coordination and cooperation into the activity; but at the same time, distributed activities hold promise for efficiency gains especially when modern ICTs are deployed to overcome distance and time barriers. Distance learning and remote work are new commonplace expressions used to describe contemporary distribution of human activities. A distributed activity necessarily increases the level of human mobility, as actors usually oscillate in-between two locations at least, and within one location as actions demand. The WIL case is an epitome of this form of distribution.

In a purposeful distributed activity – learning or work – the actor may perform two sets of localised actions, and this departs significantly from unitary localised activities in the sense that one authority or instructor can be co-present in only one localised area at any one time. In this respect, the actions that may count towards the same activity may be performed under different authorities and instructors from one location to another, as we beheld in the distant actions of the PSPs. Consequently, the individual may receive instructions from different authorities whose motives are contradictory. In short, the remote distribution of actions may complicate the contradictions associated with localised activities because of the likelihood of additional external contradictions between the motives of authorities in different locations.

Both learning and work activities exhibit similar characteristics when distribution becomes a factor in terms of the location of subjects and objects. For example, in distance learning, the subject, learning with either the real object or its representation is accountable to the instructor at some point but the immediacy of his or her environment may induce other contradictions into his or her activity. How, for instance, does he or she reconcile the learning activity with other immediate activities in the absence of the distant instructor? Distributed work is also confronted with a similar problem: the transformation of the work object usually occurs in a one location under an immediate authority whose motives may contradict those of the

distant authority. Furthermore, work and learning are similar on the grounds that in nearly all instances, individuals' actions in a distant location represent their separation from their authorities/instructors who hold the advanced motives of the distributed activity.

The first necessary upshot is that the distribution of activities induces further contradictions from other immediate dominant activities into the frame of the individual's actions. In understanding what happens when an individual contributes his or her actions to the advanced motive from a distant location, it is important to realise that the central activity of the actor may not necessarily occur in objective circumstances. For example, in contemporary distance learning, it is possible for one to conceive a learner who performs his or her central activity with computer-aided simulations and other representations of the learning object. In such an instance, the object activity is as removed from the central activity as it is with classroom-based learners.

Thus, although in most instances, the sense behind the distribution of an activity is to immediately avail the object activity to workers or learners at a distance, it is not always the case. However, even if it is not the case, the motives of the central activity are likely to contradict with the motives of any immediate activity. One considerable certainty is that since the central motive is derived from the personal sense-making of the subject, it is an intrinsic part of him or her. Thus, the advanced and object activities may remain localised and static in distributed activities, but the central activity, and hence motive, is always mobile and dynamic in response to the conditions encountered by the subject in time and space.

It must be said, however, that these scenarios above do not hold as much challenge for understanding the problems of a distributed activity as the one in which the distant learner is immersed in the object activity for practical learning or work purposes. Much of the following deliberations will therefore centre on the scenario of a distributed activity in which the distant actor is immersed in the object activity. Here, the similarity of contradictions within the subjective and objective motives of work and learning may persist and shape the actions, but the key difference remains: that is, learners begin at the periphery of the object activity compared with workers in the

core. But the difference is not as crucial as one other similarity; that is, in both distributed work and learning, efficiency dictates that the individual mainly participates in the object activity away from their distant authorities who champion the advanced motive of the distributed activity.

A third form of distributed activity appears in a hybridisation of the two extremes: work-integrated learning (WIL), experiential learning (Kolb 1984), and learning-at-work are some of its popular epithets. While these appellations depict the hybridisation, they do not sufficiently enlighten us on the impact of the distance factor. This hybrid is exemplified by the empirical case presented in Chapter 5 – learning within the object activity. The perfect instance of WIL occurs when the performances of all three activities – central, advanced and object – coincide in one location. The unity of these activities does not suggest contradiction-free actions; rather, production is subjected to a triple-nature contradiction of identity of the learner or worker. He or she identifies him- or herself as the subject of his or her central activity; he or she is identified as an object of the advanced activity by its subjects; and he or she may be identified as a tool of the object activity also by its subjects. The tool perception is key because its total reverse is full acceptance and integration into the object activity as a subject.

Distance and distribution rips apart the unity of these activities leading to a geographical separation of advanced and central activities; by implication, remote separation of learner/worker and instructor/authority. In learning, the ultimate motive is for the learner to be integrated into the object activity, leading to educational strategies which place premium on the practical aspects of learning. In addition, contemporary advancement in ICTs has greatly reduced distance and time barriers by enhancing communication, collaboration and coordination among distributed workers and among learners and instructors. These are some of the key drivers of contemporary distribution of sanctioned human activities. And within the context of earlier arguments made in this thesis, it is the nature of contradictions associated with distribution of an activity which determine the kind and range of possible actions performed by individuals in any location.

The range of possible actions is a direct result of the magnitude of control wielded by immediate authorities – if there happens to be any – in the location where an individual finds him- or herself performing remote actions of a distributed activity. In the absence of an immediate authority, the individual assumes that role; which implies that his or her central activity is likely to equate his or her object activity. For this reason, it is interesting to examine the contradictions generated by the immediate dominant motives associated with each location of a distributed activity.

The problem of contradictions in distributed activities is more complicated compared with localised activities. The individual actor is confronted with the challenges of his or her immediate environment, and at the same time with the distant advanced activities of authorities or instructors to which they have to align their actions. Essentially, the contradiction between the motives of an individual's central activity and the imposing advanced activity remains primary, even though they may be geographically separated. However, another primary contradiction is established in the individual's localised environment between his or her central activity and the immediate object activity. In other words, at a distance, and in the likely absence of the authority, there may be a contradiction between the worker's central activity and other immediate neighbour activities; the latter form of contradiction is characteristic of any localised activity. In addition to these, and more crucially, there may be another contradiction established between the motives of the authorities who control the localised object activity and the distant advanced activity (see Figure 7.3b).

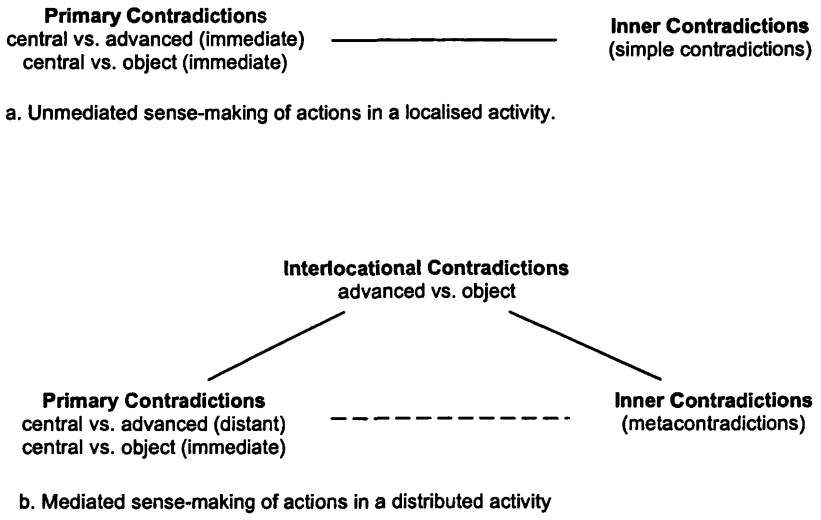


Figure 7.3: Structures of contradictions depicting mediation by interlocational contradictions in distributed activities.

It is important to note again that these two primary forms of contradictions ultimately translate into inner-contradictions in the consciousness of the learner or worker, but their interconnection is determined by the nature of the contradictions between the motives of the advanced and object activities. Although these contradictions are external from the point of view of the individual, they bear directly and continuously reshape the primary contradictions confronting the individual; that is, they mediate the central/advanced primary contradictions and the consequent inner contradictions. This continuous reshaping is a result of the power relations between the agents of the object and advanced activities, which translate into the types and range of actions the individual subject will or is allowed to perform in a distant location. If we come to think of the fact that the contradictions between the object and advanced activity reshape the primary contradictions of the individual, then it can be argued that the newly formed inner contradictions would be *metacontradictions* – contradictions of contradictions between the motives of the object and advanced activities. What would therefore abound in distributed activities are metacontradictions between the contradictions associated with the central and advanced motives on the one hand, and those associated with the central and object motives on the other hand, one set affecting the other.

The corollary is the impact on the identity, or perceived identity, of the individual in production within the immediate object activity. The individual's participation in the object activity provides him or her with a tool- or subject-identity depending on his or her degree of "social participation" (Wenger 1998) in the practice of the community of members of the object activity. For a learner, at the outset, he or she is usually a peripheral participant whose ultimate motive is the attainment of an exchange-value identity. However, peripheral participation is usually associated with undertones of non-acceptance, conformity, subjugation and being perceived as a tool by core community members. Successful participation signifies the construction of an exchange-value identity which necessitates a progression from peripheral to core membership, from use-value to exchange-value identity, from a tool of the object activity to its subject. In work, progression from peripheral to core membership is a movement from being perceived as an object to being perceived as a subject of production. Now these progressions are not givens, nor are they smooth. They potentially entail irritable problems of power, politics, control, resistance with which the learner or worker has to grapple in the process (cf. Star 1991). To wit, the individual's participatory actions are likely to be dictated, determined and controlled by subjects of the object activity – the core participants of the community.

The modes of belonging to a community, according to Wenger (1998), manifest in members' engagement in the negotiation of meanings, imagination of broader perspectives, and alignment of their energies, "activities, and interpretation of events with structures, forces and purposes beyond their community of practice" (*Ibid.*). Given the reality that both learners and workers remain accountable to their instructors and authorities, their participation in and hence alignment with the immediate object activity demands occurs concurrently with their alignment with the requirements of the distant advanced activity. In other words, individuals are bound to satisfy requirements of objective and advanced motives at the same time. This scenario creates another "double bind", but a double bind of secondary nature; that is, a double bind of double binds, which mirrors the metacontradictory nature of a distributed activity.

To conclude, it is necessary to note that one essential and distinguishing feature of a distributed activity is its immediate impact on individuals' actions. The primary

contradictions of a localised activity directly affect the psyche of an individual subject leading to his or her personal sense-making and subjectivisation of objective circumstances. In contrast, the primary contradictions of a distributed activity indirectly affect the psyche of the individual; they are mediated by interlocational contradictions between object and advanced motives. These mediating interlocational contradictions are functions of parameters such as power, control and other political motives of authorities concerned.

The individual's experience of multiple identities as a result of the distribution of an activity is interesting; however, this provides us with little insights into the understanding of his or her actions in a distributed activity. The issues that hold promise in leading us to a proper understanding of the actions of a distributed activity are the mediating factors; that is, the contradictions between the motives of the object and advanced activities. In effect, the relevance of the exposition of metacontradictions lies, not in its essence, but in its immediate source – the contradiction between the motives of the object and advanced activities. This source harbours a complex array of power interrelations within which explications of the magnitude of immediate or remote control of individuals' actions can be directly sourced. What is most interesting, therefore, is an exposition of the how these mediating factors shape the actions, and hence sense of actions, of the individual in a distributed activity.

7.3 Contradictions and the Control of Distributed Actions

In discussing power, control and actions of workers or learners, we may draw from Foucault's (1980) claim that the manifestations of the exercise of power are actions. And although the actions of a localised activity potentially entail contradictions engendered by the motives and personal sense-making of the individual, they are generally dictated by the locational sanctions imposed by those who wield power and authority. The localised nature of these actions ensures that controlling attributes such as direct supervision and observation of individuals' actions are closely knit together in an activity. The most significant aspect of this close knitting is that these actions are conducted under a singular source of control, under the direct control of the immediate authorities who sanction those actions.

In contrast, the actions of a distributed activity are likely to be conducted under multiple sources of control; and the degrees of control attributable to the advanced and/or objective requirements are variable. Note that although sources of control may be multiple, they can be divided into immediate and remote from the point of view of the individual worker or learner. The actions of a distributed activity may differ from one location to another due of the different contexts associated with each location; and at any one location at any time, both immediate and distant authorities may control individuals' actions. Note also that whether these forms of control – remote and immediate – are contradictory or not, and if contradictory, what degree of contradiction translates into control of actions, will depend on the degree of contradictions between the advanced and objective motives.

Therefore, control by authorities is a variant lying within a continuum from weak to strong. At any one location, the individual's actions are subjected to two sources of control – to the instructions and alignment demands of the immediate local motives on the one hand, and to the motives of the distant authority on the other hand. The variation in control of actions is directly related to the degree of conflict of motives between two authorities which is likely to translate into a power struggle between them. However, the most critical facet of this struggle is the degrees of co-presence of both authorities in relation to the location of the individual subject.

The strength of control of individuals' immediate actions is directly related to the relative co-presence of the distant authority. The distant authority's co-presence is, just like the contradictions, also a weak-to-strong continuous variable. His or her strongest co-presence is demonstrated by his or her personal proximity to the actions of individuals; but this form of co-presenting, is almost an impossible or at most an inefficient task for distant authorities. Quite realistically, co-presenting can be achieved by frequent visits to monitor individuals' actions; however, this will demand a lot of time, financial and energy resources. Thanks to modern ICT advancement, co-presenting can be achieved through inscription of authorities' instructions and control mechanisms into computer applications and software. Furthermore, modern ICT advancement has introduced miniature versions of desktop computers which portability ensures that controlling inscriptions can be carried from one location to another. We clearly witnessed the inscription of control mechanisms of the project

leader into PDAs with the aim of establishing a mediated form of co-presence from a distance. Although, going by the Media Richness arguments of Daft and Lengel (1984, 1986) and the Social Presence arguments of Short *et. al.* (1976), the strongest inscriptions of an authority's instructions can never be equated to his or her physical co-presence, their impact on actions can be very significant. Inscriptions can also be weak, and this also has significant implications as far as the control of actions are concerned. Altogether, the balance of actions control is a function of the strengths of co-presence and contradictions between the motives of the local and distant activities (see Figure 7.4).

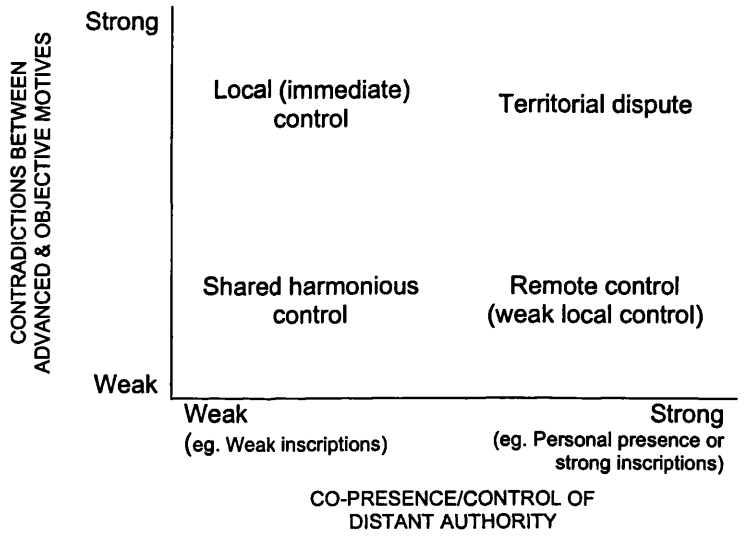


Figure 7.4: Control categories as factors of the strength of contradictions and co-presence of distant authority.

Strong contradictions are consequences of strong opposing motives of local and distant activities. They manifest when the distant advanced motives are not perceived to serve the outcome of the object activity or vice versa; the extreme version of this scenario is, however, a rarity. In most instances, the object activity represents an integral aspect of the entire activity; and although the selfish personal interests of the subjects of the object and advanced activities may conflict, the unified motive of the distributed activity is always the reference point for resolving such conflicts. This

implies that *territorial disputes*, as a combination of strong contradictions and a strong co-presence of a distant authority, are very seldom occurrences. Their seldom occurrence does not mean their emergence must be overlooked. In fact, if there is one reason that accounts for organisational political problems, then it is territorial disputes that emerge due to lack of clarity of control regulations. What individuals have to do, what they may do, or what they must not do become issues shrouded in politics and uncertainty. From the perspective of the individual worker or learner, his or her actions would reflect a typical "double bind" (Bateson 1972) situation. "In double bind situations, the individual, involved in an intense relationship, receives two messages or commands which deny each other ..." (Engeström 1987). Bateson's analogy of the Zen master's instructions to the pupil exemplifies this scenario:

> "If you say this stick is real, I will strike you with it. If you say this stick is not real, I will strike you with it. If you don't say anything, I will strike you with it." (Bateson 1972, p.208).

In such a scenario, the means through which the worker or learner avoids the "strike" will directly be reflected in the kind of actions he or she performs; to be sure, he or she "might reach up and take the stick away from the master" (*loc. cit.*) and consider that to be the rightful means of avoiding the smack. In short, actions may lose their objective meanings altogether as was exemplified in the lost objectives of the remotely-prescribed computing actions of the PSPs.

It must be said, however, that slightly moderated variants of territorial disputes may exist when either co-presence or contradictions weakens along its continuum. For example, when strong contradictions persist against a weak co-presence of the distant authority, the balance of power and control over local actions shifts into the hands of the local or immediate authority. In this sense, sound *local control* may be wielded in contravention of the conventions of the advanced motive, and this may prove counter-productive with regards to the achievement of the motives of the advanced activity. It may not, but the scenario may be exploited by individual workers or learners to enrich their identities. Most probably, they will take advantage of the established local control to align their actions to the motives of the object activity as a means of gaining full acceptance and membership into the community of subjects of the object activity. In the extreme scenario, actors will act to rebel and act in breach of the instructions of their distant authorities, or they may use the opportunity to liberate themselves from

the clutches of the advanced motive altogether. An important reminder here is that purposeful computing is normally an action of an activity. Therefore, however much the distant authority may wish to establish control over remote actions of individuals through strong inscriptions, his wishes can only be guaranteed if those individuals are allowed to compute in the first place. If the immediate authority stifles their very computing actions, then remote control is completely exterminated.

On the other hand, a strong co-presence of the distant authority within the context of weak contradictions provides the distant authority with an assurance of *remote control* of actions. Sound remote control occurs when the objective motive is in conformity with the distant advanced motive. Conformity here does not imply weak contradictions between them; rather, conformity in this sense is likely to result from strong rules of the activity which coerce even the distant subjects of the object activity to tow the lines of the advanced motive. In such an instance, the immediate authority may be merely an agent of the distant authority championing the remote control intentions of the latter. Or the entire object activity may be deriving its survival from the distant advanced activity, leaving its subjects to kowtow the distant authority. Such a scenario seems harmonious, but it can be as volatile as the local control scenario since excessive remote control is likely to disregard local circumstances, disempower workers, and lead to local revolts and a drift towards local control.

Perhaps, greater harmony in control and actions is achievable only when the contradictions and co-presence of the distant authority are both weak. Weak contradictions signify some high level of agreement between the advanced and objective motive above the other categories. Under such conditions, the co-presence of the distant authority is weakened when the degree of freedom or empowerment or trust of workers, for example, is very high. This leaves individuals with a greater degree of autonomy to perform their actions. It gives them a sense of belonging to the activity's community, it allows them to get involved, and it enables them to be more expressive of their concerns. It means that in this environment, all the democratic virtues – such as empowerment and participation in decision making – pervade and underlie individuals' actions. The corollary is that the subjects of the object activity are entrusted to control actions or individuals take control of their own actions. In short, control of actions is *shared*, but in *harmony*.

Note that these four categories are not strict classifications bounded by sharp boundaries. The practicality of power interrelations suggests that motives will drift, and so will the sense of actions and the perception of control by subjects of any central activity. In this regard, both the contradictions and co-presence of the distant authority are presented in continua; hence each of the four categories blur into each other as a symbolic representation of the drift, in practice, from one category into another.

The interlocational mediation implications of a distributed activity bear directly on computing in general, and on mobile computing in particular because computing is a physical, external action. We saw, in the empirical case, the impact which the contradictions in the motives between the project leader and the surgical team had on the PSPs' mobile computing. Thus, as far as technology use remains a dominant theme in Information Systems, contemporary remote-distribution of activities must be taken more seriously due to the naturally constraining nature of remote-distribution. But how constraining is distribution in contemporary pervasive computing? Answers to this problem are proposed in the discussions of the next section.

7.4 Control and the problem of Computing in a Distributed Activity

In the contemporary world of work and learning, computing has assumed a central or near-central role in mediating these activities. Mediation of activities itself is not a neo-phenomenon – Marx, Vygotsky and Leont'ev devoted most of their efforts to espouse physical and psychological tool mediation of human activities. Mediation by modern ICTs is rather novel, as their complexity means that they can represent physical or psychological tools, or both at the same time. Therefore, for any activity which ICTs are deployed to mediate, computing is bound to be integral in the set of actions which constitute that activity.

In the domain of a computer-supported distributed activity, computing actions are conducted alongside two fundamental sets of actions: First, the 'true'[29] actions of the

[29] The notion of 'true' actions is my arbitrary formulation used to illustrate the analytically distinct form of actions which can be performed without computing support and which computers are deployed

activity aimed at the transformation of the object of activity; and second, purposeful human mobility as significant actions of a distributed activity. We must be mindful of the fact that these sets of actions represent a mere analytical categorisation; in reality they are intrinsically intertwined and interdependent.

In the previous chapter, I argued that flexible computing is a factor of the degree of immediate control of individuals' actions and the degree of human mobility. Based on this, I argued further – with the proposition of a flexible computing model – that flexible computing decreases with increases in the level of immediate control and the degree of human mobility (see Figure 6.6). In this chapter, I have discussed the factors which affect the control of actions in any localised aspect of a distributed activity, leading to four categories of control. These categories can be integrated into the flexible computing model against the modalities of human mobility to appreciate the flexibility of distributed computing actions. This will answer the *what* aspect of the riddle. In the background, however, the question will still loom as to *how* control determines flexible computing in a distributed activity. Stated differently, how do contradictions and co-presence influence the flexibility of computing actions in a distributed activity?

Computing in Disputed Territories

A strong co-presence of a distant authority is achieved through the inscription of strong control measures into computers or into software. An even stronger co-presence is accomplished when such inscriptions are designed into portable computers such as PDAs and laptop computers. The portability of these computers ensures their mobility, but this does not necessarily ensure their manipulation on the move. When such strong inscriptions are brought into a strong contradictory context, the ensuing territorial dispute between local and distant instructions bears directly on individuals' ability to compute flexibly. Computing is a conscious action; that is, it requires a measure of the user's consciousness if desired results are to be achieved. Consciousness, however, is a direct resultant of sensuous perception and reflection – the eyes being the most dominant sensory organ in this regard.

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to support. In truth, actions which necessarily require computing actions (e.g. information generation and processing) are 'true' in themselves.

In a disputed control territory, computing, which is sanctioned by a distant authority, stands to be stifled by the immediate authority. Here, even if the rules of the activity binds the immediate authority to conform, he or she, being in strong opposition to the advanced motive and hence with the motive of the rule-producing activity, may stifle computing by increasing the load of 'true' actions or by increasing the level of local mobility of individuals or both. This scenario appears to be possible only in activities which actions do not necessarily require computing support for goals to be achieved. In this sense, computing actions may be deemed as 'false'[30], irrelevant or unwanted by the immediate authority. This authority's sense of aversion of computing actions may even be compounded when he or she perceives computing actions as a means by which distant authorities want to wield control over individual's immediate actions. Therefore, by increasing the load of these 'true' actions, the consciousness demanded by such actions consumes the conscious resources of the individual which would be used in computing.

Another consequence of the increment of the actions load is an increase in the local mobility of individuals. Local mobility in this sense must be understood as rather purposeful and sensational; contrary to movements in response to simple excitability or irritability that are intrinsic features of every living thing (Leont'ev 1982, Orbeli 1938). For this reason, purposeful mobility is a conscious action that can further consume conscious resources meant for computing. Combining high levels of purposeful mobility with strong inscriptions that are associated with anti-programming and de-scripting proclivities on the part of users, the resultant computing actions are bound to be inflexible.

In such a scenario, the strong contradictions guarantee that computing does not contribute directly to the achievement of the motives of the immediate authority; therefore, from his or her perspective, 'true' actions can proceed towards the achievement of the objective motive at the neglect of computing. In effect, the adoption of such politics of technology use can be as effective as the poor application or software design in stifling computing in a distributed activity.

[30] 'False' connotes an antithesis of 'true' actions.

Computing in Locally Controlled Environments

Still within the context of strong contradictions, computing in a locally controlled environment may even be more inflexible compared with computing in the disputed territory. In the latter environment, the co-presence or inscribed instructions of distant authorities are not as strong as they are in the former territory. Weak inscriptions ensure relatively less "structure overload" (Sørensen *et. al.* 2002), but that only becomes a possibility when contradictions are not as strong.

In a locally controlled environment, immediate authorities will usurp the advantage of the weak co-presence of the distant authority to take total control of individuals' actions, including computing actions. The strong contradictions will guarantee the manifestation of this scenario. Furthermore, it is easier for the immediate authority to pronounce his or her opposition to the advanced motives by pushing computing actions to the periphery of the actions of the object activity. Therefore, in this environment, unless external influences such as a strong rule or a shift in the objective motive occurs to moderate the strong contradiction, computing actions will remain subject to the total or near-total control of immediate authorities; hence, computing will remain inflexible and peripheral.

Therefore for computing to be flexible in this environment, computing actions have to be 'true' in the achievement of the motives of the activity; or measures such as consultation of the immediate authority in the process of application and software development have to be implemented to reduce the strength of contradictions between the motives of the object and advanced activities.

Computing in Remote Controlled Environments

From the point of view of the distant authority, this category appears to be the most ideal as far as the achievement of the motives of the distributed activity is concerned. Remote control via strong inscriptions of control mechanisms are most likely to manifest in highly flexible computing, granted that those inscriptions are very well designed. In this respect, it is likely that the weak contradictions underlying this category will ensure corroboration by the immediate authority of the distant authority's control; thereby allowing individuals relatively ample time to compute

flexibly. Besides, local authorities will most likely regulate the purposeful mobility of individuals and their actions to accommodate computing actions.

Computing in this environment remains susceptible to external forces of influences that may render computing actions less flexible in the activity. The most likely force is the strengthening of contradictions between the objective and advanced motives. Against the background that stability of motives or contradictions is not a guarantee, attitudes of immediate authorities must be placed under close scrutiny to ensure that they are always aligned with the advanced activity. Moreover, given that users are likely to follow an "anti-programme" when they are faced with strong inscriptions, it is fair to say that weak contradictions on their own may not guarantee flexible computing because users may perceive the inscribed applications as too imposing.

Computing in an Environment of Shared Control

Computer application users may welcome weak inscriptions, but most importantly, their utilisation of these applications necessarily have to occur in environments of shared control between objective and advanced motives to ensure flexible computing. This necessity provides the assurance that immediate authorities will not undermine the efforts of distant authorities to control local actions of individuals. Compared with computing in a disputed territory, there is a greater likelihood that individuals will experience greater flexible computing in this environment because of the underlying weaknesses in contradictions and inscriptions. Here, individuals are more likely to exercise much flexibility in their work or learning, and hence much flexibility in their computing actions.

More flexibility in the performance of actions is indicative of the allowance of individuals' central motives that are incorporated within the activity. Contemporary work is imbued with such flexible arrangements which are direct resultants of trade unions' campaigns for the democratisation of work and empowerment of workers. It is fair to say, therefore, that in this environment, the weakness in the controlling tendencies of both local and distant authorities leaves individuals with sizeable degrees of self-control, comparatively. In terms of technology use, such degrees of self-control are breeding grounds of reconstruction (Wartofsky 1979), flexible

interpretation (Bijker 2001) and, as extensively discussed by Orlikowski (2000), structuration of technology.

To conclude, the problem of computing in a distributed activity is complex and very susceptible to immediate control. Note the impact of interlocational contradictions between the objective and advanced motives as a crucial determinant of local control and hence of flexible computing. Thus, in the contemporary distribution of activities and the concomitant remote actions performed by individuals, analysis must first identify the particular motives of the central, advanced and object activities in order to establish the degrees of contradictions existing or likely to exist within these motives. More importantly, how the contradictions between the motives of the authorities in charge of the object and advanced activities translate into power relations between them has to be examined to unearth the strength of contradictions between them. Furthermore, this examination has to be integrated with the strength of inscriptions of designed computer applications or representations of the control mechanisms of the distant authority. This integration will provide an insight into which kind of environment the individual user is operating; and how the particular form of local control associated with that environment is being wielded to enhance or debilitate flexible computing actions.

7.5 Flexibility of Mobile Computing

The problem of ubiquitous or mobile computing is inherently a problem of distributed activities since it is the various degrees of human mobility which define the nature of distribution of an activity. I have argued beforehand, in this dissertation, that the mobility of computing is dependent on the mobility of humans since portable computers do not exhibit autonomous mobility. Furthermore, I argued that actions of a computer-mediated distributed activity are constituted by three main sub-actions – the 'true' actions, computing actions, and purposeful human mobility. It has to be added that these sub-actions are not mutually exclusive; on the contrary, they are very interrelated and interdependent. For example, when computing actions are mobile, they are necessarily dependent on human mobility; and the achievement of the goals of 'true' actions may be dependent on computing actions.

Based on the flexible computing model propounded in the previous chapter, the flexibility of ubiquitous computing can be analysed by relating the degree of human mobility with the strength of control wielded by the immediate authority. I have argued above that the strength of immediate control is a direct result of the analysis of the strength of co-presence of the distant authority on the one hand, and the strength of contradictions between the immediate and distant authority on the other hand. This analysis leaves us with four categories of control of a distributed activity which can further be examined against the magnitude of mobility which the conduct of 'true' actions require. The unity of human mobility and 'true' actions is a reminder of the influential role of the immediate authority's control of actions on mobile computing. Actions can be static or mobile or a mix of them; and actions can also be very demanding of the consciousness of individuals; but the manifestation of mobile and demanding actions or otherwise is dependent on the motive and control of the immediate authority. His or her sanctions will determine the nature of mobility or the amount of time and attention individuals must devote to actions.

One attendant issue is the fact that portable technologies are largely personal technologies, personal in the sense that their portability enables personalisation, 'wearing' and easy transportation by individual users. When they are deployed to support distributed activities, and hence are inscribed with instructions of distant authorities as a controlling measure, their use in support of the distributed activity occurs in parallel with their use in support of personal motives of the users. A personal motive may not necessarily be a central motive, but it is certainly very directly related to the personal needs of the individual user and can be as strong as the central motive. Thus, from the viewpoint of the user, deriving personal support from the personal computer may be as important as using it to support the advanced or objective motive. We witnessed this in the WIL case where the inscriptions of the instructor only contained logging and reflections writing applications aimed at supporting the achievement of the motives of the advanced activity; and consequently, their struggle to understand the reasons why they were acquired for the project in the first place. To them, those applications did not satisfy their personal, central motives.

Drawing from this, it is worth noting that, apart from the control of actions, the success of mobile computing depends on the satisfaction of users' personal needs.

Personal needs are the roots of the development of "leading" motives and their objects of satisfaction (Leont'ev 1978, 1982). In this regard, portable technologies, by virtue of their easy transportability, hold sufficient properties that can be inscribed with applications to satisfy both advanced and personal motives of use. In contrast to desktop computers, the transportability of portable computers ensures computing actions in more than one location within a distributed activity. The significance of this, in terms of the satisfaction of personal motives, is that computing actions may transcend the official territorial confines of a distributed activity; leading to a widening of the spatial domain of usage of the same computer. Consequently, reconstruction of the computer, which is derived from its objective and personal uses, becomes a more encompassing issue in comparison with desktop computing in a distributed activity.

The examination of reconstruction of a portable computer in a distributed activity, which determines the mobility of information services in the activity, must incorporate the personal needs of individual users. Needs, of course, engender motives that direct human activities (Leont'ev 1978). The distribution of an activity that results in the users' performance of distant actions is at the same time a means of spatially decoupling the advanced and central motives. This means that the reconstruction of computing tools in a distributed activity is susceptible to several personal factors that lie outside the domain of the distributed activity. It is known that reconstruction is a cognitive phenomenon; furthermore, it largely determines the user's perception of flexible or inflexible utility of a computer. Thus, inscriptions, which merely support advanced motives at the neglect of personal motives, are likely to result in inflexible computing. The reverse may be true, but very rare since distant authorities will barely sanction computing actions without inscribing applications that support the advanced motive – their interests. The perception of flexible or inflexible utility in reconstruction is significant because it affects the artefact's use in both official and personal domains. To this end, perhaps the most ideal scenario for users' impartial flexible computing is a middle ground in which inscriptions equally support both advanced and personal motives. And this must be the aspiration of instructors and designers.

Analysis of a distributed activity, therefore, has to focus on the power struggle between authorities of the advanced activity and those of the object activity over learners' and workers' actions. Within the specific domain of mobile computing in a distributed activity, it is necessary and crucial to examine the conditional dynamics – contradictions, strength of inscriptions, control, human mobility and demands of actions – which underlie individuals' performances of immediate actions. This examination is necessary because it is a means of ascertaining the interrelationships, dependencies and causal relationships between these conditional dynamics. Analysis must generally centre on the changes in these conditions over the trajectory of the performance of a distributed activity; and on the period of performance of computing actions in particular. It must be integrated with the degree of inter- and intra-mobility within and between the pockets of localised activities involved.

7.6 Chapter Summary

In this chapter, I have followed up the analytic arguments of the previous chapter with theoretical discussions concerning the specific problem inherent in the remote-distribution of an activity. Based on evidence from the empirical study and the foundations established by the principles of the theory of Activity, I have attempted to outline some general propositions about this problem. It is true that the root of problems of an activity is the contradictions of actors' motives (Engeström 1987). Based on this, it has been established that these contradictions in distributed activities translate into political conflicts of control over actions of an activity.

One significant revelation that emerged from this chapter's deliberations is that the remote distribution of an activity compounds these politics of control. Individuals' actions are therefore reflective of the strength of contradictions between the motives of the advanced and object or central activities on the one hand; and who wields greater immediate control. The discussions resulted in the development of an analytical framework depicting four possible types of control environments in which actions of a remotely-distributed activity can be assessed. These control categories are further integrated with the flexible computing model developed in the previous chapter to outlay he potential problems of computing actions. Under this, the special problem of mobile computing is also analysed against the backdrop that contemporary

distributed activities are mostly saturated with portable computers and greater human mobility.

Altogether, these discussions suggest key analytical instruments for future research endeavours relating to both the theory of activity and technology use. The general conclusions of this thesis follow in the next and final chapter.

Chapter 8: Conclusion

This is the concluding chapter of this dissertation. From its beginning, I took up the challenge to investigate computational problems associated with the intertwined issues of distribution of activities and human mobility. This thesis is the product of an extensive and in-depth investigation of computing with contemporary portable computers in a real-life distributed and mobile activity. From the outset, it has been my unwavering aim to unearth the intricacies of this real-life phenomenon from an academic viewpoint. Within this frame, my motive throughout the study was to explore this phenomenon within the context of sanctioned human activities to bring to light the essential and constraining attributes related to the distribution of an activity and their impact on computing.

Here, I round up the outcomes of the thesis – my arguments and submissions of the preceding chapters. First, I present a brief synopsis of the entire dissertation and its key arguments in Section 8.1. In Section 8.2, I outline my outstanding contributions made so far from this study. Following this, I discuss the study limitations and suggestions for future research in Section 8.3. Finally, I make a few concluding remarks in Section 8.4.

8.1 Thesis Synopsis

Chapter 1 is the introductory chapter in which I outlined the architecture of this thesis by addressing the crucial research issues which confronted this study. These issues consist of the past and contemporary precursors upon which the objectives of this study were derived, as well as the rationale for embarking on this study. In this chapter, I also outlined my inspiration for engaging myself and my resources in this research endeavour. Following this, the scope of the study and the main question of *how the phenomena of mobile computing and the distribution of work-integrated learning mutually shape each other* were presented. This presentation entailed a brief introduction of the empirical case and an outline of the research objectives.

In Chapter 2, I undertook a comprehensive review of the relevant literature of the key areas – learning, mobility and portable ICTs – upon which an understanding of the problem could be derived. I began with the under-researched area of mobility and portable ICTs, placing the pieces of assertions by various researchers together with an aim of building a holistic theoretical understanding of the relationship between human mobility and the use of portable ICTs. Next, the problem or learning was placed under review through an assessment of the various perspectives which have attempted to tackle the multidimensional problem of human development. Piaget's cognitive development as a typical form of individual learning is the starting point of this review. This leads to the counter arguments of Vygotsky who explained development from a social constructivist perspective, and which work-integrated learning exemplifies. I explored other differing viewpoints such as Wenger's Communities of Practice, Miller's Information Processing, Bandura's Social Learning and Kolb's Experiential Learning, and ultimately argued that learning is inherently social. The sociality of the learning process is, hence, applied in a review the usefulness or otherwise of mediating ICTs in contemporary learning activities.

Chapter 3 is the methodology chapter in which I detailed how the empirical study was approached and operationalised. It involved brief explanations of the two main philosophical strands of scientific inquiry – positivism and interpretivism – and subsequently justifications for my choice of the interpretive philosophy. Following this, I outlined the research design as the structure for the operationalisation of the empirical study. The design consisted of justifications for an action research strategy, qualitative evidence, several qualitative data collection techniques such as interviews, conversations and documents. Finally, the techniques and tools which were used in the interpretation of the data were briefly presented.

In Chapter 4, the analytical lens applied in addressing both the empirical and theoretical aspects of the study was also reviewed. I perceive work-integrated learning as a human development endeavour and therefore adopted the Theory of Activity as an analytical lens to conduct this study. This chapter thus presented a detailed commentary on Activity Theory that depicts its developmental psychological principles and its suitability as a theoretical framework for analysing the empirical and theoretical findings of this study. In later sections of this chapter, the principle of

mediation by signs and instruments is integrated into the concept of affordance to show how the various human sense organs function in the perception of affordances of ICTs when they are engaged in the performance of activities.

In Chapter 5, I presented the findings of the empirical work – the study of mobile computing in the WIL activities of the PSP. This is a detailed presentation of the relevant data from an action research conducted within the real-life experience of health professionals trying to derive learning support benefits from PDA applications. In this chapter, I told a story of three continuous stages of use of three different applications, and ultimately, the failure of the technology to satisfy its predetermined purposes. Following this, the key findings – marginalisation of technology and problematic learning conditions – which largely contributed to the technology failure were presented, and led to the analysis of the findings in Chapter 6.

The analysis of Chapter 6 began with the dissection of the WIL into a system of activities comprising of a central activity of the learners and neighbour activities such as the culturally more advanced activity of the instructor, the object activity of the surgical team, the instrument-producing activities which gave birth to the PDA and its applications, and the rule-producing activities which established the administrative set-up of the project. The mutually reinforcing and contradictory relationship between the motives of the central and advanced activities becomes the starting point of this analysis. Upon this, the sense made of the artefact within parameters such as its design properties, mobility, distance and distribution, control and the politics of technology use are teased out. Based on this sense-making, the reconstruction of the PDA is analysed as a factor of the mobility of computing services. Analysis culminates in the development of a conceptual model of human mobility and flexible computing which depicts a paradoxical relationship between the two phenomena.

The discussions of Chapter 8 was a corollary of the analysis of Chapter 7. In respect of the findings and implications of the previous chapter vis-à-vis the research question, it was imperative that the problems of distribution of an activity be properly teased out at an abstract and general level of discussions. *How constraining is distribution* became the pervading problem underpinning these discussions. The constraints were directly sourced from the contradictions between advanced and

central motives, and impliedly, how these contradictions could potentially induce a power struggle between the authorities of any two locations within which workers and learners act. It is predominantly argued that the *balance of control* between these authorities which are exerted on the actions of individuals determined the extent of computing actions by those individuals. In these discussions, I made several arguments, submissions and propositions on distribution and technology use which serve as my key contributions to the advancement of Information Systems.

8.2 Research Contributions

At this point, it is necessary to summarise those aspects of this thesis that I consider to be original and novel, which satisfy the criterion of what is termed as "original thought" in the scientific realm, and which are henceforth subject to scrutiny and verification. It must be quickly pointed out that "original" in no way suggests my non-reliance upon the knowledge that other scientific researchers before me have built. Our sense of "original" here rather denotes what new knowledge contribution has been made, and has an implicit connotation of a furtherance of existing knowledge. The utilisation of the principles of the theory of activity in analysing the findings of this study, for example, bears testimony to this unavoidable reliance. These contributions may be summarised as follows:

- Elucidation of the paradoxical relationship between human mobility and flexible computing, based on the strength of immediate control exerted over actions;

- Exposition of the reconstruction of portable ICTs based on drift in utility between the satisfaction of objective and personal motives;

- Revelation of the metacontradictory nature of distributed activities through the identification of locational contradictions as mediators of the contradictions between central and advanced activities; and consequently,

- Proposal of a new model of distributed activity to address the dynamics of workers' or learners' actions in contemporary technology-mediated distribution of work and learning.

For practitioners, these arguments, founded on an empirical study of a real-world adoption and deployment of portable ICTs for distributed learning, can serve as viable guidelines in their adoption and deployment of portable ICTs for the enhancement of learning and skill development of their employees.

For designers of mobile technologies – hardware and software – the insights provided by this research are a rich source of invaluable feedback as far as their design efforts are concerned. Such feedback will eventually result in better or enhanced products useful for tackling societal problems.

8.3 Limitations and Future Research

Amid the effort that went into the achievement of the contributions above, the inevitable deficiencies of the study have to be honestly recognised.

The first limitation is derived from the limits of strategy adopted for the inquiry, namely Action Research. Doing Action Research implies conducting idiographic research, which is the empirical study of one single event in a complex world of multiple and interrelated events. The multiplicity and interrelatedness of empirical events suggest that emphasising certain features of an event and overlooking or neglecting others in idiographic research is inevitable. Although idiographic research is generally more comprehensive and in-depth than its nomothetic equivalent, it lacks the advantages of repetition and wider coverage of multiple events which are the norms in nomothetic research. Thus, generalisations from nomothetic research are perceived as more valid than those which emerge from idiographic research; and verification is seen to be unproblematic. However, idiographic research has the advantages of depth and thoroughness of inquiry that are lacking in nomothetic research. And within social science research, which this study epitomises, the need for in-depth and comprehensive research of a phenomenon in its context is a necessary requirement. The wider coverage of nomothetic research disregards context, but context is the utmost strength of idiographic research. This strength notwithstanding, I acknowledge the limits of the action research strategy upon which the findings of this study were founded. I also accept that the unique contextual characteristics of every

event or phenomenon may undermine the testing and verification of my general submissions.

The data collection process was also devoid of observations of mobile computing by the PSPs. In such a study, direct evidence of the users' comfortability or frustration with mobile computing in the activity should have been the ideal. I consider the absence of an ideal situation as a problem; and therefore this problem was a significant limitation of the study. As I have already explained in Chapter 3, the legal and ethical implications surrounding the study of health workers in hospitals made it virtually impossible to conduct these direct observations.

Third, in tackling the problem of mobile computing in an activity, another ideal scenario would have been an analysis of the impact of mobile computing in the achievement of learning outcomes. Furthermore, one may argue that this impact would have served in better describing the problem of mobile computing in WIL. As it stands, this study only concentrated on the learning processes and not the outcomes. The outcome of the PSP project was to be determined only in the long-term future and not within the time frame of this study. Given its nature, the outcome would be measured against the criteria such as acceptability by medical professionals, successful assumption of junior doctors' roles and successful delivery of peri-surgical patient care. These criteria are long term yardsticks and not short term. Thus the cognitive aspect of skills acquisition was only a first step towards the achievement of the long-term outcomes. And as far as the long-term was concerned, the time frame of the empirical aspect of this research was some distance away. We are talking here of outcomes which can be appropriately measured at least five years from now, perhaps; and obviously, this study, although a longitudinal one, could not be stretched to cover this period. This implies that the role of the PDAs in the PSPs construction of professional identities, for example, could not be included in the analysis. And in this light, the temporal remoteness of the learning outcomes was a significant limitation in this study.

The problems of non-connectivity of the PDAs to the internet also effectively ruled out any consideration of mobile interaction in the WIL activity. This limitation ensured that only mobile computing could be given proper consideration in the study.

All these limitations present further challenges for future research endeavours into portable technology use in distributed and mobile settings.

8.3.1 Future Research Challenges

Circumstances permitting, the study of mobile computing and interaction in a distributed and mobile activity will provide a more holistic picture of the complexities involved in use. It has to be warned, however, that each of computing and interaction are broad sub-areas in technology use which will require a more comprehensive study; and may therefore require more resources to accomplish.

Furthermore, the challenge about the impact of mobile computing and interaction on learning outcomes can also be taken up to espouse the efficacy of these artefacts. Again, a true picture of the impact can only be obtained through a study of both the process and outcome of learning, which represents a more comprehensive task.

Future researchers of mobile computing and interaction must strive to conduct observations – direct and indirect – of technology use during activity. This is an important requirement, which, as far as the limitations of this research are concerned, can fulfil the requirements of building a more holistic evidence of activity-related problems of mobile computing and interaction.

8.4 Concluding Remarks

Although the limitations and future research pointers above leave many problems unaddressed, I have spent time to detail and stress my main points which represent the achievements of the objectives which I set at the beginning of this thesis. I could not study the whole world, but I fully admit the unavoidable shortcomings of this study, and I also accept that my arguments and submissions are no more than the first steps in a new direction of understanding technology use in a distributed activity. Yet, I believe that in unearthing the problems inherent in the mutual shaping between distribution of activities and technology use as a central issue in contemporary work and learning, I have made a significant contribution to progress in this area. In spite of this, I am not beyond reproach: I leave my ideas in this thesis to the unqualified scrutiny of all readers and critics. However, while I may be reproached about any

arguments made in this thesis, I do not dread any reproach, because my confidence is grounded on objective interpretations and scientific analyses of my findings.

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