Running Head: Strategic User Needs Analysis and Activity Theory

Activity Theory and Roles: Feature Bundling for Wireless Technologies

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Abstract

This research situates a user needs analysis method, called Strategic User Needs Analysis (SUNA) in an earlier study (Narasimhan, 2001), within the framework of Activity Theory (AT). It tests the suitability of an AT framework for classifying work roles for the purpose of studying the relationship of these roles to the uptake of PDA features by two strategic market segments, namely mobile and non-mobile professionals. Mobile professionals work outside their office for at least 30% of their working hours while non-mobile professionals spend less than 10% of their working hours outside their office. These two groups were considered early adopters of PDAs in an earlier study (Narasimhan, 2001).

A field test was conducted on 24 users using a 2X2 ANOVA design to compare mobile with non-mobile professionals as well as comparing Palm Pilot users with Handspring PDA users. In this study, SUNA used an automatic log of feature usage as a springboard to jog participants' memory with respect to the context of usage of the two features they use most often. Information concerning their work roles and the ways they used the PDA features was examined along with their nominations for additional features. The value of a generic role classification to investigate strategic questions pertaining to the development of new products and feature bundling is discussed. The results suggest that AT is a suitable theoretical framework for SUNA. Specifically, results concerning the way roles interface with PDA features and how role-based requirements are shaped by the rules and praxis of the communities in which these roles operate are in line with the predictions of Activity theory. The findings further suggest that SUNA is capable of predicting subtle differences in PDA feature usage, and that subjective estimates of the features used are quite accurate, but frequency-of-use estimates are not when the sample of features is small.

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Introduction

The range of communication features that could be provided on mobile technology platforms such as cell phones and Personal Digital Assistants (PDAs) is very wide and is increasing rapidly. As the number of features increases, so does the complexity for users of such devices. In order to manage that complexity, service providers are motivated to identify subsets of features that suit the needs of different user populations. To do this, they need to understand the characteristics that distinguish one user population, also referred to as market segment, from another in terms of their different feature requirements. To date, no reliable and valid method enabling such a distinction to be made as well as to predict which specific features a given user population is likely to adopt has been forthcoming. This thesis is an attempt to provide such a method.

The research presented here has three purposes: (1) it situates the method in a theoretical framework; (2) it validates the method for predicting the uptake of PDA features by two similar, yet subtly different, user populations; and, (3) it assesses differences between perceived and actual feature usage patterns.

The method was derived from a pilot study that identified user groups by the roles members play rather than by individuals (Narasimhan, 2001). Because the method is intended to predict the uptake of facilities to be provided at some point in the future, it is called “Strategic User Needs Analysis” (SUNA). It is distinguishable from traditional User Needs Analysis (UNA) in which the analyst’s task is to understand how a specific user population is currently using a particular device or application.

The pilot study included both a prediction of features the two selected user populations would be likely to use and a very brief test seeking to verify that prediction. The sample was too small to conduct any statistical tests, the variety of PDA devices too large, and the duration of the field study component too short to reach any definitive conclusions about the capabilities of SUNA. This was done here by testing a larger number of users for a longer period of time and controlling for the device they used.

Although many UNA approaches have been reported in the literature (Nielsen & Søndergaard 2000; Smørðal, Gregory, & Langseth, 2002; Takesh, 2000), none has a solid theoretical foundation. In an attempt to begin to link the practice of identifying user needs with a theoretical framework, this thesis explores the suitability of a particular candidate, Activity Theory, for this purpose by seeking to situate SUNA within one version of Activity Theory that has been operationalised (Engeström, 1987) in the area of Human Computer Interaction (HCI). The history, application, and operationalisation of Activity Theory are discussed in detail later.

Interviews with current users or potential future users of new services are traditionally performed in a UNA to learn about feature usage patterns. However, comparison between what users *say* and what they *do* occasionally suggests that perceived usage bears little relationship to actual usage patterns (Potosnak, 1988; Lindgaard & Fergusson, 1992; Lindgaard, 1993; 2002). Some authors suggest that this is because users are asked to provide information about their usage habits at a much finer level of detail than they normally would (Beyer & Holtzblatt, 1998). The present study obtained information about perceived and actual usage patterns in terms of the features used and the frequency of usage to assess the degree to which estimates represent

objective use of PDA features. Studies in which such comparisons have been made have employed services with a much wider range of features than the PDAs used here. It is thus possible that subjective estimates are more accurate when the number of features is quite small. If this is true, then an elaborate investigative method such as SUNA may only be necessary when the sample of possible features is quite large.

UNA and SUNA Contrasted

In the User-Centred Design (UCD) approach, a UNA is conducted in the early stages of the product design and development cycle that software engineers refer to as the “Requirements Capture”. From a software engineering perspective, requirements focus on the technical capabilities a software application must deliver, such as an accounting module linking to a billing module, a password protection module, and so forth. By contrast, UCD focuses on application users throughout the product design and development cycle. An analyst conducting a UNA collects information about the target user population(s), the tasks they aim to accomplish when using the application, the tools they currently use in conjunction with the evolving application, and the environments in which the application will be used (Shackel, 1991; Lindgaard, 1994; Mayhew, 2003). These four elements – users, tasks, tools, and environments - have been central to the field of ergonomics/human factors for several decades, and whole families of investigative methods concerning all of these have been reported in the literature since the early 1950s (Chapains, 1959). Task analysis methods, in particular, have been widely discussed; Kirwan and Ainsworth (1992), for example, list more than 40 different task analysis methods, and new books appear almost annually (e.g. Stanton, 2001; Annett &

Stanton, 2000; Diaper, 2003). However, with few exceptions, task analysis methods suffer from a lack of solid theoretical foundation. Those that do originate from theory are very interesting, but they have not been applicable in practice, especially since Command Line Interfaces (CLI) were overtaken by the so-called 'direct manipulation' user interfaces (Shneiderman, 1998). For example, the family of Command Language Grammars (CLG) (Moran, 1981) rely on perfectly predictable, routine tasks with a single completion procedure, which is no longer representative of most tasks users complete.

As is true for task analysis, there are several methods describing how a UNA should be completed, but none that provides a solid and applicable theoretical foundation. For example, the Requirements Engineering Specification in Telematics RESPECT framework (Kirakowski & Vereker, 1996) provides a UNA procedure that incorporates all the four elements to be analyzed. However, it implicitly assumes that the application to be developed will replace an existing one in a large organization, which is not the case for many new applications. Other UNA methods similarly seek to prescribe a particular procedure for analysts to follow (e.g. Mayhew, 1999; Sutcliffe, 2002; Vredenburg, Isensee & Righi, 2001), but provide no theoretical basis.

The biggest practical problem with UNA methods is the fact that they generally support analysis of the way users currently work and often assume that the aim of future technology is to replicate the present. Yet, more and more, technology changes the way people work; it must meet new demands concerning how, when, and where it will be accessed. For service providers to plan the introduction of new products or novel features they hope will be successful in the market place, they must predict who will use these under what circumstances. Traditionally, such predictions have been made in an ad hoc

fashion. SUNA, which aims to support predictions of future usage of new technologies, products or features, attempts to occupy precisely this space of strategic importance to service providers. Therefore, rather than focussing on individual users and individual tasks, SUNA concentrates on the roles groups of people play in an organization and the responsibilities these roles carry. It is argued that occupational roles are less susceptible to rapid change than individual tasks or the sequence of sub-tasks, and that by concentrating on roles and responsibilities, it is possible to predict product and feature usage patterns more accurately than by applying the traditional UNA methods. The notion of roles is discussed in more detail later.

Feature Bundling and Market Segmentation

SUNA addresses “feature bundling”, which is an important strategic issue that manufacturers of PDAs and other wireless technologies are faced with (Bauer et al, 2002; Chiasson, 1999; Colias, 2002; Levy, 2002). Despite the importance of matching product features and applications to the needs of users grouped into market segments, the issue of bundling is currently addressed in an ad hoc manner. McLaughlin (2000) suggests that the increase of features offered in PDAs should lead to a segmentation of the market such that different features will be packaged and bundled for different sets of users, but he offers no method for determining how this could be achieved. Users are generally grouped into very broad segments such as, residential- and enterprise users (Sone, 2001; Brock, 2003) without an in-depth understanding of the socio-cultural, psychological or contextual factors that trigger the need for HCI. The outcome of such broad segmentation and ad hoc bundling practices has led to the proliferation of access devices, making it difficult for users to select the devices that best match their needs (Bayer and Stoughton,

2001; Heylar, 2001), not least because the task of identifying one's needs requires attention to very low-level, usually inaccessible detail of one's own habits (Beyer & Holtzblatt, 1998).

Rutter (2001) addresses two common practices in industry, which often lead to a product's downfall in the market place. The first is the so-called "feature creep syndrome" where a product development team adds features and decides upon functionality without customer input. The criterion for inclusion of new features is that the technology can accommodate them. The second is referred to as the "Kreskin syndrome", a senior management issue where the phrase "I've been in the business X number of years and I know what is best for the product" is often used to justify why features need to be added. Rutter demonstrates the need for a systematic approach to understanding users in order to determine what features are most appropriate in a given device, however, there is no mention of a method to prevent the Kreskin Syndrome. Without involving users, considerable time and effort is spent designing features that have no real customer value. The feature creep and Kreskin syndrome are very costly and often lead to product failure because customers are unwilling to pay for features which are of no real value to them, or else they simply fail to use them. Rutter does not provide evidence to substantiate the effects of feature creep and Kreskin syndrome. Thus, while there is some agreement in the literature that communication features need to be packaged for different user groups, and that it may be advantageous to concentrate on user roles rather than on actual users performing current tasks, there is as yet no systematic method for doing so.

The Notion of Roles

The notion of “roles” in HCI is an abstraction of what a certain group of users “do” rather than referring to a particular user and a given user’s tasks. In an attempt to identify task sets that define user roles and develop user profiles Beringer, Corbett and Schmidt (2001) used a reasonably unstructured brainstorming technique. In traditional UNA methods, user profiles refer to descriptions of user characteristics, whereas Beringer and his colleagues use the term to define relevant characteristics of roles, thereby bringing the notion of user profiling to a higher level of abstraction. Beringer et al.’s method is based on an informal user role modeling approach, which is a loose collection of role labels accompanied by informal descriptions of the relevant characteristics of each role. In an attempt to rely on more accurate information about roles, SUNA abstracts user roles based on needs, expectations, behaviours and job responsibilities as recommended by Constantine and Lockwood (1999). Whereas Beringer et al. provide no information on users’ environment and context of use, Constantine and Lockwood (1999) and SUNA, which is in part derived from these authors’ framework, do.

In accordance with this reliance on roles, Bittner (2000) describes an entire business in terms of roles in the workplace with emphasis on applications, information and services that an individual needs to fulfill his/her role. Within Bittner’s framework, organizational roles can be viewed from two perspectives: the “functional” comprising the dominant activities an organization performs, and the “process” perspective, which consists of the key business processes and resources required to enable them. The elements, which define a user role for an organization, include the responsibilities, objectives, information needs, interaction among roles in a process, internal and external

collaboration, typical work environment, and user profiles including skills and typical activities. While the author argues that incorporation of role-specific communication tools significantly improves knowledge management, no data are provided to support this claim. According to Bittner, each role has an objective, for example, to increase sales, that carries with it certain responsibilities such as to manage the sales force, set goals, provide strategy, or measure progress. In order to carry out these responsibilities, certain types of information are needed. The role incumbent requires certain skills and has to perform a set of tasks in a typical work environment, which might involve travel and field work. The necessary collaboration with other people inside and outside the organization leads to different types of information- and communication needs. This reliance on the notion of occupational roles and the communication requirements that must be met for a person to fulfil that role is central to SUNA, in which these form the basis for predicting usage patterns of user groups, even when these differ only slightly from each other. However, in contrast to Bittner's study, actual usage data are provided in this thesis to confirm predictions made by the method.

The literature does provide some support for the importance of occupational roles in predicting feature usage patterns. For example, in a study of usage patterns of advanced telephone network facilities involving several user groups in a telecommunications research laboratory and using several experimental manipulations aiming to increase such usage over a four-week period of time, Lindgaard and her colleagues (Lindgaard & Fergusson 1992; Lindgaard, 1993; Lindgaard, 2002) failed to find any experimental effects whatsoever. However, when reclassifying the data independently of the experimental groups, relying on occupational role requirements

instead, clear usage patterns emerged. This led to the conclusion that “the most important finding in this study is that occupational role determines both the range and the frequency of network facilities usage” (Lindgaard & Fergusson, 1992, p.31).

User Role Modeling

A model is defined as a schematic description of a “system, theory, or phenomenon that accounts for its known or inferred properties and may be used for further study of its characteristics” (dictionary.com). Role modelling focuses on the concept of work and the working objectives of users (Constantine & Lockwood, 1999). The authors state that a role model is developed by first listing user roles to be supported by a system. Each role is described on the basis of user needs, interests, expectations, behaviours, and/or responsibilities. *Needs* are requirements for the user with respect to certain features embedded in the application or device, such as the need to receive e-mail or alphanumeric text messages. *Behaviours* reveal how someone uses the device by observing the volume and frequency of usage. *Expectations* are defined in terms of device reliability, speed, access, and mobility. *Job responsibilities* indicate typical activities that a person would carry out using the device, such as contacting customers or checking inventory. Next, a set of one or more focal roles has to be identified. Focal roles are roles that are deemed particularly important from a business perspective, for example from the standpoint of early adoption of new technologies. On the basis of this analysis, a role map is developed as a diagram/schema to represent the relationship of the roles. These role-modelling concepts of describing roles in terms of user needs, interests, expectations, behaviours and/or responsibilities, the selection of focal roles and the role

mapping were applied in the SUNA pilot study as well and are explained in the following section.

Strategic User Needs Analysis: A Pilot Study

The need for a sound approach to feature bundling was the focus of the pilot study (Narasimhan, 2001; Narasimhan & Lindgaard, 2002). SUNA was developed using a combination of investigative methods from HCI and market research and based on the notion of user role modeling (Constantine & Lockwood, 1999) as well as the context in which the role was executed (Beyer & Holtzblatt, 1998). The method was tested very briefly in the field using a sample of twelve users representing two market segments identified to represent early adopters of wireless technologies and therefore strategic importance for PDA network service providers. The two market segments were mobile and non-mobile professionals. SUNA appeared to effectively relate the needs of the users in the two market segments to their work roles. SUNA involved differentiating and bundling features of PDAs to match the requirements of each user role. This was accomplished by conducting a brainstorming session to list all of the user types that could use the PDA. The user types were then grouped into roles after they were examined for their needs, expectations, behaviours and responsibilities. Two focal roles seen to represent early adopters of the technology were then selected. The two focal roles chosen were mobile and non-mobile professionals. The roles and responsibilities were subsequently verified by analyzing job descriptions from the Human Resources departments of two companies. Twelve participants were then recruited. Mobile professionals spent more than 30% of their time working outside of their offices and non-mobile professionals spent less than 10% of their time working outside the office. Users

with a Palm OS were tracked with an automatic logging device while users of other devices were given a log sheet and asked to keep track of their usage. A face-to-face interview was conducted in the work setting of participants and log sheets or usage data were used to remind them of the features they had used, their role, their interaction with other devices and so forth. The data was only used to determine the two most frequently-used features.

Improvements to the Pilot Study

The pilot study was not anchored in a theoretical framework, explaining why roles would be important for segmenting the market into specific user groups with different work requirements. In addition, the typical relationships between the roles and the devices used could not be explored in depth because the twelve subjects were using different wireless devices. Hence, while questions of importance to strategic design of new products, and consequent strategic marketing were addressed, the statistical validity and reliability of the method itself could not be explored. Further, the various devices contained different features. Some of the devices could not accommodate the data logging software, so the relevant users were asked to log their feature usage in a journal. The accuracy of the journal notes was deemed questionable compared to the automated logs. Due to the incompatibility of the journal notes data with the automatically logged data, the logged data were not analysed in detail. To overcome these problems, users of two specific devices namely, Palm and Handspring were included in the present study and all were tracked using automated logs. The sample of users was also quite small in the pilot study due to the difficulty of gaining access to corporate users and mobile professionals. While the difficulty associated with gaining access to these participants

remained in the current study, it was decided that doubling the sample to a total of 24 participants would help rectify the problem of the small sample size. Finally, the period of time during which feature usage data were collected in the pilot study was too brief to yield conclusive data. To rectify this, data were collected for two consecutive weeks from each user in the present study.

Traditionally, research performed early in the product development cycle has relied on interviews with potential users and/or market surveys. While it is important to obtain information about users' opinions, such data alone is unlikely to reveal accurate usage patterns (Beyer & Holtzblatt, 1998). The data logging method used in this thesis enabled exploration of the difference between actual and perceived feature usage to determine the accuracy of perceived usage patterns when the sample of features is quite small. A literature review on logging and automated metrics suggests that automated evaluation enables more accurate measurements than the recording of data (Ceaparu & Thakkar, 2000).

Identifying an Appropriate Theoretical Framework for SUNA

The HCI literature emphasizes the need for adopting a socio-psychological framework to interpret the structure, development and context of activities involving the use of intelligent devices such as computers and PDAs (Nardi, 1996; McGrath & Uden, 2000; Kaasboll & Smørdal 1996; Torvinen, 1996). According to Kaptelinin and Nardi (1997) the initial work in HCI based on the cognitive science model of humans as information processors does not provide a social and organizational context for analysing interactions of humans and computers. Indeed, there is a need to study these interactions in the light of social and cultural realities.

One purpose of this research is to situate SUNA in a theoretically derived framework that can integrate social, organizational, and cultural relationships to provide a context for the interactions. A theoretical framework for our purposes is defined as a high level and coherent conceptualization of a phenomenon. For a theoretical socio-psychological and contextual framework to be appropriate for SUNA, it will need to meet several criteria. It must:

1. Be amenable to the interpretation of role as an abstraction of allocated responsibilities in an organization or in society generally;
2. Capture the responsibilities of the roles users try to fulfill while using a variety of devices;
3. Incorporate socio-psychological factors that influence the users' interaction with their devices;
4. Consider the environment and context in which users operate and the norms of the social and cultural settings that influence interaction with devices;
5. Enable assessment of the extent to which the device or technology in the current and proposed form leads to the fulfilment of responsibilities and goals; and,
6. Make explicit the barriers that users face and the problem areas that the new product addresses;

Possible theoretical candidates for SUNA were examined to study their fit to the above criteria. Because of their strong theoretical foundation, the Goals, Operators, Methods, Selection rules (GOMS) models, Norman's Seven Stage Action Model,

Cognitive Complexity Theory (CCT), and Activity Theory (AT) were examined for their suitability to serve as a framework for SUNA.

The GOMS (Goals, Operators, Methods, Selection Rules)

GOMS is a family of analysis techniques originally proposed by Card, Moran and Newell (1980; 1983). GOMS was an attempt to translate many of the principles from cognitive psychology into the HCI arena. GOMS models provide a description of behaviour, which is exclusively tied down to expert and error-free performance.

The model breaks down activities of a user task into components and links each component to relevant information processes. A goal defines a state to be achieved and determines a set of possible methods to realize the state. A hierarchy of goals and sub-goals is assumed to exist in the user's memory because GOMS relies exclusively on highly experienced users and routine tasks. For example, a call centre operator could have an overall goal to handle a call (Gray, John, & Atwood, 1993). A typical sub-goal (unit task) within this overall goal could be to determine who should pay for the call. Appropriate methods exist for achieving each sub-goal. The methods in turn use operators. Operators are elementary, perceptual, motor, or cognitive sets, which are necessary to change the user's mental state or the task environment. Examples of operators could be to listen to the customer, talking to the customer, assimilating information and determining action. Selection rules are operationalised by conditional "If-Then" statements. For example, if it is a collect call then the called party should pay. The input to this model is a detailed description of the user interface right down to individual keystrokes necessary to perform the tasks. The output consists of quantitative measures such as time taken for a telephone operator to complete a call for the collect call

category. In addition to predicting performance time the GOMS model could provide qualitative explanations for the empirical data such as what would happen if the design on the keyboard changed for entering billing information. GOMS is valuable when modelling routine, repetitive tasks. However, because GOMS models focus on routine, error-free task performance, GOMS is unsuitable as a framework for a method seeking to predict future behaviour based on an understanding of the relationships between groups of users, their tool such as a PDA, and their work role performed in a specific context or setting. In addition, GOMS has no reference to context and the socio-cultural environment in which groups of users are performing their activities (Verenekina & Gould, 1998) and was therefore rejected as a suitable theoretical framework for this study.

Cognitive Complexity Theory (CCT)

Whereas the GOMS models describe the general methods for accomplishing a set of tasks, CCT adds some cognitive dimensions such as delayed gratification (effort to meet a goal), and hidden dependencies (information links between the items in the artefact). CCT requires detailed specification about the knowledge users bring to the task to be analyzed, which includes knowledge about the device, about computers in general, and about the task domain.

The knowledge represented in a GOMS model could be represented as a production system (Kieras & Polson, 1986). The production system model based on CCT is more formal than the qualitative description of the knowledge necessary to perform tasks obtained through GOMS models. Quantitative predictions for training time, transfer and execution time for various tasks are possible. Bovair, Kieras & Polson

(1990) have tested the assumptions underlying the predictions of production models and have shown that the time required to learn a task is linearly related to the number of rules that must be acquired for the purpose of executing the task. This model is very limited because it is based on two basic principles of psychology. The first is that people act to attain goals via rational actions given the structure of a task. The second principle is that problem solving activity can be described in terms of a set of knowledge states, operators for changing states, and control knowledge for knowledge application. This model was found to not be suitable for this study because a wider context beyond tasks and design is necessary.

Norman's Seven Stages of Action Model (1988)

Norman's Seven Stages of Action Model (1986, 1988) divides user actions into seven components in order to highlight where users are likely to encounter problems with a user interface. It includes: (1) forming the goal; (2) forming the intention; (3) specifying the action sequence; (4) executing the action; (5) perceiving the state of the world; (6) interpreting the state of the world; and, (7) evaluating the outcome. In this model, as in GOMS, a goal is the state a person wishes to achieve whereas an intention is the decision to act in order to achieve the goal. An example outlining the steps is provided in Table 1.

Table 1

Norman's Seven Stage Model: User Action into Seven Components

Step	Definition	Example
Forming the goal	A goal is the state a person wishes to achieve.	Make an appointment with a supplier.
Forming the intention	An intention is the decision to act in order to achieve the goal.	Use PDA to lookup schedule and find the supplier's phone number in order to place a call to set up the appointment.
Specifying the action sequence	Translation of psychological goals and intentions into the desired system state and forming a mental specification of the actions to be executed.	Turn on PDA, switch to schedule, look up date desired, plan conversation and so on.
Executing an action	Is the first step that involves doing something. The actions required are determined by the choice of available input devices (buttons, screen, speech).	Type or write-in appointment.
Perceiving the state of the world	Perceiving what has actually happened.	See the appointment recorded in scheduler.
Interpreting the state of the world	Linking physical state to users psychological goals and then interpreting them.	Feeling a sense of accomplishment from following a set of procedures with PDA to manage time.
Evaluating the outcome	Evaluation of the system state by comparing the perceived system state with the desired goals	Examining if appointment has been scheduled without conflicts.

The model is useful for evaluating specific components of an interface. For example, the datebook application is not clearly identifiable, is positioned awkwardly or is not shown on the opening screen and could therefore slow down the execution of the task. The model is good for usability testing because it can reveal if the physical state of the system and its control mechanisms are in line with user goals. The weakness of this model is that user activity does not always progress as a simple sequence of stages. The stages may occur out of order and be skipped or repeated. Sometimes an activity is performed in a reactive manner, for example, where goals are not fully known, rather than proactively where goals are known. The model is not suitable for studying the needs of specific groups of users to predict the uptake of features of new technology or to appropriately bundle features in a new product. This is because in a situation involving SUNA there is no fixed task- sub-task sequence. Also, the lack of context and environment, and their influence on the human-device interactions in particular renders Norman's seven stage action model unsuitable for the task on hand.

GOMS, CCT and Norman's seven stage action model all originating from American cognitive psychology were found unsuitable for the task on hand because these models ignore social, organizational, and cultural relationships that provide a context for the interactions between humans and information technology. By contrast, Activity theory (AT), which integrates social-cultural history with the human psyche, had its beginnings in German philosophy of Kant and Hegel and was later developed by Russian psychologists (Verenekina & Gould, 1998). It will be reviewed next.

Activity Theory

AT was mainly a result of an effort to develop a new psychology based on Marxist philosophy. Activity theory is not a “theory” in a strict interpretation of the term, that is, a set of principles devised to explain a group of phenomena, especially one that has been repeatedly tested and can be used to make predictions about natural phenomena (Bannon, 1997). AT has yet to be able to make strong predictions.

AT however does provide a set of basic principles, which can be used as a foundation and conceptual framework for the development of HCI models (Bannon, 1997). AT has its roots in the works of Vygotsky (1896-1934) and his colleague Leontiev. It takes a very broad view of the human psyche as being the product of cultural and social forces (Vygotsky, 1978). Also, AT offers a set of perspectives on human activity and a set of concepts for describing that activity (Nardi, 1996).

Vygotsky

When Vygotsky presented his ideas about the mediation of psychological tools, such as language and symbols, in carrying out human activity, he was modelling these on Marxist ideas about how tools or instruments “mediate.” That is, they act as a means, i.e., act as a means of carrying out labour activity. As a Russian scholar, in the post-Czar era, he, like all Russian scholars of that time, was forced to phrase his research in a Marxist framework. The term mediation is used throughout the AT models and the closest meaning one can derive is one of a facilitator, something that enables the desired outcome to be accomplished. To explain the notion of mediation, Vygotsky (1981) states:

Thus, in the instrumental act, a new intermediate link - the psychological tool, which becomes the structural centre (i.e., the feature that functionally determines all the processes that form the instrumental act) - is inserted between the object and the psychological operation toward which it is directed. Any behavioural act then becomes an intellectual operation. (p.39)

The first generation AT represented Vygotsky's idea of tool-mediated and object-oriented action in the form of a triangle. The nodes of the triangle are the subject, the tool, and the object. Each side of the triangle reflects a relationship between each pair of nodes. Activity is conceived as originating from a subject (person); it is directed at an object with the aim of transforming it to achieve a desired outcome. For example, a salesperson (subject) would use a PDA's datebook (tool) to set a time for an appointment with a client (object), which can be a person, concept or thing to be acted upon to achieve a positive customer relationship (outcome). This relationship between the user, the tool, and the object on which the user acts to achieve an outcome is useful for strategic design and SUNA.

In Vygotsky's work the focus was on object-oriented activity, that is, an activity directed at changing an object in the objective world to achieve an outcome. Psychological tools such as language and symbols mediate this activity. Contrary to the way AT was later operationalised, Vygotsky considered only individual human beings rather than groups of people functioning in a wider social and cultural context. Every activity is directed toward something that objectively exists in the world.

Leontiev

Leontiev extended the domains of Vygotsky's theory by emphasizing the relationship of individual actions to collective activity of the system. For example, a company's motive is to grow sales and increase profit. In order to achieve this, the collective activity of all company employees is translated into a division of labour, which is further divided into roles and responsibilities. Responsibilities are goals to be achieved by the various roles and a collection of responsibilities will result in the ultimate fulfillment of the motive. The sharing of the final rewards of this collective activity is expected to result in achievement of individual goals for example, an annual bonus.

Leontiev (1981) also expands on the context of human activity presented in Vygotsky (1978) to include social interaction. He states:

"labour appears from the very beginning as a process mediated by tools (in the broad sense) and at the same time mediated socially." (Leontiev, 1981, p.208)

Leontiev's (1981) statement on the division of labour is critical to the formation of roles within organizations:

(...) what unites the direct result of this activity with its final outcome? Obviously nothing other than the given individual's relation with the other members of the group, by virtue of which he gets his share of the bag from them, i.e., part of the product of their joint labor activity. This relationship, this connection is realised through the activity of other people, which means that it is the activity of other people that constitutes the objective basis of the specific structure of the human individual's activity, means that historically, i.e., through its genesis, the

connection between the motive and the object of an action reflects objective *social* connections and relations rather than *natural* ones. (p.212; italics added)

Translating these concepts into the world of SUNA, one can conceptualize the notion of “role” as an abstraction of actions directed at fulfilling “responsibilities”. Just as tools enable (mediate) collective activity to fulfill a “motive,” and an individual action to reach its “goal”, they can also be expected to mediate a role to fulfill its “responsibility”. For a predictive method such as SUNA to capture the different features necessary in a tool such as a PDA, it must know the various roles and responsibilities of users in selected market segments that the PDA is expected to mediate/facilitate.

Figure 1. Levels of activity in an organization.

Source	Level of Activity	Driving Force	Example
Corporation	Collective	Motive	Leader in telecom
↑ ↓	↑ ↓	↑ ↓	
Abstraction	Role	Responsibility	Increase 50% revenues
↑ ↓	↑ ↓	↑ ↓	
Individual	Individual Action	Goal	Contact 10 clients per week

Figure 1 shows how a corporation may have the motive to be a leader in telecom and is engaged in collective activity to achieve this outcome. The division of labour within the organization allows for roles, which are abstractions with responsibilities to achieve parts that lead to fulfillment of the ultimate motive of being a leader in telecom. The third level consists of individual actions performed by individuals to reach a goal, which is part of their responsibility. Although the levels in Figure 1 are useful to

conceptualize human activity, it is important to note that the levels of activity may change position in the hierarchy. For example what is an individual 's action goal can become a role's responsibility when abstracted or vice-versa.

The role-responsibility continuum shown in Figure 1 is critical to SUNA because it is constructed on the assumption that roles describe what individuals must accomplish to fulfill their responsibilities. Since a role is an abstraction of actions, a responsibility is an abstraction of goals. Instead of the subject-tool-object triad, one can substitute the role-tool-responsibility triad. For example, the field executive role has the responsibility for establishing and maintaining customer relationships, which means that the mediating tool would be expected to have features that assist customer relationships such as the address book and calendar in a PDA. As described by Strens and Dobson (1994), who present a concept they call "responsibility modelling for collecting user needs", the rationale for people's behaviour, their perceptions, and their need for specific resources and information are closely related to their roles and responsibilities.

The description of action as a coordinated part of a collective activity is critical to the division of labour concepts and consequently the basics of role modelling in SUNA.

AT with the inclusion of concepts from Leontiev indicates that the achievement of an outcome is a multifaceted function which depends not only on the ability of the tool to facilitate an action that the subject intends to perform but also on the "praxis" of the community to which the subject belongs. Praxis is defined as a way of doing things guided by the norms and expectations of the community. Furthermore, the attainment of the outcome is also influenced by the norms and values of the communities, which are

affected by the subject's action e.g., the customer, the supplier or the co-worker. The relationship of an individual to a community is useful for the construction of roles because every working individual belongs to an "internal" community of the organization, e.g., a sales group, or a service group. The individual is responsible for performance of his/her role within the organization, which contributes to the achievement of the overall motive of the organization. In addition to belonging to an internal community, the individual's role may require dealing with an "external" community such as customer or suppliers or the lawmakers. For example, a sales person trying to contact customers, using his address book in a PDA, is performing a role to fulfill his responsibility of external contacts to increase the goal of higher sales for the organization that he/she is working for. In this example one expects the sales person to have internal exchange, meaning internal communication, with other company employees to coordinate activities such as delivery and billing and external exchange/communications with the customers.

Yrjo Engeström

Although Leontiev (1981) introduced the notion of labour in Activity Theory, he did not integrate division of labour and community into the activity model itself. Engeström (1987) saw that there were almost two separate models one relating the subject to tool and collective activity and another relating community and division of labour to the object. His model suggested that the original triad of interacting elements, namely subject, tools and object be expanded to include three more interacting elements, namely, the *community* in which the activity is performed, the *rules* governing the activity, and the *division of labour* between subjects (Engeström, 1987). The six

interacting elements of the expanded view of AT as seen by Engeström (1987) are often represented as nodes of a triangular diagram (Figure 2). Problems and conflicts within and between these nodes can occur and are termed contradictions. Often contradictions are seen as promoting development or change (Nardi, 1996; Hassan, 1999). However, this research does not deal with problems and conflicts. Instead it uses Engeström's model to show how typical organizational roles can be derived and used in field studies to test the interaction of generic roles with tools in strategic market segments. A so-called activity system is shown in Figure 2. An activity system can be described from many different perspectives. For example, it could be used to represent the collective activity of an organization, describe a mobile or non-mobile professional, or a specific role.

Figure 2. Engeström's model of activity.

For the purposes of SUNA, which relies on modelling work into roles and predicting the use of tools on the basis of roles driven by responsibilities, Engeström's model thus presents an opportunity to represent the activity model from the perspective of roles.

The top triangle in Figure 2 depicts subjects grouped in a segment to use a variety of tools or devices to fulfill the responsibilities of the roles they play in order to achieve outcomes expected of their roles. The degree to which each device enables the fulfilment of the role's responsibilities can be captured in the interaction of the role played by the subject with the tool. For example, mobile professionals (subjects) with an external exchange role of contacting clients or potential clients may use a PDA (tool) to obtain phone numbers and dial up a cell phone (another tool) to make an appointment with a customer (object) and record this in their datebook on the PDA. The top triangle in Figure 2 implies that the needs of a communication role motivated by the responsibility of increasing something say "sales" in the case of a salesperson must include features such as an address book and a scheduler. The activity system represented in Figure 2 also allows for more than one device assisting the role because the abstract nature of the role does not specify a particular tool. Also, there can be many subjects with the same role of external communication with similar needs. The top triangle thus describes the interaction of the role played by the subject with the tool, which is critical for uncovering similar needs of similar roles. The subject playing a specific role uses a device such as a PDA in conjunction with other devices, say a cell phone. It is this feature of Engeström's model that renders AT suitable for understanding the needs of users representing a certain

market segment of strategic importance in order to predict the features needed in a particular device.

The bottom right triangle shows how division of labour facilitates goal achievement through specification of roles among members of an internal community of an organization for the purpose of acting on the object to achieve an outcome. For example, the members of a production group (internal community) within an organization could be assigned roles (division of Labour) by the Production Manager in order to increase production speed and cut costs (responsibilities). In this context, an internal production role vested with a production supervisor (subject) may have the responsibility to act upon the production line (object) to increase speed of production. In this production-related action, the PDA (tool) could be of assistance in supporting a to-do list (feature) and thus help the internal production role in fulfilling the production responsibility. The bottom right triangle is of direct relevance to role modelling. The division-of-labour node allocates certain roles with responsibilities to every member of the internal organizational community, which in turn contributes to the overall achievement of the organizational objective (motive).

The bottom left triangle depicts the relationship between the subject and the community mediated by rules or “praxis” which is a way of doing things, e.g., the managers may use their PDAs to schedule luncheon appointments with clients. The scheduling feature may assist the manager if it also provides the facility to record associated addresses and phone numbers of the place of meeting, guided by the “praxis” of the community. The bottom left triangle could also be used to depict how the subject as a worker relates to the internal community of the organization, i.e., the coworkers and

management mediated by the norms, rules and policies. It could also be used to depict the external community and environment that a subject has to communicate or deal with, mediated by rules of social behaviour or norms; for example, a serviceman has to arrive on time at the customer's place. Smørðal, Gregory and Langseth (2002) describe how the praxis of the medical community was a barrier in using the PDA as a reference tool.

In Engeström's activity system the four aspects of work are introduced namely production, distribution, exchange and consumption. As discussed later, these aspects of work could be used to classify roles with some modifications.

Figure 3. Engeström's model of activity and the four aspects of work modified.

A consistent way to represent the roles in a typical product/service organization is to consider them in terms of: production/service, distribution, and exchange and consumption. Engeström model of AT, termed the “structure of human activity” includes

the four aspects of work. However, Engeström (1987) model could be further modified due to the flexibility of the activity system to represent how roles played by a subject interact with tools. In this model, which is a product of the current research, “division of labour” provides roles in an organization. The subject is then viewed in the abstract form of roles he/she/they play. With this change the roles interact not just with one tool but many tools to fulfill the responsibility of the role. The responsibility should be viewed as a driving force behind the role mediating through the tool to act on an object to produce an outcome, which fulfils the responsibility. The role, however, is guided by the rules and praxis of the communities with which it is communicating (exchange). The community could be purely internal to the organization (internal community) or external as in the case of customers and suppliers, or both internal and external. The modified activity system with communities representing both internal and external community, division of labour creating the roles, and the subject playing the roles is shown in Figure 3.

Another modification is that service has been added to production as an aspect of work that is closely related. Along with this activity system, the current study uses the four aspects of work to abstract organizational roles into four generic categories, namely production/service, distribution, exchange and consumption roles. In addition, since service roles could be performed in the field this role has been classified into internal and external production service roles. Similarly, the exchange role, which is mainly a communication role, has been categorized into an internal exchange role, meaning that the communication is within the organization and external exchange role, meaning that the communication is with the community outside the organization.

The six new roles generated from the four aspects of work as outlined by Engeström's model include:

1. The production/service role: its responsibility is an outcome obtained through physical and psychological tools. Production could also be used to define service roles. For example, a consultant working at a client's office to produce a marketing report is providing a service. The service is similar to a product in that the outcome is obtained through either physical or psychological tools used by the consultant on the client's premises. Service could be provided either within the organization, as in the case of a TV repair shop, or outside the organization as a consultant working on the client's premises. The production/service role could thus be classified as internal/external. The role is placed in the upper triangle because it predominantly uses tools to achieve necessary outcomes.
2. The distribution role: Its responsibility is to divide and organize human and capital resources to achieve the desired outcome by acting on the relevant object/objects. It is placed in this segment because it mainly deals with the community, especially internal workers. It achieves its outcome through appropriate division of labour manifested in the form of roles and responsibilities assigned to individuals.
3. The exchange role: Its responsibility is the communication with internal and external communities mediated by the rules, norms and beliefs. Because communities could be internal and/or external,

exchanges could be both internal and external to the organization. The exchange role is placed in the bottom left triangle because exchanges (communications) are mediated by praxis and rules of the communities with which the exchange is conducted. For example, certain rules may apply to internal communications between a manager and his/her workers, while a different set of rules may prevail for external communications with the finance department.

4. The consumption role is a meta-role whose responsibility is to use the outcome of the activities of production, distribution and exchange. Although there is no direct mention of what the consumption role might include, it appears to include responsibilities for strategic planning and sales because these are at a meta-level and deal with the consumption of what the organization produces.

The definitions for production, distribution, exchange and consumption are taken from the four aspects of work described by Engeström (1987) using Marxist concepts. The internal and external dimension to production and exchange has been created to study roles in this research. Hereafter these six roles will be referred to as AT roles. This research involving the use of a PDA, seeks to identify needs through an understanding of different AT roles and uses this to predict feature usage for the two selected market segments (mobile and non-mobile professionals). Also, it is expected that the feature usage in the two market segments will differ on the basis of the AT roles present in each segment.

Contradictions and tensions can occur between the role and the tool, which may result in changes to the tool's mediation capabilities, which, when implemented, will expand the horizon for the role-tool interaction, thus permitting better achievement of the desired outcome. Similarly, the tool-praxis interaction could face tensions requiring changes to the tool. For example, a mobile executive may want to use the phone feature only if the tool is shaped as a cell phone not as a box with ear-or headphones because the latter would not conform with his/her image (appear different). AT sees all relationships as two-way, which means when faced with tensions, roles, rules, and tools could all lead to changes in tool features, assignment of roles, and praxis to improve the outcome.

Summary of SUNA

SUNA is an attempt to create a method directed at addressing strategic issues such as feature bundling in new technologies such as wireless PDAs. The activity system describing the interaction of organizational roles as shown in Figure 4 demonstrates that an organization has a number of goals to achieve. In order to reach these goals management organizes work, which is referred to as the division of labour. The division of labour concerns who does what, "who" refers to a person or group of people, and "what" refers to the responsibility assigned to the person or group of people. Division of labour thus creates a number of roles. One person could play many roles e.g., internal production and distribution as a production manager and sometimes many persons may be needed to play a single role, e.g., the entire sales force for external exchange. A role is not a person or a position. Each role in an organization has some responsibility for partial

or complete achievement of the organization's desired outcome expressed in the mission statement (Strens, Turner & Turner, 1999).

The organizational perspective relevant to the role modelling aspect of SUNA is elaborated at a high level in Figure 4. It shows how management (abstraction of role played by managers in an organization) can act on the financial, customer satisfaction or human relationship aspects (objects) to effect a change and thereby collectively achieve an outcome, say a "successful organization." In order to achieve this outcome management could use many tools to facilitate actions e.g., communication equipment, computers, PDAs, knowledge databases, trucks, etc. The behaviour of management would be governed by the rules, ethics and norms of the internal community, which they lead e.g., workers and the external community in which their organization is situated, e.g., laws, regulations, environment protection codes, consumer rules, etc. It is extremely important to note that while tools mediate between management and the object (the items to be acted upon to achieve an outcome), division of labour mediates between community and objects by deciding on the roles necessary to act on the object and achieve the outcome.

Figure 4. An activity system describing the interaction of organizational roles.

Figure 5. A 3-d model of AT and roles

A Three Dimensional Physical Model for SUNA

The activity system describing the interaction of organizational roles in Figure 4 could be made into a triangular pyramid in which the apex is a meeting point of the three mediators namely, rules, roles and tools as shown in Figure 5. The advantage of this model lies in the fact the three critical interfaces for HCI can be viewed: roles-tools, roles-rules, and rules-tools. In this model, if SUNA addresses the roles-tools and rules-tools interface, it will indirectly address the roles-rules interface because the rule/praxis

of the community (be it internal or external) will govern the behaviour of the role. For example, by addressing the external exchange role of a consultant in the field and the way in which the Datebook application in the PDA assists (mediates) the consultant in attending a face-to-face meeting on time, it can also address some of the praxis of the consultant community, which are “keep your appointments and do not be late for meetings.”

Hypotheses:

The present research aims to test the following hypotheses:

1. Some AT roles are either associated with either mobile or non-mobile market segments.
2. Tools people use differs for different AT roles and different market segments. Knowledge of these can predict the uptake of PDA features.
3. Perceived usage is not equal to actual usage.

Method

Design

Table 2 shows the design of the study comprising two groups of participants (mobile and non-mobile professionals) using either a Palm Pilot or a Handspring PDA device.

Table 2

Design of the Field Study

Device	Mobile	Non-Mobile
Palm	6 Users	6 Users
Handspring	6 Users	6 Users

Participants

Twenty-four participants representing mobile ($n = 12$) and non-mobile professionals ($n = 12$) were recruited. Volunteers were sought for participation from several companies and government organizations. Of the 24 participants recruited 21 were male and 3 were female and all were intermediate-expert users with their PDA device. The occupations of the participants included technology consultant, sales person, team leader, information architect, teacher, journalist, executive, systems analyst, researcher, office manager, engineer, and medical educator. A notice of recruitment was

given to personal contacts to help identify others who may be willing to participate in the study. This same notice was posted on newsgroups and forums on the Internet for PDA users as shown in Appendix B.

Handspring Visor or Visor Deluxe and Palm Pilot m100, V, and IV models were selected because they offer very similar features. The Handspring has a modular design that allows for many upgrades (digital camera, mp3 player, voice recorder, etc.). The basic features for these two devices include a scheduler/datebook, address book, to do list, memo pad, e-mail (messages synchronized with PC e-mail), and Hotsync (Backup and synchronization of data between PC and PDA). Users are able to customize features by buying modules for the Handspring to make it wireless or by buying additional applications such as Quick Office (A mini-version of Word, Excel and PowerPoint). All features used during the field study were tracked and logged.

It is important to note that the Research in Motion BlackBerry™ and Handspring Treo™ devices were originally preferred for the study. However, it proved extremely difficult to find non-mobile professionals who used these devices with wireless capabilities. The reason for this might be that these devices are still relatively new and quite expensive. Also, each service provider packages the same models of a device with different features, making it difficult to recruit users with similar feature sets.

Participants had to meet the criteria for the mobile or non-mobile market segment. A mobile professional is an individual who is out of the office for 30% or more of their workweek. Mobile professional user/job types were identified earlier (Narasimhan, 2001) to include stockbrokers, traveling executives, journalists, and sales representatives.

A non-mobile professional spends less than 10% of their time out of the office in a week. As defined in Narasimhan (2001), non-mobile professionals user/job types include HR professionals, dispatchers, researchers and developers, professors, administrative assistants, and managers. All participants were screened for the above criteria and were either Palm or Handspring PDA users. None were paid for their time. The selection process resulted in approximately 40 potential participants either being disqualified due to the above criteria, or participants withdrawing from the study due to time constraints. Six participants were tracked twice (4 weeks) due to the loss of the logged data from their devices.

Materials

A brief questionnaire to determine perceived PDA feature usage was developed as shown in Appendix C. A free downloadable automatic usage application was used to track feature usage as shown in Appendix D, and a questionnaire developed for the pilot study (Narasimhan, 2001) was expanded to collect the information necessary to test the predictions in this study. This is shown in Appendix E. Appendix D contains the notice for recruitment that was given to some personal contacts and posted on the Internet newsgroups for PDA users. Appendix F includes the notice for debriefing a participant.

Procedure

Participants were introduced to the study and screened to ensure they met the criteria for one of the two roles being studied. Participants were then given an informed consent form to sign (See Appendix A). Each participant was interviewed briefly to determine his or her perceived feature usage and perceived frequency of use. The interview protocol is shown in Appendix C. Participants were provided with automatic

usage logs, through an application usage program installed on their Palm Pilots or Handspring PDAs. Some participants were e-mailed the program and asked to install it while others who were available locally had the application beamed onto their device by the experimenter. Participants' PDA usage was then captured for 14 consecutive days to determine their PDA feature usage patterns. To ensure that no data was lost, participants were asked to e-mail their logs to the researcher on the 7th day and 14th day of usage. At the end of the two-week tracking period, a face-to-face interview was conducted at a time and place of convenience to the participant such as off hours in the office, at a public venue, or by phone if the participant was mobile and out-of-town. Consistent with the method described in Narasimhan (2001), usage data were employed to initiate discussion regarding the participant's role and how they used the PDA to fulfill that role. Participants were requested to bring their PDA to the discussion in both face-to-face and phone interviews so that they could refer to it. Participants were debriefed before the application usage program was removed from their PDA. (See Appendix F for debriefing form).

Data Analyses

Two types of data collection methods were employed: (1) interview with participants using a questionnaire (Appendix E) and (2) automated logged data of usage from PDAs. Hypothesis 1 and 2 used data from the interviews and hypothesis 3 used both data from an interview and PDA logs. The statistical analysis for hypothesis 1 and 2 involved the use of chi-square tests to measure association between: (1) AT roles and market segment; and, (2) Tools used and AT roles as well as tools used and market

segment. Finally, to test hypothesis 3, a t-test for related samples was performed for perceived vs. actual usage.

Results

Summary tables for all chi-square statistics, frequency and proportion cross-tabulation and the corresponding chi-square test tables as well as ANOVA summary tables are given in Appendices G and H. The first section of the analysis examines the classification of Activity Theory (AT) roles and whether they show association with the mobile and non-mobile segments. The second section examines if the tools people use differ according to AT roles and market segments and the degree to which this knowledge can help predict the uptake of new PDA features. The third section examines the extent to which perceived usage reflects actual usage. The fourth section examines additional findings with respect to frequently-used features and their relation to the AT roles as well as the purpose for which they are used. That section also examines the additional features desired by different market segments

AT Roles and Market Segments

Classification of Participant Work Roles into AT Roles

Hypothesis 1 stated that 'some AT roles are either associated with either mobile or non-mobile market segments. To test this, all participants were first asked to describe the four main roles they play in their work, yielding a total of 96 responses. A total of 26 different roles were mentioned. These were then grouped into the six AT roles, namely external production, external exchange, distribution, consumption, internal exchange and internal production (see Figure 3, p. 35), which were eventually compared using the chi-

square statistic. The allocation of a mentioned role to an AT role was based on the descriptions provided by participants. For example, an “internal production” role included project management, product development, and systems analysis. The “distribution” role included financial management, staff management, and human resource management. The consumption role included responsibilities for strategic planning and sales management, which are at a meta level and deal with consumption of what the organization produces. Finally, some examples of the external exchange roles are client relations, marketing, education, networking, and interviewing.

Table G1 in Appendix G shows the participants’ four main work roles classified into the AT roles. Of the 96 mentions of roles 42 (43.8%) were internal production roles, 23 (23.9%) were external exchange roles, 13 (13.5%) were distribution roles, 7 (7.3%) were external production roles, and 4 (4.2%) were internal exchange roles.

Eight out of the 26 different roles mentioned fell into more than one AT role because of the way participants described these. For example, one participant was a mobile consultant who did most of the requirements gathering outside of the office while the other was an engineer who gathered most of the requirements within an organization. This led to classifying one participant into the internal production role, while the other was classified as external production

Table 3 shows the distribution of the 96 responses to the roles mentioned by the mobile and non-mobile market segments after allocation into the six AT roles. Table 3 indicates that all (7/7) mentions of the external production role were from the mobile group. Similarly, a majority of external exchange (19/23) and consumption (5/7) roles

were also from the mobile group. A majority of the mentions of the internal production role (30/42) and distribution role (10/13) were from the non-mobile group. Mentions of the internal exchange role were equally divided between mobile (2/4) and non-mobile (2/4) groups.

Table 3

AT Roles within Mobile and Non-mobile Groups

AT Roles	Mobile	Non-mobile	Total
External Production	7	0	7
External Exchange	19	4	23
Consumption	5	2	7
Internal Production	12	30	42
Distribution	3	10	13
Internal Exchange	2	2	4
Total	48	48	96

The chi-square statistic confirmed a significant association between the AT roles and market segments (mobile and non-mobile), $\chi^2 (5, N=96) = 29.55, p < .001$.

Specifically, the external production, external exchange and consumption roles are evidently associated with the mobile market segment while the distribution and internal production roles are associated with the non-mobile market segment.

Predicting the Uptake of PDA Features

Hypothesis 2 stated that tools people use differs for different AT roles and different market segments and this knowledge can predict the uptake of PDA features. To test this participants were asked to identify up to 5 tools they used to fulfill their role responsibilities. These were then rank ordered by frequency as shown in Table 4 and related to the respective market segment before being submitted to a chi-square analyses.

Some 37 different tools were identified. While the complete distribution of these is shown in Table G7 in Appendix G, the 12 most frequently mentioned tools are shown in Table 4. The Table indicates that face-to-face meetings were mainly found in the external exchange role (12/40), internal production role (11/40), and distribution role (9/40). The PDA is predominantly used for the internal production role (27/64) and external exchange role (17/64) while the Internet (11/19), Netmeeting (4/7), PC/computer (16/31), telephone (17/36), and Microsoft project (4/5) were predominant in the internal production role. The cell phone was predominant in the external exchange role (9/16). The distribution described above indicates that some devices are related to certain AT roles. A chi-square test was performed and showed that the cellular phone $\chi^2(5, N=96) = 24.33, p < 0.001$ and face-to-face meetings $\chi^2(5, N=96) = 11.57, p < 0.05$ were significantly associated with the external exchange role, while paper was significantly associated with the distribution role $\chi^2(5, N=96) = 12.12, p < 0.05$.

Table 4

Distribution of Tools Used in Conjunction with the AT Roles

	External Production	External Exchange	Distribution	Consumption	Internal Exchange	Internal Production	Total
PDA	6	17	8	4	2	27	64
Face-to-face	2	12	9	3	3	11	40
Telephone	1	8	5	3	2	17	36
E-mail	1	11	6	3	3	11	35
PC/Computer	4	5	4	1	1	16	31
Internet	1	3		3	1	11	19
Cell phone	4	9		1		2	16
Netmeeting			1	1	1	4	7
Outlook for		2	2		1	2	7

	External Production	External Exchange	Distribution	Consumption	Internal Exchange	Internal Production	Total
scheduler/to do list							
Paper			3	1		1	5
Microsoft Project			1			4	5
Teleconferencing			1			1	2

When analyzing the distribution of tools by market segment as shown below in Table 5, the devices used in conjunction with the PDA reveal a clear pattern. The cell phone (93.8%) is predominantly used by mobile professionals while the computer (64.5%) and Netmeeting (85.7%) are used more frequently by the non-mobile segment. It would seem reasonable that the mobile professionals would rely on their cellular phone to perform their external exchange role since they do not have access to a landline while in the field. Similarly, non-mobile professionals would rely on their desktop computer for fulfilling more responsibilities due to the data intensive nature of their work roles. Non-mobile professionals also use Netmeeting as a means of communicating with those abroad.

Table 5

Distribution of Tools Used in Conjunction with the Mobile and Non-mobile Market Segments

	Mobile	Non- mobile	Total
Cell phone	15	1	16
PC/Computer	11	20	31
Netmeeting	1	6	7
PDA	30	34	64
Face-to-face	17	23	40
Telephone	16	20	36

	Mobile	Non- mobile	Total
E-mail	19	16	35
Internet	12	7	19
Outlook	3	4	7
Microsoft Project	2	3	5

Use of the PDA, face-to-face meetings, the telephone, e-mail, Outlook and Microsoft project appear to be distributed approximately equally between the mobile and non-mobile market segments. This seems reasonable considering that the two segments overlap with respect to certain roles; the tools needed to fulfill these should be similar. For example, both mobile and non-mobile segments may need to plan projects and coordinate meetings using e-mail and Microsoft project. A chi-square test was performed for each tool to see if any of these tools were significantly associated to either market segment. Only the significant results are reported. The cell phone was significantly related to the mobile market segment $\chi^2(1, N=96) = 14.7, p < 0.001$ while the PC/computer $\chi^2(1, N=96) = 3.86, p < 0.05$ and Netmeeting $\chi^2(1, N=96) = 3.85, p < 0.05$ features were significantly related to the non-mobile market segment.

Perceived versus actual usage

Hypothesis 3 claimed that perceived PDA feature usage is not equal to actual usage. To test this, a pre-tracking interview was first conducted to obtain data on perceived PDA feature usage. This was then compared with actual usage as determined via the automatic data log. A t-test for related samples revealed that participants underestimated the frequency with which they used their PDA features $t(23) = -4.313, p < .01$. This supports one part of Hypothesis 3 and substantiates the need for an

automatic tracking feature when the purpose of an investigation is to assess the network capacity needed to service clients.

Contrary to the prediction that users' estimates of features would differ from actual usage, participants here were able to identify PDA features they use quite accurately. Consequently, the t-test for related samples comparing perceived and actual usage yielded no significant difference. Since the PDAs studied here came pre-packaged with the same basic set of features, namely, a scheduler, address book, to do list, memo pad and Hotsync, it is likely that accuracy in estimates increased because of this small sample of features. The proportion of variance accounted for was very low $r^2=0.112$. Therefore, the lack of significance was not due to solely to having a small sample of users.

Baseline for Usage Patterns

Participants were tracked for two weeks using an automatic log to track the frequency of use for the features on their PDA. The raw frequency data are available in Appendix H. To see if two weeks was long enough to reveal stable usage patterns a t-test for related samples was performed by comparing data collected in week 1 with those obtained in week 2. There was no significant difference in frequency of use, $t(23)=.022$, $p>0.80$. Therefore, a period of two weeks of data collection was sufficient to reveal a stable pattern of use.

Device-Independence

Two devices were chosen to track PDA usage. In order to ensure that usage frequency was device-independent, a 2X2 ANOVA was conducted for market segment

(mobile and non-mobile) and device (Palm and Handspring). There were no significant main effects and no significant interaction. Thus, participants did not differ in their usage regardless of whether they were Palm- or Handspring users, or whether they belonged to the mobile or non-mobile market segment. The proportion of variance accounted for (r^2) was examined and found to be very low (mobility = 0.09, device = 0.09, and mobility x device = 0.07) indicating that low power alone could not account for the lack of significance.

The proportion of features used was also measured to verify device-independence. The 2X2 between groups ANOVA for device and mobility with proportion of features as the dependent variable resulted in no significant main effects or interactions. Thus, participants did not differ in the proportion of features used whether they were Palm, Handspring, mobile or non-mobile users. The proportion of variance accounted for (r^2) was examined and found to be very low (mobility = .001, device = 0.13, and mobility x device = 0.06) indicating that low power alone was not the reason for failing to find significance.

The number of features that mobile and non-mobile participants used was also examined. A t-test for independent samples was not significant, suggesting that mobile and non-mobile professionals use approximately the same number of PDA features. This is not surprising considering the limited number of features provided on the PDA devices selected.

*Additional Findings**Frequently-Used Features and the Purposes for which the Features are Used Differ**According to AT Roles*

Participants' frequently-used features were identified (Appendix H). The AT roles were examined to see if there was any relation between the role a participant was playing and the first- and second most frequently-used features. First, the distribution between the role a participant plays and the first most frequently-used feature were examined followed by a chi-square test to determine if any association exists. Since there was little variety in the features most frequently used, the results, although significant, are presented in Table G15 in Appendix G; instead the results based on analysis of the second most-frequently used feature are presented here. The distribution between the role a participant plays and the second most-frequently used feature is shown in Table 6. From Table 6 it appears that the datebook was used for both the internal and external exchange roles (2). The address book (8/12) and e-mail (1/1) were predominantly used for the external exchange role. The to do list (2/2), memo pad (4/4), and Hotsync features (2/3) were used mostly for the internal production role.

A chi-square test was conducted to see if the second most frequently used features were associated with AT role-played when using that feature. The chi-square test indicates that the AT roles may determine the set of features required for that role, $\chi^2(15, N=24) = 36.2, p < 0.01$.

The mobile and non-mobile market segments did not differ significantly with respect to the second most frequently-used features, $\chi^2(5, N=24) = 6.7, p > 0.25$. This is expected given the low number of features to select from.

Table 6

AT Roles Played when Using Second Most Frequently-Used Feature on PDA

Feature	External Production	External Exchange	Internal Production	Internal/External Exchange	Total
Datebook				2	2
Address Book		8		4	12
To Do List			2		2
Memo Pad			4		4
Hotsync	1		2		3
E-mail		1			1
	1	9	8	6	24

The mobile and non-mobile market segments were examined to see if the way in which participants used the second most frequently-used features differed. Table 7 shows that of the second most frequently-used features, the datebook was used by mobile participants to schedule both internal and external appointments (2/2). The address book was predominantly used by mobile professionals (7/8) to add or lookup contacts while in the field. The same address book feature was used by non-mobile professionals to look up both internal and external contacts (4/4). The to do list (2/2) and memo pad (3/4) were mostly used by non-mobile professionals to keep track of action items, to store passwords and jot down notes. Hotsync was used to back-up data from the PDA by non-mobile professionals (2/3). E-mail was used to fulfill urgent requests by a mobile professional (1/1). A chi-square test was conducted and revealed that how a participant uses a second most frequently-used feature is related what market segment they belong to $\chi^2(6, N=24)$

= 14.83, $p < 0.05$. So, although the features that are used do not differ, the purposes for which they are used are associated to either the mobile or non-mobile market segments.

Table 7

How the Second Most Frequently-Used Features were Used by Mobile and Non-mobile Segments

For which purpose was the frequent feature used?	Mobile	Non-mobile	Total
Datebook: To schedule internal and external appointments	2		2
Address book: To add or look-up contacts while in the field	7	1	8
Address book: To obtain internal and external contacts		4	4
To do list: To keep track of action items		2	2
Memo Pad: To store passwords, lists and jot down notes or ideas	1	3	4
Hotsync: To back-up on PC	1	2	3
E-mail: To fulfill urgent request	1		1
Total	12	12	24

Features Desired Differ by Market Segment

In the post-tracking interview participants were asked to nominate three features they would like to see added to their current PDA. Table 8 shows a distribution of the features wanted by mobile and non-mobile users. Mobile users seemed to desire the phone (11/16), GPS (5/5), and a better search feature (2/2). The non-mobile users selected additional memory (2/2), voice-to-text recognition (4/4), voice recorder (3/3) and linking of datebook and to do list feature (2/3).

Table 8

Three Features to be Added to Current PDA

Feature	Mobile	Non-mobile
Phone	11 **	5
GPS	5 **	
Voice Recorder		3 **
Voice Recognition To Text		4 *
Linking Of Features	1	2 *
Memory		2
Improved Search	2	
E-Mail	5	4
Internet	3	2
Backlighting	1	1
Text Messaging		1
Keyboard	2	4
Dictionary		1
Compactness		2
Package With Quick Office	1	
Color Display	1	
Built In Speaker		1

* Indicates significant chi-square at 0.05 level

** Indicates significant chi-square at 0.01 level

A chi-square test was performed for each desired feature and revealed that the mobile market segment was associated with wanting the cell phone $\chi^2(1, N=24) = 6.75$, $p < 0.01$ feature more than the non-mobile market segment as well as the GPS feature, $\chi^2(1, N=24) = 6.32$, $p < 0.01$. The non-mobile market segment desired a voice-to-text recognition feature $\chi^2(1, N=24) = 3.95$, $p < 0.05$ as well as a voice recording feature $\chi^2(1, N=24) = 5.96$, $p < 0.01$ and a way to link the datebook feature and to do list associated with the to do's for the date they are viewing in their scheduler $\chi^2(1, N=24) = 5.45$, $p < 0.01$.

0.02. These differences in desires for additional features indicate that the two market segments require different sets of additional features for their devices.

Discussion

Support for the research hypotheses

Hypothesis 1 stated that AT roles could appropriately differentiate between the mobile and non-mobile market segments. Results (Table 3, p.50) show that all mentions of the external production role were from the mobile professional group. A majority of external exchange and consumption roles were also from the mobile group. A majority of the mentions of the internal production role and distribution role were from the non-mobile group. Mentions of the internal exchange role were equally divided between mobile and non-mobile groups. The chi-square statistic confirmed a significant association between the AT roles and market segments. The field test results thus indicate that the classification of participant work roles into AT roles is satisfactory.

The AT framework and the generic role classification using the six AT-generated roles comprising internal and external exchange, internal and external production, distribution, and consumption appears to accommodate at least the 26 different roles mentioned in this study well. The theoretical implications of these results are described later.

The results indicate that the AT roles can differentiate the mobile from the non-mobile market segment: the proportion of external production, external exchange, and consumption roles were significantly higher among mobile professionals compared to non-mobile professionals. By contrast, the proportion of internal production and

distribution roles were significantly higher among the non-mobile professionals. It is particularly significant that the classification of roles using the AT definitions, which elevate the roles mentioned by participants to a higher level of abstraction, was able to distinguish between two quite similar roles that differ only in very subtle ways, and based on a very limited sample of PDA features. In a typical market segmentation analysis using larger samples than the one used in this study, and incorporating many roles that would differ considerably from one another, one would assume that this framework of AT roles should perform even better. This is important for service providers faced with the problem of designing and bundling features in communication devices.

Hypothesis 2 stated that tools people use differ according to AT roles and market segments and this knowledge can predict the uptake of PDA features. The field tests showed that the tools people use differs for different AT roles and different market segments (see Table 4, p.51) and that knowledge of additional tools used can help predict the uptake of new PDA features. For example, the mobile market segment used the cellular phone and face-to-face meetings as tools for their external exchange and external production roles, suggesting that communication and travel are a necessary part of their activity to fulfill their responsibilities. Tools such as these that aim to predict future usage from a theoretical basis and from knowledge of roles rather than merely focusing on what has loosely been referred to as “User Context” (Kirakowski & Vereker, 1996) are much needed. The current interaction with specific tools is only the first step to understanding the activity profile of roles.

Given the strength of the relationship of cell phones and face-to-face meetings, one can easily derive that GPS, Maps, location-information systems, e-mail, short

message systems and cell phones could be included as part of a PDA package for mobile professionals in addition to their datebook and address book. The role analysis is not only interesting from the point of view of what the roles need in terms of features, but also in terms of identifying what the roles do *not* need. For example, alarms including the alarm clock in the basic features of the BlackBerry™ are assumed to be effective for PDA users. However, this study suggests that the praxis of this mobile community does not allow for alarms and beeps. It is interesting to note the association of the distribution role with paper (see Table 5, p.52). The role's responsibility to "document" offers an explanation; the distribution role involves internal management of resources and people. Acting on the basis of organized notes and documenting what happened in meetings, the deliverables, the commitments, etc., is an important part of the role. While the Graffiti used in some PDAs has been a significant barrier to using these as a writing tool, it appears that the distribution role could benefit from a voice recording facility allowing dictation of messages and notes. Furthermore, a voice-to-text recognition feature enabling conversion of the messages into writing that can be transferred to the computer would also seem beneficial to this role.

The data presented in Table 8 (p.59) provided some insights to the above interpretations. An analysis of the three most desired features in a PDA suggested that these are in line with the AT roles the participants played. The features desired by mobile professionals include GPS to enable face-to-face client meetings and cellular phone for communications, which is in line with their external exchange role, external production and consumption roles. The features desired by non-mobile professionals which include voice-to-text recognition to avoid hassle of typing/writing, and voice

recorder seem to be in line with their major roles of distribution and internal production, which involve producing lots of documents.

Taken together, these findings indicate that the method deserves further research to test the degree to which they may generalize to other roles and other new technologies.

One limitation of the present study is that the PDA is already available and that the two professional communities studied have adopted it. In addition, since the PDAs studied here contained such a small sample of features and capabilities, it is not surprising that the most features used do not differ between the two segments. What is important is that the purpose of use of the features such as datebook and the address book differ between the two populations. Also, the link between the datebook and address book for the mobile professionals and the datebook and to do list for the non-mobile professionals, as elicited from the responses on how they used the features (see Table 7, p.58) indicate that the method is sensitive enough to obtain activity sequences and flows. The hypothesis that perceived frequency of usage differs significantly from actual usage is important because it suggests that methods other than interviews, surveys, and similar techniques designed to capture user opinion should be supplemented by other, more objective data collection methods. Even where a new technology or new features to an existing technology are proposed, it should be possible to log some kind of user activity data that can give an indication of user needs that could (or should) be covered by the new product(s). For example, better knowledge of the context in which mobile professionals typically work could have inspired manufacturers of the BlackBerry™ to sacrifice the alarm clock and provide, say, an integrated address book and mobile phone instead.

Theoretical Implications

The AT framework suggested by Engeström (1987) is of interest to HCI researchers who are exploring different aspects of the activity system. Nardi's research (1996) focuses on understanding individual users' activities, in social contexts. Engeström has applied the AT framework to actual work situations as part of a redesign of those situations. His focus is also on the tensions that can arise between the different nodes in the Activity System. Neither Nardi nor Engeström have specifically explored the "roles" stemming from division of labour in AT. Hasan, Gould, and Hyland (1998) have looked at Executive Information systems and the usefulness of AT in developing the EI systems. Larkin and Gould (1999) have discussed the use of AT in developing role profiles. However, none of these authors have attempted any generic classification scheme to classify roles as was done here.

The current study contributes to the application of AT to organizational roles; specifically, it presents six generic roles from the four aspects of work, as identified by Engeström (1987), and the internal and external communities served by these roles, as identified in this study. The field test revealed that the 6 generic roles based on AT are versatile in abstracting and classifying organizational roles as well as being capable of differentiating the two market segments selected for this study and relating the devices used by these roles and segments.

This study presents a three-dimensional model (Figure 5) to illustrate how the three mediators in AT, namely roles stemming from division of labour, praxis stemming

from rules of the communities, and features stemming from tools could conceptually interface with each other. The tip of the triangular pyramid represents the meeting point of all three mediators. The interaction between the mediators in this model is important because roles interact with features of tools and praxis of communities to enable the subject to work on the object to achieve an outcome. The three-dimensional model places consumption at the base of all organizational activity, which is in line with Leontiev (1987), who viewed all collective activity leading up to an ultimate motive—e.g., organizational activities leading up to a mission statement such as being a “world-leader in wireless communications”. It is also argued that the three-dimensional model is well in line with organizational perspectives in which strategic management encompasses all activities of the organization aiming to set a direction for appropriate planning and execution of roles’ responsibilities. The three-dimensional model thus retains the integrity of the original two-dimensional model of Engeström (1987) although it expands it specifically for the purpose of role modelling.

This study suggests that the three-dimensional model developed for SUNA could provide a framework to analyze the interface of roles with features of tools and the interface of roles with the praxis of the communities in which the roles operate. By understanding user needs from the viewpoints of roles that are generically classified on the basis of six AT roles, this study suggests that it is possible to identify features suitable to different market segments comprising a certain combination of these generic roles. An accumulation of documented information on roles may lead to the formulation of role theory based on activity systems. If knowledge of roles and their interaction with praxis and features were available for the entire set of work roles, it would be possible to have a

manual for role classifications based on job descriptions. The database should also have a list of all the basic responsibilities of each role and how various feature sets are currently being used from a variety of tools including writing on paper or face-to-face meetings. The logistics for developing and maintaining this manual might appear daunting but it is possible given that there are job classification manuals currently available to human resources personnel. With such a road map revealing the necessary details on the roles and patterns of behaviour related to their responsibilities, it would be possible for strategic market researchers and product designers to work together to create offerings with appropriate features for each market segment of importance.

Another advantage of generic role typing is that it can be employed at any level in the organization. For example it could be employed at the organizational level, departmental level or unit level to understand how the organizational roles together lead to the achievement of the organization's motive or what is generally called the "mission statement."

The six generic AT roles, if tested on a variety of market segments and found to be as versatile as the present study suggests they may be, have the potential to reduce the level of complexity in organizational role descriptions. For example, in this study participants mentioned 26 different roles, which were then abstracted to the six generic AT roles. In the pilot study (Narasimhan, 2001) without the generic AT roles, 31 job types mentioned in a brainstorming session were abstracted to six roles. However, these six roles were not generic and, therefore, on repeating the study with another set of job types there may be a need to add new roles to be studied. With the AT roles, the

complexity of role classification is reduced by using the six generic AT roles. One next step could, therefore, be to test the classification in different market segments.

The three-dimensional model presented earlier opens our eyes to the importance of “praxis” in studying feature bundling or any strategic design aspect. The research by Smørdal et al. (2002) indicates that the medical community did not adopt the e-book in a PDA. The medical students had a way of doing things that rendered the e-book reference inconvenient and not viable. Based on the three-dimensional model of activity proposed in this study, it may be possible to explain why the medical community had problems with the e-book on a PDA. It appears that the features of the tool did not match the “praxis” of the medical community. A theoretical explanation can also be found for the success of the design of mini databases on a PDA to match the requirements of different roles within a water quality monitoring plant (Nielsen & Søndergaard,, 2000). These authors found that the roles of the plant operator were drastically different than that of the foreman and manager. On understanding the types of information required by each role, the authors designed a PDA that would link the central PC system and the worker observations to provide appropriate information in a specific context and environment that was most relevant to each role. Their research showed that the information presented on the PDA would differ by role thus reducing the complexity of the display and making it more usable. Theoretically, the tool features in this study have been modified to match the roles and praxis of user groups.

Methodological considerations

Perceived versus actual usage of features differed significantly in this study, suggesting that it is best, where possible, to generate an automated log of activities. This log would not only confirm feature usage but also serve as a reminder to jog users' memory regarding the specific roles and related responsibilities covered at the time of using the feature. The study shows that the two-week period provides a reliable baseline (see page 54) since there were no significant differences between week 1 and week 2. It may thus be sufficient to collect data for one week. The study also demonstrates that users are quite weak at estimating the frequency of use of their applications (see page 53). Hence, merely asking respondents about usage frequency may not provide accurate indications. The statistical results suggest that although the two market segments are similar in their usage patterns, they use the same features for different reasons. For example, the study shows that while both mobile and non-mobile professionals use their datebook and address book the purpose for which these features are used are quite different. In the case of a mobile professional, the datebook use is often followed by a phone call thus suggesting a linkage between the datebook and address book would be useful. On the other hand, non-mobile professionals often have a list of things to do for a specific meeting and would like the datebook to link to the relevant to do list for their reference. Although these are minor tweaking of features, service providers who base the design of such fine-tuned observations will be able to penetrate the market segments better than those who don't.

The questionnaire used for the field study (Appendix E) yielded unambiguous responses; however, it could be shortened because the responses for some questions were

similar. For example, one question stating, “To what extent did the PDA (clarify which PDA) help you carry out your purpose?” was not very useful because the previous question had already stated: “Could you elaborate on what you were doing and the role you were playing?” Thus, the questionnaire could benefit from careful revision.

The study revealed that importance ratings on a list of possible features, a technique generally used in market research, was burdensome for participants. By the same token, another question yielded answers that tied in well with respondents’ roles and the features necessary to fulfill the roles. The results from the question “If you had the opportunity to add 3 functionalities to your handheld devices what would they be?” yielded information that tied back to the roles and how they were using their PDA features (Table 8, page 59). For example, the mention of GPS and cell phones by the mobile professionals tied in well with their external exchange role for which communication capabilities and directional capabilities in a supportive device such as a PDA are important. Similarly, those in the distribution role, that is, internal managers, currently use a lot of notepaper and would like to have voice-to text recognition to reduce the burden of writing. Although some of these revelations may seem obvious, it is worthwhile to note that this may not be the case for other market segments. For example, it would be hard to guess what paramedics and other emergency technicians may want in their PDAs.

The study also showed that whereas participants’ perceived frequency of usage of features differed significantly from actual usage, their perception of which features were used did not differ from what they actually used (p.54). However, more testing is

required to see if their memories are reliable when there are many features that are being used.

Theory Building

With respect to theory building, Roberta Hamilton (1996) states that it is about ...Constructing informed interpretations of what has been, of how we arrived where we are, of the meaning this has for different participants, and then, on that basis, attempting to draw informed predictions about the possible outcomes...(pp.13-14).

Engestrom's model of Activity Theory (1987) has provided a conceptual framework for SUNA and has facilitated the analysis of user needs with respect to disruptive technologies. Engestrom's model provides a coherent, logically linked pattern of relations between the concepts of intentional, collective, human activity in a social community mediated by tools, rules and division of labour (roles). This framework is helpful because one can propose various hypotheses in light of the relationships expounded by the model. When these hypotheses are tested in the field, further evidence can be gathered to support, expand, modify or dispute the model. The framework is also helpful in explaining why the role modelling approach of Constantine and Lockwood (1999) is successful as a practical approach to studying usage centred design. Without a strong theoretical framework, such approaches lack conceptual integrity and also the opportunity for logical exploration of yet to be discovered patterns of relationships.

The current research has expanded on Engestrom's Activity Theory by focusing on the interactions between the role-tool and role-rule interface in a three-dimensional representation in which the mediators converge at the apex of a triangular pyramid. The

hypothesis confirms that roles have an impact on the use of features in a tool; similarly, the praxis of a community not only governs the behaviour of the user or the roles played by the user but in a way affects the fit of the tool features to the communities with which the exchange takes place. The research indicates that the four aspects of work could be used to classify roles in an organization, especially when the roles are considered in relation to the communities in which they are played, for example communities internal to the organization or external to it. Studying the six generic roles adds clarity and reduces the complexity of role classification.

As stated earlier, AT provides a conceptual framework for user-role modelling and, therefore, renders SUNA a method worthy of further expansions and modifications. As further research is undertaken, one can study the relationship of a variety of variables that define the community, tool, rule, and division of labour nodes. Each node provides ample opportunities for theory building. For example, the influence of the environment is one aspect of community that needs expansion and so is the influence of culture including organizational culture and the culture of professional communities with their own praxis such as lawyer, doctors, teachers, carpenters, etc. Similarly, division of labour could be studied with respect to job functions, roles and organizational motives for different types of organizations.

The above arguments lead to the conclusion that whereas AT assists SUNA in creating a logical pattern for interpretation of user needs in strategic situations, further field testing will enable the building of AT models and help in the prediction of outcomes based on observed behaviour of the variables contained in the Activity System. Since the Activity System can operate at different levels, e.g., at the collective level, the abstract

role level and the individual action level (Figure 1, p.30) the opportunities for studying the relationships are endless. The accumulation of experience through testing will help in better prediction of future relevance of tool features to users in strategic groups such as mobile and non-mobile professionals.

Future research

The application of role modelling stretches into the distant future for adaptive applications. Adaptive architecture is an IT architecture that is seen as necessary to meet the multitude of roles and changing needs of users (Mulholland, 2002). This architecture is aimed at supporting multiple roles of an individual as a consumer, worker and member of society. This type of IT architecture may be helpful for devices such as wireless PDAs that have the potential to be “always on” and available for any type of interaction. According to the authors, these types of technological innovations and customer needs should allow organizations to meet consumer lifestyles in a society that is increasingly “always on” meaning that individuals stay connected and are engaged in constant exchange necessary for a variety of roles. To help in adaptive architecture design, SUNA would have to expand its horizons to looking at multiple roles of an adaptive lifestyle in which a user’s corporate, private and community demand for information overlap each other. The information gathered during our study indicates that the merging of corporate and private lives is already happening and soon feature bundling has to keep this in view. For example, a non-mobile professional may not use a specific PDA feature at work but then may need to use it for his/her private life e.g., a role as a parent. SUNA methodology may require modifications in the future to address adaptive architecture solutions. In addition, the merging of personal with corporate needs raises some privacy

issues. Also, the cost of providing one set of tools to manage the enterprise and private lives of employees may be too high. The role of SUNA in adaptive architectures is perhaps too remote for now. In the meantime a practical step would be to explore the applicability of generic roles in the various market segments, accumulate experience on the role-features-praxis interactions, and document them systematically. As stated earlier, this accumulated database would be of significant help to strategic marketers and designers.

Conclusion

Because SUNA followed an experimental design with only two devices and a relatively small sample of users, it was able to uncover the areas of strengths and weaknesses of role modelling in strategic design. The appropriateness of the Activity Theory framework is apparent from the fact that work roles could be classified on the basis of generic AT roles and that they were able to differentiate the two market segments. In addition, different tools were used by the two roles and provided some clues as to what the desired features might be. The desired features provided by respondents were explainable on the basis of other tools used in connection with the PDAs. Whereas the uptake of features was similar in the two segments, the way in which the features were used differed, leading to fine-tuning ideas based on activity flows. Whereas SUNA has been situated in an appropriate framework, more research is necessary to test the generic role classification for different market segments. The experience accumulated may in turn lead to operationalizing the division of labour node in Engestrom's model of Activity and the feature-role-praxis interactions suggested in the three-dimensional model of this study.

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Appendix A

Informed Consent Form to Conduct a User Needs Assessment on Handheld Devices (PDAs)

Introduction

The purpose of an informed consent is to ensure that you understand the purpose and your involvement in the study. The informed consent must provide enough information so that you can determine whether or not you wish to participate in this study.

Study

User Needs Assessment on Handheld Devices (PDAs)

Research Personnel

The following personnel are involved in this research project and may be contacted at any time. Sheila Narasimhan, snarasim@connect.carleton.ca (Principal Investigator), Dr. Gitte Lindgaard (Faculty Sponsor), 520-6629, gitte_lindgaard@carleton.ca. If any ethical concerns about this study should arise please contact Dr. M. Gick (Chair, Dept. of Psychology Ethics Committee), 520-2600 ext. 2664, mary_gick@carleton.ca. Should you have any other concerns about this study, please contact Dr. John Logan (Chair, Dept of Psychology, 520-2600, ext. 2648).

Purpose

The purpose of this study is to identify user roles for personal digital assistant devices (PDAs). The identified roles will lead to recommendations on how to differentiate/bundle these products in order to satisfy the different user role requirements.

Task Requirements

If you use a Palm OS-based PDA, an application to track your usage will be installed on your device (<http://www.bene.hr/appusage.html>). After the automated logs are analyzed, you will be contacted for an interview to get more detailed descriptions of your use as well as any suggestions on how the device may be improved to suit your needs better.

Duration and Locale

The duration of this study will be 14 days and the experimenter may phone you at the end of each week to ensure the data for that week is collected from the usage program via e-mail. The interview following the study may take up 30 minutes of your time and can be conducted during a lunch hour or after hours.

Potential Risk or Discomfort

All participants' data will be coded and remain anonymous. Therefore, no harm shall occur as a result of auto-tracking data from the PDAs.

Confidentiality

The data collected will be coded such that your name will not be associated with the data. The data is to be used only by the researchers involved in this project. Also, we are only interested in analyzing usage of work-related applications.

Right to Withdraw

You have the right to withdraw from the study at any time without penalty.

I have read the above description of the study and understand the conditions of my participation. I agree to participate in this research project.

Participant Name: _____

Participant Signature: _____

Researcher Name: Sheila Narasimhan

Researcher Signature: _____

Appendix B

Announcement For Recruitment (Newsgroups or given in person)

Palm Pilot/Handspring Visor Study

Hi, my name is Sheila Narasimhan from the Human Oriented Technology lab at Carleton University. I will be conducting research on Palm Pilot/Handspring Visor users. The purpose of this study is to identify user roles for personal digital assistant devices (PDAs). The research will lead to recommendations on how to bundle features for these products in order to satisfy different customer requirements.

I need your help!

The study will take two weeks and will not be intrusive. First, I will conduct a brief interview on how you use your device. At most, this interview will take 5 minutes of your time.

Your usage will then be tracked for two weeks using an automatic logging program. The program will track frequency and duration of application use, not what you actually input into the device. For example, if you were to send e-mail, I would only know that you opened your e-mail editor; I would not be able to read the contents of your message or determine what you were doing with the program.

After I examine the usage log, I will contact you for an interview. The interview would last for approximately 30 minutes and aims to get more detailed descriptions of your use as well as any suggestions on how the device may be improved to suit your

needs better. The interview may be conducted by phone or in a public venue such as a restaurant, cafeteria at your workplace or coffee shop.

Please note that this study is in no way connected or affiliated to the organization you work for.

For any additional information, e-mail me at snarasim@connect.carleton.ca.

Thanks again for your participation!

Sheila Narasimhan

Preliminary Interview Questionnaire

1. What is your job title?
2. Do you spend more than 30% of your time outside the office? Y N
3. Do you spend less than 10% of your time outside the office? Y N
4. Could you please indicate which applications you use in Table 1?
(write down if phone interview)
5. Also, please indicate how you use the _____ (application) on average per week.

[illegible]

Application Used	Number of Times Used in a Week
-	-
-	-
-	-

Note. The dashes indicate that the participant had to fill in the cells of this table.

Thanks for this information. I look forward to touching base with you after usage on your PDA has been tracked for two weeks. I will be sending you a program that will automatically log the frequency and duration of the applications you use. I will then call you at the end of each week and guide you on how to e-mail the data to me.

May I have your e-mail address and phone number so that I can guide you on installing the tracking program?

E-mail:

Phone Number:

I appreciate your participation and look forward to working with you!

Appendix D

PDA Automatic Usage Log for Palm Users

Figure D1 illustrates the four main screens of the automatic usage log application, Application Usage 0.8.1, installed on the participants' PDAs.

Figure D1. Screenshots of the Automatic Usage Log

Appendix E

Interview Guide

Introduction

Hello, _____. Thank you for participating in this research project. I have looked at your log sheet for portable devices. It reveals a number of interesting usage patterns, which we will explore shortly. First of all, I would like to discuss the various roles you have in carrying out your job.

User Roles

A role is an abstraction, say, for example: Managing your staff, maintaining client relations, improving productivity, increasing sales, budgeting, field service, researching, managing the business, public relations, and marketing.

Fill out the answers to questions 1-3 in Table 1.

1. What would you say are your 4 main roles?
2. *Probe for each role.* Which devices do you use for the _____ role?
3. *Rate each device by role in the grid of Figure E1.* On a scale of 1 to 5, where 1 is very unimportant, 3 is neutral and 5 is very important, to what extent is this device important for this role?

Very Unimportant	Unimportant	Neutral	Important	Very Important
1	2	3	4	5

Figure E1. Importance rating scale

Table E1

Responses to Questions 1-3

Roles	Devices	Ratings				
		1	2	3	4	5
	-	-	-	-	-	-
	-	-	-	-	-	-
-	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
-	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
-	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
-	-	-	-	-	-	-
	-	-	-	-	-	-

Note. The dashes indicate that the interviewer had to fill in the cells of this table.

4. Are there other portable wireless devices that you use in addition to the ones mentioned above?

5. From your log analysis, I noted that in the 14 days your PDAs were used for the following purposes. *Insert graphs and data gathered.*
6. Is this representative of your usage pattern? *If answer is "no", then probe for reasons.*

Scenario 1

7. Let us look at your most frequently used application, i.e. _____. To be more specific, let us look at log # _____, which refers to this application. Could you elaborate on what you were doing and the role you were playing?
8. To what extent did the PDA (clarify which PDA) help you carry out your purpose?
9. Did you need to use other devices in conjunction with the _____ (PDA)?
10. Please explain how the _____ (other device) was used in conjunction with the _____ (PDA).
11. What would say are the key advantages of the _____ (the PDA) with respect to _____ (this particular function)?
12. What are the key drawbacks of the PDA with respect to _____ (this particular function)?
13. If you were to suggest improvements to the _____ (specific function on this PDA), what would they be?

Scenario 2

14. Is there another function of importance corresponding to one of the logs here that we should talk about? If yes, could you elaborate on what you were doing and the role you were playing.
15. To what extent did the PDA (clarify which PDA) help you carry out your purpose?
16. Did you need to use other devices in conjunction with the _____ (PDA)?
17. Please explain how the _____ (other device) was used in conjunction with the _____ (PDA).
18. What would say are the key advantages of the _____ (the PDA) with respect to _____ (this particular function)?
19. What are the key drawbacks of the PDA with respect to _____ (this particular function)?
20. If you were to suggest improvements to the _____ (specific function on this PDA), what would they be?
21. Of the following features and functionalities, which ones are important to your use of handheld devices? Please rate each feature or functionality on a scale of 1 to 5, where 1 stands for very unimportant, 3 stands for neutral and 5 stands for very important. *Note responses in Table E2.*

Table E2

Importance Ratings of PDA Features

Feature/ functionality	Importance				
	1	2	3	4	5
Overall Size (Compactness)	-	-	-	-	-
Large Screen Size	-	-	-	-	-
Wireless Connectivity	-	-	-	-	-
Functionalities					
Phone	-	-	-	-	-
Voicemail	-	-	-	-	-
E-mail	-	-	-	-	-
Fax	-	-	-	-	-
Unified Messaging	-	-	-	-	-
GPS	-	-	-	-	-
Internet Access	-	-	-	-	-
Corporate Intranet Access	-	-	-	-	-
Information Services (Maps, Stock Quotes, Hotel + Airline Booking)	-	-	-	-	-
Banking	-	-	-	-	-
E-commerce (Shopping)	-	-	-	-	-
Alarm	-	-	-	-	-
Scheduler	-	-	-	-	-

Feature/ functionality	Importance				
	1	2	3	4	5
To Do List	-	-	-	-	-
Voice Memo	-	-	-	-	-
Address Book	-	-	-	-	-
E-Wallet	-	-	-	-	-
Collaborative Apps (Planned and Ad hoc communications)	-	-	-	-	-
Other: _____	-	-	-	-	-
Other: _____	-	-	-	-	-
Other: _____	-	-	-	-	-

Note. The dashes indicate that the interviewer had to fill in the cells of this table.

Concluding Questions

22. Why did you decide to select _____ (PDA name) over other PDAs?
23. If you had the opportunity to add 3 functionalities to your handheld devices what would they be?
24. On a scale of 1 to 3 where 1 stands for novice and 3 for expert, where would you place your level of expertise with your most used handheld device? *Note name of handheld device and expertise on the grid of*

Figure E2.

Handheld Device Type: _____	Novice	Intermediate	Expert
	1	2	3

Figure E2. Grid Describing Handheld Device and Level of Expertise

25. Why did you rate yourself as a _____?
26. What are the barriers that prevent you from using the PDA to its full capabilities?

Thank you for your time. I will provide you with a synopsis of my findings.

Appendix F

Debriefing

The research I am conducting is of interest to high-tech companies in the wireless space, which are engaged in identifying functionalities of PDAs that would suit critical user groups. Currently, a large number of wireless devices proliferate the market and has left the user much confused with respect to comparative advantages and disadvantages. This confusion has slowed down the adoption of these devices. High-tech companies are interested in understanding the users of such products and their needs as the wireless space becomes increasingly significant.

The present research was designed to identify user roles for personal digital assistant devices (PDAs). User roles are abstractions derived from user types. A sales representative and a traveling executive could be user types. The identified roles will lead to recommendations on how to differentiate these handheld products in order to satisfy the different requirements of users in various roles.

The log of PDA usage that you provided has been useful in enabling us to focus on specific examples of use to answer the following questions:

1. Which PDA functions are used most frequently by each user type or role?
2. What is the relationship of the PDA functions to the work done?
3. What other devices are used to accomplish what the user wants?

4. What gaps prevail in the current devices and their interactions toward completing the work of each user role? What features would be advantageous?
5. What are the users in this role trying to accomplish?
6. What are the main tasks of users in this role?
7. What capabilities are required to support whatever users in this role need to accomplish?

The data we gathered from this study will enable us to determine the key changes in features or functionalities that are necessary to the PDAs currently available in the market in order to make future devices more effective for users in critical roles.

Thank you for participating in the study. Your time and effort are greatly appreciated!

Please feel free to contact us at any time if you wish to discuss any aspects of the research. Sheila Narasimhan, snarasim@connect.carleton.ca (Principal Investigator), Dr. Gitte Lindgaard (Faculty Sponsor), 520-6629, gitte_lindgaard@carleton.ca. If any ethical concerns about this study should arise, please contact Dr. M.Gick (Chair, Dept. of Psychology Ethics Committee), 520-2600 ext. 2664, mary_gick@carleton.ca. Should you have any other concerns about this study, please contact Dr. John Logan (Chair, Dept of Psychology, 520-2600, ext. 2648).

Appendix G Summary Tables for Hypotheses 1 and 2

*Summary Tables Related to Hypothesis 1*Table G1 *Classification of Roles Mentioned by Participants into AT roles*

Role	AT Roles						Total
	External Production	External Exchange	Distribution	Consumption	Internal Exchange	Internal Production	
Client relations		9					9
Marketing		2					2
Education		2					2
Networking		2					2
Interviewing		1					1
Field reporting		1					1
Fundraising		2	1				3
Staff management			10		1		11
Financial management			1				1
HR management			1				1
Project management						9	9
Technology solutions						4	4
Systems analysis						3	3
Innovation						2	2
Photographer						1	1
Videographer						1	1
Product development	1					5	6
Research	3	2				7	12
Support	1	1			1	4	7
Design	1					3	4
Process				1		3	4

	AT Roles						
Role	External Production	External Exchange	Distribution	Consumption	Internal Exchange	Internal Production	Total
development/strategies							
Corporate strategy				4			4
Sales				1			1
Client account				1			1
management							
Quality assurance	1						1
Requirements gathering		1			2		3
Total	7	23	13	7	4	42	96
χ^2 (5, N=96) = 303.3, p < 0.001							

Table G2

Chi-square Test for Roles Mentioned by AT roles

Chi-square Test	Value	Df
Pearson Chi-Square	303.344**	125
Likelihood Ratio	217.966	125

** $\chi^2 (5, N=96) = 303.3, p < 0.001$

Table G3

Roles Mentioned by Participants in Mobile and Non-mobile Groups

Role	Statistic	Mobile	Non-mobile	Total
Client relations	Frequency	8	1	9
	Row %	88.9%	11.1%	100.0%
Marketing	Frequency	2		2
	Row %	100.0%		100.0%
Innovation	Frequency	2		2
	Row %	100.0%		100.0%
Sales	Frequency	1		1
	Row %	100.0%		100.0%
Corporate/business strategy	Frequency	3	1	4
	Row %	75.0%	25.0%	100.0%
Networking	Frequency	2		2
	Row %	100.0%		100.0%
Account management	Frequency	1		1
	Row %	100.0%		100.0%
Quality assurance	Frequency	1		1
	Row %	100.0%		100.0%
Interviewing	Frequency	1		1
	Row %	100.0%		100.0%
Field reporting	Frequency	1		1

Role	Statistic	Mobile	Non-mobile	Total
	Row %	100.0%		100.0%
Design	Frequency	1	3	4
	Row %	25.0%	75.0%	100.0%
Project management	Frequency	2	7	9
	Row %	22.2%	77.8%	100.0%
Financial management	Frequency		1	1
	Row %		100.0%	100.0%
Systems analysis	Frequency	1	2	3
	Row %	33.3%	66.7%	100.0%
Product development	Frequency	2	4	6
	Row %	33.3%	66.7%	100.0%
HR management	Frequency		1	1
	Row %		100.0%	100.0%
Raise funding	Frequency	1	2	3
	Row %	33.3%	66.7%	100.0%
Process development/ strategies	Frequency	1	3	4
	Row %	25.0%	75.0%	100.0%
Requirements gathering	Frequency		3	3
	Row %		100.0%	100.0%
Photographer	Frequency		1	1
	Row %		100.0%	100.0%

Role	Statistic	Mobile	Non-mobile	Total
Videographer	Frequency		1	1
	Row %		100.0%	100.0%
Technology solutions	Frequency	2	2	4
	Row %	50.0%	50.0%	100.0%
Education	Frequency	1	1	2
	Row %	50.0%	50.0%	100.0%
Research	Frequency	7	5	12
	Row %	58.3%	41.7%	100.0%
Staff management	Frequency	4	7	11
	Row %	36.4%	63.6%	100.0%
Support	Frequency	4	3	7
	Row %	57.1%	42.9%	100.0%
Total	Frequency	48	48	96

Table G4

Chi-Square Test for Roles Mentioned by Participants in Mobile and Non-mobile Groups

Chi-square test	Chi-square value	df
Pearson Chi-Square	31.850	25
Likelihood Ratio	39.898	25
$\chi^2 (25, N=96) = 31.85, p > 0.1$		

Table G5

AT Roles Within Mobile and Non-mobile Groups

AT Roles	Statistic	Mobile and Non-mobile Groups		
		Mobile	Non-mobile	Total
External Production	Frequency	7		7
	Row %	100.0%		100.0%
External Exchange	Frequency	19	4	23
	Row %	82.6%	17.4%	100.0%
Distribution	Frequency	3	10	13
	Row %	23.1%	76.9%	100.0%
Consumption	Frequency	5	2	7
	Row %	71.4%	28.6%	100.0%
Internal Exchange	Frequency	2	2	4
	Row %	50.0%	50.0%	100.0%
Internal Production	Frequency	12	30	42
	Row %	28.6%	71.4%	100.0%
Total	Frequency	48	48	96
	Row %	50.0%	50.0%	100.0%

Table G6

Chi-Square Test: AT Roles by Mobile and Non-mobile

Chi-Square Test	Chi-Square Value	Df
Pearson Chi-Square	29.552	5
Likelihood Ratio	33.610	5
$\chi^2 (5, N=96) = 29.55, p < 0.001$		

Summary Tables Related to Hypothesis 2

Table G7

Tools Employed by Participants to Fulfill AT Roles

Tools	External Production	External Exchange	Distribution	Consumption	Internal Exchange	Internal Production
Face-to-face	2	12	9	3	3	11
PDA	6	17	8	4	2	27
Internet	1	3		3	1	11
PC/laptop	4	5	4	1	1	16
X-ray						1
E-mail	1	11	6	3	3	11
Netmeeting			1	1	1	4
Telephone	1	8	5	3	2	17
Radio						1
Cell phone	4	9		1		2

Tools	External Production	External Exchange	Distribution	Consumption	Internal Exchange	Internal Production
Scales						1
Paper			3	1		1
Newspapers						1
Stethoscope						1
Printer						2
Poster		1				
Teleconferenc ing			1			1
Outlook		2	2		1	2
Laptop		3				1
Database	1					2
Consultants	1					
Graph software		1				1
Microsoft Project			1			4
Guitar tuner						1
Statistics on side effects		1				
Books/Papers						2
Blood tests						1
Camera		1				1
Conference						1

Tools	External Production	External Exchange	Distribution	Consumption	Internal Exchange	Internal Production
Whiteboard			1			1
Classes						1
Prototypes			1			
PowerPoint		1		1		
Frontpage						1
Video						1
Newsgroup		1				
Piano		1				

Table G8 *Chi-Square Test of Tool Used (Cell Phone) in Conjunction with AT Roles*

Cell	External Production	External Exchange	Distribution	Consumption	Internal Exchange	Internal Production	Row%
Selected	25.00	56.25	0.00	6.25	0.00	12.50	16
Not Selected	3.75	17.5	16.25	7.5	5.00	50.00	80

 $\chi^2(5, N=96) = 24.33, p = 0.00019$

Table G9 *Chi-Square Test of Tool Used (Paper) in Conjunction with AT Roles*

Paper	External	External	Distribution	Consumption	Internal	Internal	Row%
	Production	Exchange			Exchange	Production	Total
Selected	0.00	0.00	60.00	20.00	0.00	20.00	5
Not Selected	7.69	25.27	10.99	6.59	4.40	45.05	91

 $\chi^2(5, N=96) = 12.12, p = 0.033$
Table G10 *Chi-square test of device used (face-to-face) in conjunction with AT roles*

Face-to face	External	External	Distribution	Consumption	Internal	Internal	Row%
	Production	Exchange			Exchange	Product ion	Total
Selected	5.00	30.00	22.50	7.50	7.50	27.50	40
Not Selected	8.93	19.64	7.14	7.14	1.79	55.36	56

 $\chi^2(5, N=96) = 11.57, p = 0.041$

Table G11

*Distribution of Tools Used in Conjunction with the Mobile and Non-mobile Market**Segments*

Tools	Statistic	Mobile	Non-mobile	Total
Face-to-face	Frequency	17	23	40
	Row %	42.5%	57.5%	100%
PDA	Frequency	30	34	64
	Row %	46.9	53.1	100%
Internet	Frequency	12	7	19

Tools	Statistic	Mobile	Non-mobile	Total
	Row %	63.2%	36.8%	100.0%
PC	Frequency	11	20	31
	Row %	35.5%	64.5%	100.0%
Telephone	Frequency	16	20	36
	Row %	44.4%	55.6%	100.0%
Cell phone	Frequency	15	1	16
	Row %	93.8%	6.3%	100.0%
E-mail	Frequency	19	16	35
	Row %	54.3%	45.7%	100.0%
Netmeeting	Frequency	1	6	7
	Row %	14.3%	85.7%	100.0%
Outlook	Frequency	3	4	7
	Row %	42.9%	57.1%	100.0%
Microsoft Project	Frequency	2	3	5
	Row %	40.0%	60.0%	100.0%

Table G12

Cell Phone Used to Support Mobile Market Segment

Cell Phone	Mobile	Non-Mobile	Row%
			Total
Selected	93.75	6.25	16
Not Selected	41.25	58.75	80
Total	50.0	50.0	96

$\chi^2(1, N=96) = 14.7, p = 0.00013$

Table G13

PC Used to Support Non-mobile Market Segment

PC	Mobile	Non-Mobile	Row%
			Total
Selected	35.48	64.52	31
Not Selected	56.92	43.08	65
Total	50.0	50.0	96

$\chi^2(1) = 3.86, p = 0.049$

Table G14

Netmeeting Used to Support Non-mobile Market Segment

Netmeeting	Mobile	Non-Mobile	Row% Total
Selected	14.29	85.71	7
Not Selected	52.81	47.19	89
Total	50.0	50.0	96

 $\chi^2(1) = 3.85, p = 0.05$ *Additional Analysis*

Table G15

AT Roles Played When Using Most Frequently Used Feature on PDA

Most Frequently Used Feature	Statistic	External Production	External Exchange	Internal Exchange	Internal/External Exchange	Total
Datebook	Frequency		4	8	7	19
	Row%		21.1%	42.1%	36.8%	100.0%
Address Book	Frequency		3		1	4
	Row%		75.0%		25.0%	100.0%
To Do List	Frequency	1				1
	Row%	100.0%				100.0%
Total	Frequency	1	7	8	8	24
	Row%	4.2%	29.2%	33.3%	33.3%	100.0%

Table G16

Chi-Square Test: Activity Theory Role Played when Using Most Frequently Used Feature

Chi-Square	Chi-Square	Df
Tests	Value	
Pearson Chi-Square	29.194**	6
Likelihood Ratio	13.979	6

** $\chi^2(6, N=24) = 29.19, p = 0.00006$

Table G17

Chi-Square Test: How the Feature Was Used Related to Most Frequently Used Feature

Chi-Square	Chi-Square	Df
Tests	Value	
Pearson Chi-Square	48.00**	10
Likelihood Ratio	29.56	10

** $\chi^2(10, N=24) = 29.19, p = 0.0000009$

Table G18

Chi-Square Test: Purpose for Which the Most Frequently Used Feature's Use Related to Mobile and Non-mobile Segments

Chi-Square	Chi-Square	Df
Tests	Value	
Pearson Chi-Square	15.905**	5
Likelihood Ratio	20.938	5

** $\chi^2(5, N=24) = 15.90, p = 0.007$

Table G19

Chi-Square Test: Mobile and Non-mobile Segments and Most Frequently Used Feature

Chi-Square	Chi-Square	Df
Tests	Value	
Pearson Chi-Square	2.474	2
Likelihood Ratio	2.908	2
$\chi^2(2, N=24) = 2.47$ p = 0.290		

Table G20

Chi-Square Test: Mobile and Non-mobile Segments and Second Most Frequently Used Feature

Chi-Square	Chi-Square	Df
Tests	Value	
Pearson Chi-Square	6.667	5
Likelihood Ratio	8.653	5
$\chi^2(5, N=24) = 6.67$ p = 0.247		

Table G21

Chi-Square Test: Second Most Frequently Used Feature and Role Played when Using Feature

Chi-Square Tests	Chi-Square Value	Df
Pearson Chi-Square	36.22**	15
Likelihood Ratio	39.12	15
$\chi^2(15, N=24) = 6.67, p = 0.002$		

Table G22

Chi-Square Test: Mobile and Mon-mobile Segments by how Second Most Frequently Used Feature is Used

Chi-Square Tests	Chi-Square Value	Df
Pearson Chi-Square	14.833	6
Likelihood Ratio	18.925	6
$\chi^2(6, N=24) = 14.83, p = 0.02$		

Table G23

Chi-Square Test: Mobile and Non-mobile Wanting a Phone as an Additional Feature for Their PDA

Chi-Square	Chi-Square	Df
Tests	Value	
Pearson Chi-Square	6.75	1
$\chi^2(1, N=24) = 6.75, p = 0.0094$		

Table G24

Chi-Square Test: Mobile and Non-mobile Wanting GPS as an Additional Feature for Their PDA

Chi-Square	Chi-Square	Df
Tests	Value	
Pearson Chi-Square	6.32	1
$\chi^2(1, N=24) = 6.32, p = 0.012$		

Table G25

Chi-Square Test: Mobile and Non-mobile Wanting Voice to Text Recognition as an Additional Feature for Their PDA

Chi-Square	Chi-Square	Df
Tests	Value	
Pearson Chi-Square	3.95	1
$\chi^2(1, N=24) = 3.95, p = 0.047$		

Table G26

Chi-Square Test: Mobile vs. Non-mobile Wanting Voice Recorder

Chi-Square Test	Chi-Square Value	Df
Pearson Chi-Square	5.96	1
$\chi^2(1, N=24) = 5.96, p = 0.015$		

Table G27

*Chi-Square Test: Mobile vs. Non-mobile Wanting Linking of Datebook and To Do List**Features*

Chi-Square Test	Chi-Square Value	Df
Pearson Chi-Square	5.45	1
$\chi^2(1, N=24) = 5.45, p = 0.02$		

Appendix H : Summary Tables for Hypothesis Three

Table H1

Predicted and Actual Data

Mobility	Device	Predicted	Predicted	Predicted	Actual	Actual	Actual	Actual	Week 1	Week2
		Frequency	Number	Proportion	Number	Proportion	Frequency	Frequency	Frequency	Frequency
			of	of	of	of		Proportion		
			Features	Features	Features	Features		Used		
			Used	Used	Used	Used				
Mobile	Palm	183.00	5.00	38.46	4.00	30.77	140.00	4.17	67.00	73.00
Mobile	Palm	84.00	5.00	38.46	3.00	23.08	107.00	3.19	50.00	57.00
Mobile	Palm	55.00	6.00	46.15	4.00	30.77	172.00	5.13	81.00	91.00
Mobile	Palm	27.00	3.00	23.08	2.00	15.38	31.00	.92	16.00	15.00
Mobile	Palm	54.00	4.00	30.77	4.00	30.77	122.00	3.64	53.00	69.00
Mobile	Palm	25.00	5.00	38.46	5.00	38.46	134.00	4.00	71.00	63.00
Mobile	Handspring	85.00	6.00	46.15	5.00	38.46	122.00	3.64	67.00	55.00
Mobile	Handspring	35.00	3.00	23.08	5.00	38.46	57.00	1.70	36.00	21.00
Mobile	handspring	74.00	9.00	69.23	6.00	46.15	258.00	7.69	122.00	136.0
Mobile	handspring	242.00	6.00	46.15	5.00	38.46	268.00	7.99	145.00	123.0
Mobile	handspring	35.00	3.00	23.08	5.00	38.46	181.00	5.40	84.00	97.00
Mobile	handspring	140.00	6.00	46.15	5.00	38.46	413.00	12.31	201.00	212.0
Non- mobile	palm	28.00	5.00	38.46	6.00	46.15	247.00	7.36	148.00	99.00
Non- mobile	palm	39.00	3.00	23.08	2.00	15.38	39.00	1.16	20.00	19.00
Non- mobile	palm	58.00	6.00	46.15	4.00	30.77	59.00	1.76	27.00	32.00

Mobility	Device	Predicted	Predicted	Predicted	Actual	Actual	Actual	Actual	Week 1	Week2
		Frequency	Number	Proportion	Number	Proportion	Frequency	Frequency	Frequency	Frequency
			of	of	of	of		Proportion		
			Features	Features	Features	Features		Used		
			Used	Used	Used	Used				
Non-mobile	palm	18.00	2.00	15.38	3.00	23.08	93.00	2.77	41.00	52.00
Non-mobile	palm	56.00	5.00	38.46	5.00	38.46	171.00	5.10	77.00	94.00
Non-mobile	palm	38.00	5.00	38.46	5.00	38.46	46.00	1.37	21.00	25.00
Non-mobile	handspring	66.00	7.00	53.85	5.00	38.46	118.00	3.52	73.00	45.00
Non-mobile	handspring	41.00	4.00	30.77	5.00	38.46	61.00	1.82	35.00	26.00
Non-mobile	handspring	142.00	6.00	46.15	5.00	38.46	253.00	7.54	118.00	135.0
Non-mobile	handspring	23.00	5.00	38.46	6.00	46.15	182.00	5.43	98.00	84.00
Non-mobile	handspring	40.00	2.00	15.38	1.00	7.69	12.00	.36	7.00	5.00
Non-mobile	handspring	53.00	5.00	38.46	5.00	38.46	68.00	2.03	28.00	40.00

Table H2

T-Test: Difference of means between perceived frequency of usage and actual frequency of usage

Pair	t	df	P
Frequency Predicted and Actual	-4.313	23	.000
Frequency Used			

Table H3

T-Test for Paired Samples Test: Difference of means between perceived number of features used and actual number of features used

Pair	t	df	p
Predicted Number of Features Used –	1.70	23	.102
Actual Number of Features Used			

Table H4

Independent Samples Test: Proportion of features used by mobile and non-mobile professionals

	t	df	P
Proportion of features	.152	22	.880

Table H5

Independent Samples Test: If Mobiles and Non-mobile use Same Frequency of PDA Features

	t	df	P
Frequency of Usage	1.429	22	.167

Table H6

One-way Between Groups ANOVA Mobility X Frequency of Usage: Do Mobile and Non-Mobiles Differ in Frequency of Usage

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17930.667	1	17930.667	2.042	.167
Within Groups	193195.833	22	8781.629		
Total	211126.500	23			

Table H7

2X2 Between Groups ANOVA Mobility X Device: Is Usage frequency Device-Independent

Source	df	F	P
Device	1	2.03	.17
Mobility	1	2.19	.15
D * M	1	1.56	.22
D Within-Group Error	20		
Total	24		

Table H8

2X2 Between Groups ANOVA: Is Proportion of Features Used is Device-Independent.

Source	df	F	η	P
Device (D)	1	3.10	.13	.09
Mobility (M)	1	.03	.001	.87
D * M	1	1.25	.06	.27
D Within-Group Error	20			

Table H9

Paired Samples Test: Difference in Usage Frequency in Weeks 1 and 2

Week	t	df	p
Week 1 – Week 2	.224	23	.825