TOWARDS A FRAMEWORK, THROUGH ACTION RESEARCH, FOR MOBILE COMPUTING DIFFUSION AND ADOPTION WITHIN A SMALL-TO-MEDIUM SOUTH AFRICAN CONSTRUCTION COMPANY

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Abstract

Although many organizations strive to employ the latest technologies, the adoption and diffusion of these technologies might not happen as anticipated. The growth of small-to-medium businesses can have a detrimental impact on the efficiency of the employees in executing internal business processes. In many cases, particularly in this scenario, technology was called upon to remedy the situation. Through a canonical action research project, we investigated and analysed the technology adoption and diffusion issues that the professional construction management team of a small-to-medium-sized construction company was experiencing. During this action research project, literature suggested that technology adoption issues were confirmed. In addition new issues were identified and analysed. By means of a conceptualized figure, the changes in the understanding and relationships among mobile computing adoption and diffusion issues experienced in this construction company were illustrated. This study concludes by providing a theoretical framework that illustrates the mobile computing adoption and diffusion issues, as well as an explanation of significant issues that should be considered in the endeavour of successful mobile computing adoption and diffusion within a small-to-medium-sized construction company, based in Gauteng, South Africa.

1. Introduction

In the last few years there has been exceptional growth in all facets of the property sector of the South African market (Ramabodu, Kotze and Verster, 2007: 10). This has resulted in exceptional growth for property development and construction companies. Market conditions in South Africa allowed the entry of many newly formed local entrepreneurial businesses and international investors to the market, resulting in an increase in competitiveness within the sector (Ramabodu, Kotze and Verster, 2007:10). These two components, increased growth of the sector and the market demand to improve the delivery of products and services, are forcing companies to explore all possible means of improving construction processes, administration processes and reporting transparency (Chotchai, Ogunlana and Ning-Fu, 2004: 645).These are similar to the pressures felt in first world countries and which have challenged the industry to become more efficient and integrated (Bowden *et al.,* 2006: 664).

The author believes that companies in the construction industry in South Africa generally strive for the same strategic objectives: generation of greater profits to effectively increase their "bottom line". However, we need to consider the fact that these strategic objectives cannot be achieved without the proper adoption of innovative technological solutions (Yetton, Johnston and Craig, 1994: 57). Although the term "technological solutions" may also include innovation in terms of a construction company's daily construction practises, in this specific research project we refer to innovative use of Information and Communications Technology (ICT).

It can be agreed that ICT covers a great spectrum of technologies. However, for this research project the researcher restricted himself to mobile computing. For the purpose of this study, the term "mobile computing" was defined as referring to battery-powered, portable, and computing and communication devices that can connect wirelessly to and through the Internet or to a private network to access centrally located information or application software, or which permit formal communication via email or Internet faxing (Mobile Computing, 2007). This would include devices such as laptop PCs (also known as notebooks) with wireless LAN or WAN or 3G technology, smart mobile phones and Personal Digital Assistants (PDA's) with 3G connectivity. With this definition in mind, we believe that, with the increase in affordability, maturity and the pervasiveness of mobile computing technologies such as handheld computers (PDA), Smart Phones and Laptop PC's, together with the latest generation wireless communications infrastructure, it is

becoming more and more feasible to employ mobile technology functionality on South African construction sites.

Bearing the foregoing in mind, the author believes that there is a need to establish the feasibility of the successful implementation of mobile computing technologies within small-to-medium South African construction companies, not only focusing on the available mobile computing technology, but specifically considering the implication of this on professional workers, in an attempt to identify barriers to users' adoption of this, as well as the impact of the technology.

In simpler terms, the objective of this study can be put as a question: What are the main issues influencing the process of mobile computing diffusion and adoption within a small-to-medium South African construction company?

This study focused on a small-to-medium construction company based in Gauteng, South Africa. The author holds the position of IT Manager at the research site and also acted as facilitator for the adoption of mobile computing. The aim therefore was to facilitate the process of mobile computing adoption that would allow the author (IT Manager) to identify, analyze and expand on the understanding of the main issues that should be considered in the extensive adoption of mobile computing, specifically at managerial level within this construction company. This objective was achieved by introducing mobile computing technologies to specifically identified users, monitoring the impact of these, documenting the findings and presenting the findings by means of a conceptualized figure highlighting the main issues that should be considered when attempting the extensive adoption of mobile computing.

In his attempt to answer the question posed above, the author considered literature of similar situations encountered. However the literature available was very limited, because of the research location (South Africa) and the research topic. Interesting conclusions from previous studies were found with regard to SMEs in South Africa, the construction industry and ICT in South Africa and, of course, the adoption of ICT in the South African context. Although literature presents the results of studies conducted with regard to Mobile ICT, many studies focused on the industry (macro-analysis) as a whole or considered enterprise type companies in first world countries. The author was therefore able to contribute to the current scientific knowledge by identifying and

resolving issues perceived as barriers, with the aim of enhancing the process of adopting mobile computing within the South African context.

The paper proceeds as follows: contextualising the research title by consulting scientific knowledge available, followed by a holistic description of the problem issue. Thereafter a theoretical explanation of possible mobile computing adoption and diffusion issues, as suggested by the literature survey, is provided. This is followed by a description of the research methodology blueprint that was employed to address the research question presented above. Analysed and documented findings are presented in Chapter 3 in the form of a conceptualized figure that provides a cohesive theory of the main mobile computing adoption and diffusion issues that were identified during this research project. Final deliberation remarks on the findings as presented are then considered. In conclusion recommendations are made for possible future research endeavours.

2.   Contextualization of the research problem

The purpose of this section is to provide the context of this research project with regard to the specific research topic. The aim therefore is to allow preliminary reflection on the current understanding of the ICT adoption issues within a South African construction company in the small-to-medium enterprise (SME) sector.

In order to allow a clear understanding of the concepts within the scope covered by the title of this paper to the researcher will provide some background on the three main concepts. Firstly, he will provide background on the importance of the small-to-medium enterprise environment in an economy such as that of South Africa. Secondly, he will expand on the understanding of ICT in the South African construction industry. Finally the researcher will consider literature that sheds light on issues that might be encountered within this South African construction company, specifically with regard to the adoption of mobile computing technology.

2.1   The South African Small-to-medium enterprise sector

Based on the fact that this study was carried out in the SME sector, it was thought that it would be insightful to enlighten the reader on the author's understanding of this sector and it was considered important to provide some background of the characteristics of the sector. Let us first consider some definitions: The SME Department of the World Bank employs the following definitions: Micro enterprise – up to 10 employees, total assets of up to $10,000 and total annual sales of up to $100,000; Small enterprise – up to 50 employees, total assets and total sales of up to $3 million; Medium enterprise – up to 300 employees, total assets and total sales of up to $15 million" (Ayyagari *et al.,* 2007:433). Based on the fact that the construction company studied here has a total workforce of 250 employees, and an annual turnover of $14, 6 million (R120 million annual turnover based on a rand-dollar exchange rate of R7.50), the construction company studied can be classed as a medium-sized enterprise within the South African economy.

Berry *et al.*, (2002: 4) state that SME's as enterprises "have economic roles to fulfil". SME's contribute to a specific country's GDP by manufacturing goods of value or through the delivery of services to consumers within the market (Berry et al., 2002: 4). The World Bank Group expands on this concept and believes that the SME sector plays

a role in sustained global and regional economic recovery (Ayyagari *et al.*, 2007:415). Furthermore, according to Ayyagari *et al.,* (2007:415) the World Bank Group also considers the development of the SME sector as vital to its strategy for fostering economic growth, employment and poverty alleviation. The extent of the importance of SMEs in developing countries such as South Africa is substantiated by the statistics provided by Ayyagari *et al.,* (2007:419), who states that, within South Africa, the SME sector employs 82% of the total formal labour force in manufacturing. Berry *et al.,* (2002: 4) even believe that, at least in theory, South African SMEs haves considerable potential to generate employment and upgrade human capital. This thought is supported by Ladzani and Van Vuuren (2002: 154) who state that the proliferation of SME's "contributes significantly to job creation, social stability and economic welfare across the globe".

Although the foregoing is very brief, its intent is only to suggest the importance of the SME sector, provided that the construction company being studied is considered as a medium-sized enterprise based on the definition provided by the World Bank Group (Ayyagari *et al.*, 2007:433). Let us now consider ICT within a South African construction company that operates within the SME sector.

2.2   ICT in the South African construction industry

Riemenschneider, Harrison and Mykytyn's (2001: 270) study of "Understanding IT adoption decisions in small businesses" was conducted in a different environment from that of South Africa (United States) and focused on different aspects (IT Adoption decisions of small business executives regarding a website), however their findings provide support for the preliminary concept presented in this paper. They found that many SME businesses had basic problems with the use of PC technologies, including poor software quality, lack of training and inability to relate ICT investments to business value. Peansupap and Walker (2006: 370) support this notion and state that an SME faces unique ICT adoption constraints and should foster a supportive environment to allow effective adoption of ICT. This environment should facilitate ICT diffusion by allowing for constructive sharing and building of internal knowledge. This knowledge refers to how the ICT initiative technically works and how it should be applied to enhance the business processes. Peansupap and Walker (2006: 370) also mention that many IT managers in an SME business also lacked technology awareness, and therefore obstructed ICT innovation benefits. Love *et al.,* (2001: 36) agree with this but refer to

these issues as organizational barriers and encountered these issues in their attempt to implement an emergent technology such as e-commerce in small-medium-sized construction contracting companies in Australia.

In the case of the construction company studied here we can relate to the concept that "experienced construction project managers generally have limited ICT knowledge themselves if their experience was shaped before ICT became integral to current management practice" (Peansupap and Walker, 2006: 373). Most of the construction project managers in the construction company being studied here fit this statement exactly, in the sense that most of their experience dates from the period before ICT became integral to the average employee's daily function. With the above-mentioned in mind, it can be agreed that the lack of general computer skills and the significant limitation to ICT application use (Peansupap and Walker, 2006: 374), could ultimately hamper the process of ICT innovation and adoption. Although they do not explicitly state this, Love *et al.,* (2001: 34) agree with the concept mentioned by Peansupap and Walker (2006: 374) above. They approached this issue from a different perspective and referred to it as a "lack of IT awareness". They believe that the "lack of IT awareness" is a barrier that tends to inhibit the adoption of information and technology in the construction industry. Also, as mentioned by Peansupap and Walker, (2006: 374) most professional construction workers are generally engaged with site management work and have minimal professional development time to learn new skills, specifically ICT skills. Peansupap and Walker, (2006: 374) suggest that site foremen (managers) in particular, had little time to learn ICT skills and that many of them did not have the foundation computer literacy skills possessed by many younger staff members with tertiary education. This notion is also supported by Love*.,* (2001: 34) who suggest that the "lack of employee education and training" is also seen as a perceived threat to the adoption and diffusion process. With project managers engaged in even more rigorous management tasks across a portfolio of projects, the situation presented allows even less time for ICT training.

Bearing the limitations and situation presented above and with the growing pervasiveness of wireless Internet connection, laptops, smart phones and PDA's, it is believed that the adoption of these technologies could provide a major impact on the daily function of the average professional construction worker (Bowden *et al.,* 2006: 664).

Unfortunately, the implementation of ICT type solutions is not straightforward. This implies that, although the physical technical deployment of a solution may be simple, its successful adoption may not be quite as simple (Love *et al.,* 2001: 36). This raises a major issue – although the company would like to implement the latest technology, its actual benefits may not be realized because of other related issues. In the case of the construction company studied here, although its executive management team believe that ICT is vital from a strategic point of view, many of the experienced employees in managerial positions do not really visualize the benefits that ICT may contribute to the overall productivity of their daily function. It can therefore be assumed that possible underlying issues may pose a threat and are thus seen as possible barriers to the successful adoption of ICT within the company.

Let us now consider possible ICT adoption issues from the perspective of the medium-sized construction company studied here.

2.3 ICT Adoption and diffusion in South Africa

As mentioned previously, the author believes that organizational strategic objectives cannot be achieved without the proper adoption of innovative solutions, specifically those solutions provided by ICT. Many argue that ICT is considered the "silver bullet" that will solve all business issues. But is this the case? It is believed that we need to consider other non technological issues, to allow successful ICT adoption. Peansupap and Walker (2006: 365) believe that understanding of ICT diffusion constraints could contribute to the ability to the better management and improvement of the ICT diffusion processes through identification of the barriers and devising ways of overcoming these. Furthermore, Songer *et al.*, (2001: 9) argue that poor implementation of IT systems could be attributed to the corporate culture rather than to technology issues. With that in mind, for the purpose of this study the impact of corporate culture on the adoption of ICT will be referred to as social issues.

There are many studies that attempt to identify key drivers and barriers (issues) of successful ICT implementation (Laage-Hellman and Gadde 1996; Songer *et al.,* 2001; Tucker *et al.,* 1999; Stewart *et al.,* 2002). Although these research studies adopted different approaches, their findings suggest that common barriers include low levels of IT skills and lack of IT investment. Love *et al.,* (2001: 36) are more specific and mention two barriers that can be considered as non-technological issues: "lack of employee

knowledge" and "a reluctance to form collaborative partnerships". Peansupap and Walker (2006: 370) support the first-named issue and found that senior business managers' lack of experience in ICT may ultimately lead to user resistance and lack of confidence in ICT implementation strategies. They also consider the issue of training vital to the successful adoption of IT, a notion that is supported by Love *et al.,* (2001: 34). However, Peansupap and Walker (2006: 371) also believe that, although the importance of training is highlighted, the content coupled with the delivery method and the quality of the training could impact on the diffusion of ICT. They believe that the provision of basic training could provide an elementary understanding of the ICT concepts, benefits and know-how, but that this may lead to trainers focusing on technical context, leaving no platform to allow users to learn how to apply the ICT innovation in their daily function.

Love *et al.,* (2001: 34) and Stephenson and Blaza (2001: 11) agree that users should have an effective support system. However, this relates not only to support on a training level or from top management, but also to technical issues. Stephenson and Blaza (2001: 5) mention that training is an ongoing activity and forms part of systems development. The uncertainty of functions and complexity of the ICT application can also lead to lack of confidence in users' perception of its value or effectiveness and could effectively promote user resistance (Peansupap and Walker, 2006: 371). Although Stephenson and Blaza (2001: 5) acknowledge these concepts in a systems development situation, it can be agreed that the objectives of systems development and of the diffusion of mobile computing can be reduced to a single objective: the successful adoption of an innovative technological solution. Stephenson and Blaza (2001: 5) also state that, without the support and ongoing process of training, personal learning gaps may develop and that, as this gap widens, users will give up using the ICT application and ultimately develop negative perceptions regarding its use.

It is clear from the above that suitable support structures are vital to the successful adoption of an ICT component. However, it is necessary to take note of the delivery method of the support tool. Technical support which is provided remotely may be perceived as negative, because many users prefer to have "hands-on" assistance to solve an ICT-related issue – a "show me how" rather than a "tell me how" learning approach applies (Peansupap and Walker, 2006: 373). This need for training and technical support, predominantly delivered by a "hands on" approach, is confirmed by other research studies (Laage-Hellman and Gadde 1996; O'Brien 2000; Love *et al.,*

2001; Stephenson and Blaza 2001; Tucker *et al.,* 2001; Whyte and Bouchlaghem 2001; Weippert *et al.,* 2002). This concept is relevant to the research environment of this particular company and is a plausible objective because of the size of the construction company and the number of professional construction workers who depend on ICT to perform their daily functions effectively and would require ICT support.

Although most of the studies mentioned above reported on ICT diffusion initiatives in a first world country such as Australia, they reported on several non-technological issues with regard to ICT innovation implementation and that are important in the context of this research project. They specifically mentioned the fact that intense management interventions are necessary to facilitate a supportive environment. The author concurs with this concept; the executive team should not only acknowledge its support by an informal nod, but should constantly drive and assist the ICT champion to allow the successful adoption of mobile computing within this medium-sized construction company. This suggests that the executive management of this medium-sized construction company should be actively and closely involved in aligning the ICT strategic objectives with the company's overall strategic objectives. Bowden *et al.,* (2006: 665) list some of the objectives, from a construction company's perspective, that may be achieved by employing innovative ICT solutions. These include:

- reduction in defects (snagging process);
- reduction in waste (due to time lost due to disconnected; communication from site personnel and material not provided within allowable quantity);
- increase in productivity (real time access to company network);
- increase in predictability (transparent reporting model); and
- effective reduction in operation and maintenance costs.

Although the above stated concepts are indicative of an appealing desire, it is the author's opinion that the actual successful implementation of ICT-based solutions within a SME business run much deeper than the actual technology itself.

Love *et al.,*(2001: 36) and Songer *et al.,*(2001: 9) support the fact the non-technological issues should not be ignored or sidelined and state that many construction companies appear to have insufficient understanding of the organizational and non-technological issues of strategic ICT adoption.

Bowden *et al.,* (2006: 664) show that many argue that the reason for the construction industry being slow to adopt new technologies is that these technologies have not yet been modified to suit the needs of the industry. The author agrees with Bowden et

al.,(2006: 664), who state that new technologies are easier to implement in a stable environment that is clean, such as a manufacturing production line housed within a factory. Another issue is the fact that workers, especially the professional construction management team, have to travel to the construction site and take the technology with them (Bowden *et al.,* 2006: 664). Furthermore, on the construction site the worker is exposed to extreme conditions such as natural elements and crime. The technology is also exposed to these conditions, as well as to an unacceptable mobile service provider network infrastructure (Bowden *et al.,* 2006: 664). Although the author agrees with this to some extent, it cannot be denied that there are other related non-technological issues that may pose greater barriers to the successful adoption of ICT – more specifically barriers to the adoption of mobile computing in a medium-sized construction company.

Peansupap and Walker (2005: 195) state that very few of the empirical studies focus on factors and processes influencing the diffusion and adoption of ICT. Their study thus provides an illustration of their perceived process during the adoption of ICT within a construction company in Australia. They believe that the adoption of ICT is initially triggered by internal policy regarding core ICT competencies; thereafter a champion emerges with support from external ICT resources. This process is followed by a decision to invest in the ICT initiative and then by its actual adoption. Thereafter the company is said to adopt and implement the initiatives resulting in business results. They also believe that the company's vision has a direct influence on strategic ICT adoption and implementation within a construction company. They believe that a company's vision functions as a long-term strategic objective of ICT adoption, while the company's policies support ICT implementation by providing the framework for business processes and employee behaviour.

The successful implementation of ICT initiative is thus a resource-intensive activity that needs to be closely integrated with business initiatives (Peansupap and Walker, 2006: 375). Not only should standard support systems, such as an IT help desk, be provided but consideration should also be given to using other supporting structures, such as peer and collegial support.

In the next section the literature presented above is considered as a whole and specific issues that will ultimately have an impact on the outcome of this research project are identified.

2.4   A pre-conception of specific ICT adoption issues within a medium sized construction company

The following section presents issues of the author's pre-conception of the logically identified ICT adoption issues, as suggested within the literature above, that could be considered in order to influence the adoption and diffusion of mobile computing within the this particular construction company.

2.4.1. Organization Level

It is important to note that a platform or environment is provided by the executive management team that allows employees to execute their daily functions at a predetermined output rate, as required by the organization. There are issues and concepts defined within this domain that are maintained and mainly influenced by the organization. Although identification of the issues identified is based on the findings of other authors, as mentioned in Sections 2.1, 2.2 and 2.3, a set of issues based on the findings in the literature was drawn up and grouped into four logically identifiable issues. The main issues mentioned, derived from preliminary literature review, include: "Politics", "Training and Support", "Technology compatibility" and "Company Vision, Strategy and Internal Policy". These issues are described below.

2.4.1.1 .   *Politics*

Songer *et al.*, (2001: 9) state that poor implementation of IT systems can mainly be attributed to corporate culture rather than to technology issues. In this study this concept is referred to as forming part of company politics. It is the author's opinion that this is mainly due to the fact that the company's corporate culture and politics describe how the organization as a whole is influenced.

2.4.1.2 .   *Training and Support*

Peansupap and Walker (2006: 370) state that organizations should foster a supportive environment to allow effective adoption of ITC. This environment should facilitate ICT diffusion by allowing for constructive sharing and building of internal knowledge. Although this statement could include a range of items, Peansupap and Walker (2006: 371), Love *et al.*,(2001: 34) and Stephenson and Blaza (2001: 11) agree on two specific concepts that need to be addressed: ICT training and ICT support. Peansupap and Walker (2006: 371) and Love *et al.*,

(2001: 34) consider the issue of training as vital to ICT adoption and Love et al., (2001: 34) and Stephenson and Blaza (2001: 11) agree that users should have an effective support system. These issues are grouped together because of their overlapping definitions and consequences, but can also be considered as separate issues. Stephenson and Blaza (2001: 5) support this statement by stating that training is an ongoing activity, part of systems development. But this statement by Stephenson and Blaza (2001: 5) should be correlated with the meaning of "support", depending on the internal policy of a company followed, in terms of the support system adopted. This can be achieved if the organization adopts a policy of training users in providing support.

2.4.1.3. *Technology compatibility*

Bowden *et al*., (2006: 664) raise the issue of technology compatibility and argue that the reason that the construction industry has been slow to adopt new technologies is that these technologies have not yet been modified to suit the needs of the industry. Since most professional employees within this environment will face natural elements on a daily basis, the author agrees with Bowden *et al.,* (2006: 664) who state that new technologies would be easier to implement in a stable environment that is clean, such as a manufacturing production line housed within a factory.

2.4.1.4. *Company Vision, Strategy and Internal Policy*

As mentioned within the literature Peansupap and Walker (2006: 369) believe that the vision of a company has a direct influence on strategic ICT adoption within a construction company. They state that a company's vision functions as a long-term strategic objective of ICT adoption, whereas the company's policies support ICT implementation by providing the framework for business processes and employee behaviour. These terms were grouped together because of their significance and relevance. As the literature suggests, the ICT strategy direction of a company is governed by the company's vision and achieved through the implementation of its internal policies.

2.4.2. User Level

The author also identified set of issues that are mainly influenced by a user within this construction company. These issues ultimately relate directly to an employee. For the

purpose of this study this situation refers to the issues manifested by the participants in this study, as suggested by the literature mentioned above. This concept refers to the personal boundary of a user. This could also be seen as the skills, knowledge and social dimension that the users and employees have gained and which allows them to execute their functions at a pre-determined standard. Concepts defined within this domain are considered to be maintained and mainly influenced by each user individually. The main issues mentioned within this domain and derived from preliminary literature review include: "Education level", "Personal belief","ICT literacy", "Experience and exposure".

2.4.2.1.   Education level

As previously mentioned, Peansupap and Walker (2006: 371) and Love *et al.,.,* (2001: 34) all consider the issue of training to be vital to the successful adoption of IT. Although this issue was addressed in "Training and support", the approach here is more on an individual level, whereas in the section "Training and support", the perspective was more from the organizational viewpoint. Peansupap and Walker (2006: 371) also highlighted the content-coupled issues with regard to the delivery method and the quality of training that could impact on the diffusion of ICT. This, based on this researcher's understanding, might suggest differentiation of the types of users, based on the level of their formal education, as well as on the institution at which it was obtained.

2.4.2.2.   Personal belief

This concept is derived from Peansupap and Walker (2006: 371) who stated that uncertainty of functions and the complexity of the ICT application could also lead to a negative perception among users of its value or effectiveness and could effectively promote user resistance. However, this sentiment can be changed through the adoption of an effective training and support strategy.

2.4.2.3.   ICT literacy

Peansupap and Walker (2006:374) refer to the lack of general computer skills and to the significant limitation to ICT application use, which they regard as barriers to the adoption of ITC. Love *et al.*, (2001: 34) refer to this concept as a "lack of IT awareness" and, as previously mentioned, consider it a barrier to the adoption of IT in the construction industry. Also, as mentioned by Peansupap and Walker (2006: 374), most professional construction workers are generally

engaged with site management work and have minimal professional development time to learn new skills, specifically ICT skills.

2.4.2.4. Experience and exposure

Love *et al.*,(2001: 36) and Songer *et al.*,(2001: 9) agree that, on a organizational level, construction companies appear to have insufficient understanding of the organizational and social issues of strategic ICT adoption. Peansupap and Walker (2006: 370) consider this concept on an individual level and believe that user resistance is based on the consequence of senior business managers' "lack of experience in ICT". In this research project, this issue is considered from an individual's perspective. This deduction is based on the fact that individual users would have to be influenced if organizational change is to take place.

The findings of other authors have been taken into consideration and it is now possible to provide context with regard to the issues that may impact on the successful adoption of ICT by this medium-sized construction company. The next section will provide a background of the research environment and will consider the issues identified above from a practical perspective and will ultimately serve as a problem statement.

## 3.	Issues and Background to the Problem

At the outset the author decided that he wanted to work with a real world problem and would therefore have to base the study on a local company with local issues. To make it even more relevant he decided to base his study on the company by which he is currently employed – a small-to-medium construction company based in Gauteng, South Africa. He currently holds the position of IT manager and is seen as the ICT adoption champion within this construction company.

Yetton, Johnston and Craig (1994: 57) found that smaller companies may not adopt new technology as quickly as larger companies, even though the ICT solution does not require a substantial amount of capital (Riemenschneider, Harrison, and Mykytyn, 2001: 276). These statements largely correspond with what was initially found from analysis of the environment in this particular company for this research project.

3.1. The Research Environment

The company selected operates within the small-to-medium business sector, but is considered a medium-sized construction company. It has been active since 1995. The company has been involved in a large amount of projects across South Africa and has its head office in Gauteng, South Africa. It has been involved in civil, residential and commercial projects over the past 12 years. Its current focus is on undertaking civil work for the national energy supplier, as well as on residential property projects. However it is also expanding its current operations with regard to commercial property projects.

In most of its construction projects it fulfils the role of main contractor and relies heavily on subcontractors for most of the construction work on a particular project. This suggests that the company requires robust administration processes that allow the successful administration of the payment certificate claims, as well as of payments to suppliers and subcontractors.

3.2. Research Background

The executive management team of the particular construction company under investigation believes that ICT is vital from a strategic approach. However, many of the experienced employees who occupy managerial positions do not appreciate the benefits that ICT may contribute to their overall productivity. With this in mind, the ICT technologies and packaged software applications employed by some members of the management team are quite impressive. However this unfortunately only includes a handful of persons if the size of the workforce is considered. Some employees do not employ ICT technologies to the same extent. This suggests either a lack of awareness or that these employees may not yet have been exposed to the possible benefits that ICT may offer, or that there may be other related issues that may impact on the successful adoption and diffusion of ICT.

Although the packaged software applications that have been successfully adopted by certain members of the management team are only visible in specific business areas, they have made a positive difference in the administration burden of these areas. However, the executive management team does not seem to be able to relate these benefits or ICT investment to business value. This is borne out by the fact that ICT costs incurred are assumed as an expense and are budgeted for on a monthly basis. There is

also no platform of evaluation of implemented ICT solutions that would allow the executive management team to evaluate these solutions, thereby providing a means for calculating the business value of the particular ICT investment.

Based on the initial analysis of the research environment, it is the author's opinion that the technology is not failing the people within this construction company, but that the people (employees) are failing the technology. To expand on this statement, it is believed that underlying "social issues" are perceived as the possible causes of resistance to ICT and thus constitute a barrier to the successful adoption and diffusion of ICT within this company. Peansupap and Walker (2006: 371) support this finding and consider this as one of the three main gaps in terms of constraints to the implementation of ICT. Peansupap and Walker (2006: 371) also state that "The second gap is associated with senior managers' lack of experience in ICT adoption when introducing ICT applications into an organization. This can also lead to user resistance". Love *et al.*, (2001: 36) and Songer *et al.,* (2001) refer to these issues as organizational and "social issues". With reference to the third gap, they also state that many construction companies appear to have understanding of organizational and "social issues" with regard to strategic ICT adoption.

In the paragraph above reference was made to organizational and "social issues". However, for the purpose of this research project, the focus will be on "social issues" and on their impact on the successful adoption of mobile computing.

In elaborating on the concept of "social issues" the following set of statements may be considered as explanation. Taken together, these statements were considered to form the definitions used in this research project. As mentioned by Love *et al.* (2001: 34) "social issues" refer to:

- "resistance from management" (especially middle management);
- "lack of investment in an IT infrastructure";
- "lack of IT awareness";
- "lack of employee education and training";
- "degree of organizational change required"; and
- "a belief that the industry is doing well without IT".

With this in mind the author believes that "social issues" directly impact on the successful adoption and diffusion of mobile computing within this small-to-medium construction company.

In some instances experienced employees are very keen to adopt innovative solutions, but the effort to acquire the skills to adopt these innovative solutions successfully seems to present barriers to their successful adoption. With this in mind, it can be argued that, from a business users' perspective, there is a need to establish an environment that would facilitate the easier acquisition and sharing of knowledge so as to aid the users to perform their daily functions more effectively. Yetton, Johnston and Craig (1994: 57) agree with this notion although in a different situation. They believe that the technical issues are resolvable in many cases and will decrease over time, but that people or "social issues" involved in adopting a particular emergent technology need more attention and are perceived to be a greater threat to the successful implementation of the particular technological innovation.

3.3.   The Research Objective

With regard to the objective of this study, the goal was to use it to identify and expand on the understanding of the issues involved in the extensive adoption and diffusion of mobile computing technology, specifically at managerial level within the selected construction company, specifically focusing on the "social issues" aspect. The findings from this research project have allowed the ICT adoption champion to identify and better understand these issues, and enabled him to manage and execute his function more successfully.

The author believes that the participants have benefited from this study. It is thus suggested that the findings derived from this study provided the IT manager with possible techniques that can be implemented to address and possibly overcome the social barriers to successful adoption of mobile computing technologies by this medium-sized construction company. This, in turn, allowed the internal IT department to establish an environment that provided tools and support methods whereby the users could empower themselves and become more efficient in their daily function. This took the form of training tools that allowed users to address skill shortages, or the provision of extensive internal IT support structures that addressed any IT-related issues, particularly business critical issues.

3.4. The Participants

The 5 participants (A, B, C, D and E) selected for this research project are employed by the construction company and have very different backgrounds. Each participant was specifically selected because of certain specific characteristics in their backgrounds.

Participant A has held the position of Site Agent for the last four years and previously held the position of Site Manager (Foreman). He does not have a formal tertiary qualification and his knowledge and skills are mainly based on practical experience. His selection was based on his middle management status and on the fact that he fulfils his job function from a construction site office. His situation presented the researcher with a well suited research scenario that was analysed for issues that impacted on the successful adoption of mobile computing technologies.

Participant B has held the position of Contract Manager for the last ten years. He obtained his degree in construction management in 1995and has recently completed a course in project management. Although Participant B had only been with the company for a few months at the initiation stage of this research project, he had already identified vital issues regarding the current business processes and is currently involved in a project to implement best practices with regard to work execution on site. Based on his dynamic approach to taking on tasks, the author believed that he would be an A list Participant and it was expected that he would manifest no or very few barriers to the successful adoption of ICT within this company. His selection was based on the fact that he would provide constructive feedback on the action research activities and possible mobile computing adoption and diffusion issues.

Participant C obtained his Honours degree in construction management in 2006, and has held the position of junior Contract Manager for the last year. Because of his fresh memory of his construction management degree studies and the fact that his generation would be the users to take innovative ICT solutions forward, a decision was made to include Participant C in the study. The assumption was that Participant C would be very susceptible to innovation offered in the form of technological advancement as well as re-engineering of business processes.

Participant D obtained his degree in 1977, and was Site Manager in previous his career. Participant D was appointed as a Contract Manager at this construction company and

has been employed at this company for the last two years. Participant D's environment is depicted by the fact that he is not able to function like a fellow head office colleague by using basic technology such as email, electronic faxing or standard tools such as word processing and spreadsheet-like applications as a standard in executing his daily function. Although Participant D can envisage the benefits that technology may provide within the building industry, he is expected to manifest most of the barriers to successful adoption of mobile computing within this construction company.

Participant E obtained his degree in 1979 and in previous positions mainly held the position of Contract Manager. He worked for a well known construction company in South Africa for most of his career. On leaving that company he joined a small-to-medium-sized construction company stationed in Gauteng, South Africa, where he worked up until 12 years ago when he and a then colleague founded their own construction company – the construction company which is the subject of this study.

The decision to include Participant E allowed better understanding of the vision with regard to ICT technology employment within the company. Also, Participant E has an in-depth understanding of the current business processes in place. He has held all the positions listed above and has seen the impact and benefits of ICT on the current business process. Therefore, in his position of Managing Director, Participant E will also provide vital feedback with regard to possible suggestions for improvement of current business processes via the deployment of mobile computing technologies.

The diagram below provides an organogramme of the participants that were selected for this research project:
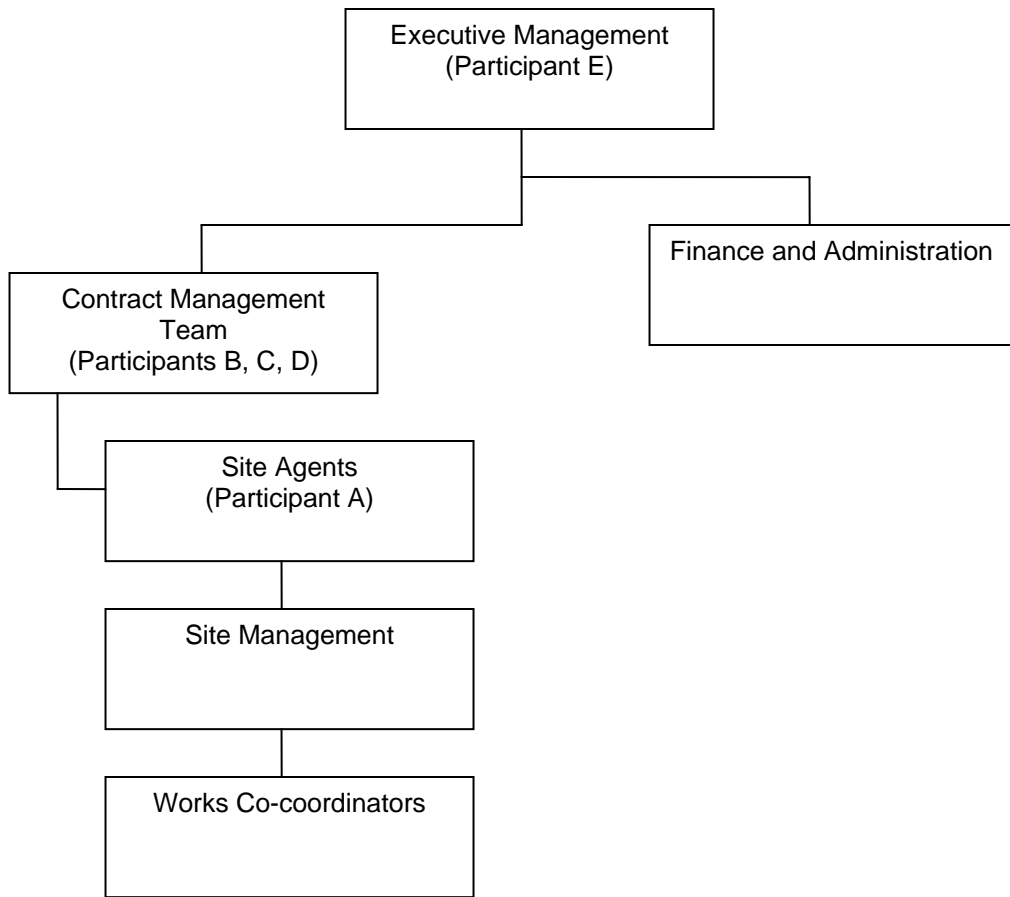
Figure 3.1:   Organogramme of the action research environment

The motivation for the inclusion of the selected participants has been discussed. The section that follows provides a background to the efficiency issues that the participants experience on a daily basis and that can be positively affected through the adoption and diffusion of mobile computing technologies.

3.4.1.   Participant A

Participant A has been with the construction company for the last 8 years. He has been mainly involved with the execution of works-coordinated activities on actual building construction sites. He currently holds the position of Site Agent. Some of his duties are administration-related and he reports to head office from time to time. However, in order to allow for better business process transparency there is a need to execute these administration activities from the actual building construction site office.

Participant A has recently been involved in a development of up-market suburban townhouses in the western part of Gauteng and has handed over all the units to clients. At the start of this research project he was occupied with a process called "snagging". "Snagging" refers to the fixing of building defects detected at practical handover of the unit to the prospective client. The whole process of snagging is coordinated by the appointed external project manager of the development project. The project manager is employed by the developer and would notify the construction company's head office personnel responsible for snagging for the particular project, usually via email or fax, of a building defect detected. The applicable head office person would then formally document the building defect details and distribute the action item to the applicable Site Agent or Site Manager via telephone, fax or pigeon holes.

The process of snagging has always been a cumbersome item as, not only could action items evolve into very expensive after-sales items, but also provide very negative perceptions of the company's image. In a perfect world the idea would be to have no items on the snag list. In practise, however, this is highly unlikely. Therefore the goal within this scenario is to decrease the turnaround time for resolution of building defects. One of the suggestions by the development's directors was to make provision for a more direct and transparent communication channel with the Site Agent or Site Manager, specifically with regard to the "snagging" process. Although a cell phone is a good communication channel, this channel does not allow for effective auditing of information flow and communication. One possible solution was to provide the Site Agent or Site Manager with electronic communication facilities on site. Unfortunately this is a very impractical, and tends to be a maintenance and reliability nightmare in providing the site office with a computer, Internet connectivity or fax machine.

3.4.2. Participant B

Participant B joined the company when this research project was initiated and has been a Contract Manager for most of the last 10 years. His main duties are administrative and he acts as production control manager, ensuring that the project is on schedule from a construction point of view and that work is completed within the planned budget.

Although his duties are mostly administration-related, he feels that he needs to spend most of his time on the construction site in order to ensure effective production control. This, however, poses an issue with regard to getting access to the head office

administration systems and to the information needed to enable him to execute his daily functions.

The in-house administration system has been designed on an Internet Protocol platform. This means that the user of any workstation that has Internet browsing capabilities would be able to view the administration system, provided that he/she is within the head office network area or is connected to the head office network via a secure private Internet connection.

The construction company has also centralized its electronic information assets. All electronic company-related information is stored on a shared network hard drive that can also be accessed within the confines of the head office network, or if the user's computer is connected to the head office network via a secure private Internet connection.

Another process that requires effective controls, but which can undermine its efficiency, is the process of approving orders raised via site requisitions. The process of approving orders allows the relevant Contract Manager to approve the possible expense to be incurred on his project. An order is generated via a Site Requisition form that can be initiated by the Site Manager, Site Agent or Contract Manager. The Contract Manager then has to confirm the details of the items to be ordered, as well as the quantities and delivery details. He therefore constantly compares the budgeted expenses with actual expenses incurred for that specific project. An approval process has been built into the administration system. Contract Managers are assigned security privileges that allow only them to approve orders. Therefore, in order to approve orders, the Contract Manager has to go to head office or be connected to the administration system via a secure private Internet connection, so that he can approve the applicable order simply by pressing a computer key.. The order's metadata would then be updated with the person who approved the order, which action would also change the status of the order and would allow the procurement officer to forward the order to the relevant supplier. This poses issues as, in some cases the Contract Manager may not report to the head office for several days at a time, but is involved in site activity planning and management meetings. If an order needs to be approved urgently, the Contract Manager could request the junior Contract Manager appointed to the project to approve the order or could make use of a 'phone service. The 'phone service enables the Contract Manager to 'phone a system administrator to approve the order on his behalf. Unfortunately these scenarios can give rise to issues regarding communication breakdown and integrity of

details of the Order. For example, a junior Contract Manager is not intimately involved with the budgeting processes of the project and may not necessarily know where to find the details pertaining to the allowable item price or quantity allowable. There is therefore a good possibility that a junior Contract Manager might assume that the Order is correct, which he would then incorrectly approve, which action may have repercussions later in the profitability evaluation of the project.

A possible solution is to allow the Contract Manager access to the administration system remotely from the building site. But, as mentioned before, this could be a logistical nightmare in providing users on site with a computer and Internet connectivity.

3.4.3. Participant C

Participant C's role involves assisting a senior Contract Manager (Participants B and D) with the administration duties that involve production planning and cost management. He basically acts as a junior Contract Manager. The junior Contract Manager's tasks mainly involve the administration of payments to subcontractors and the compilation of payment certificates (invoices) to the client or developer.

The subcontractor payment administration refers to a process whereby the subcontractor's work completed on the actual building site is physically recorded on spreadsheet-like documents, based on the specific trade. Subcontractor progress evaluation is performed on a monthly basis and is recorded in the administration system. A payment based on the total work completed, as recorded within the administration system for the relevant subcontractor is then compiled and processed.

The payment certificate process refers to compiling a progress payment claim (a VAT invoice) that is provided to the developer, based on work successfully completed by the main building contractor at that specific time. This process and the subcontractor payment process are closely related and it has been accepted that the junior Contract Manager should be responsible for both these processes. However, the junior Contract Manager is usually assigned to two or more projects and the projects undertaken have 12 to 137 residential units. This represents an enormous workload for the junior Contract Manager.

To complete the subcontractor payment administration, the junior Contract Manager would print history progress sheets of the all the subcontractors on a spreadsheet-like document. He would then physically capture the current progress on the printed sheet at the actual building site by hand. On his return to head office the information of each individual subcontractor progress sheet would be captured in the administration system. Based on the progress sheet, payments would then be generated for all the relevant subcontractors.

The payment certificate runs parallel with the subcontractor payment administration. However, the payment certificate process differs in the sense that the junior Contract Manager would then need to complete the process of overall progress of the project from the main contractor's perspective to allow for invoicing to the developer. Again the junior Contract Manager would physically capture the project progress via progress sheets and, on his return to head office, record the progress in the administration system. This poses an administration nightmare for the junior Contract Managers. Although the current administration system allows for effective subcontractor payment administration and payment certificate invoicing, issues have been reported regarding the usability and the response time of the system with the processing of payments and certificates for large projects.

A possible solution to this problem would be the provision of an efficient access portal to the administration system, thus enabling electronic information to be provided from the actual building site. This would reduce the time between the physical capturing of progress and the actual capturing of the progress in the administration system. Again this means that establishment of a workspace on site and provision of a computer with Internet connectivity, as well as a fax machine would be necessary.

3.4.4. Participant D

Participant D can be seen as a classic example of an old-school Contract Manager. For example, he believes that any paper document used as part of a business process should be filed or indefinitely stored. This could be any informal documentation that was provided or generated by the site personnel. He always refers to how they "used to" request quotes from suppliers via messenger or post. Although not very IT literate, and having a personal assistant at his disposal, Participant D agreed to use a desktop workstation as part of his daily function. Unfortunately his involvement is limited to

viewing reports and approving orders. Emails are still being replied to and compiled by his personal assistant. However, it has to be acknowledged that Participant D approached the researcher at the initiation of this research project and requested some training in the use of some form of mobile computing device.

3.4.5.   Participant E

Participant E is one of the co-founders of the company and is an active member of the executive management team. Although he graduated in the late 1979, he has always seemed to be aware of new technological advancements with regard to building construction administration.
He was the key driver in implementing an in-house developed administration system. Before this system company used Quattro Pro and then Microsoft Excel to successfully administer the progress payments and budgets of its building construction projects. The company has recently appointed an IT manager to take over that role and to manage the IT infrastructure more effectively and implement innovative business process solutions.

Almost four years ago, Participant E was the first user within the company to use a PDA as part of his daily functions. However, the full capability of the device with regard to email inbox, calendar and contacts synchronization function has only recently (6 months before the start of this research project) been realised, using 3G Internet connection offered by the cell phone network. His feedback with regard to issues experienced with the PDA email inbox synchronization via 3G was significant, based on the fact that he had been employing the technology for some time before he was included in this research project.

3.5.   Summary

As previously mentioned, the executive management team in this construction company has identified ICT as a strategic enabler for future growth opportunities and would like to establish an environment more acceptable to the successful adoption of ICT. Although it is considered as an SME, it has implemented and employed advanced technologies that, for example, allow remote access to company email, company information assets and the company administration system. To complement the concept of ICT adoption within this construction company, this research project contributed to and complemented the ICT adoption objective through identification and understanding of the "social issues"

that may impact on the successful adoption of mobile computing by this construction company.

The above background of the participants identified efficiency issues that the employees of this construction company experience on a daily basis. The problem issues were specifically identified and isolated. These issues were used by the author as an exploitation method to analyse the social issues that may impact on the successful adoption of mobile computing. The selected participants each have unique problem issues, but in summary the following mobile computing related issues were identified:

- Although this construction company allows users to gain access to the company email inbox via the Internet, managerial employees (middle management) do not have the ability to access their email inbox from a construction site.
- This construction company allows users to gain access to the company information resources stored on the head office shared-drive and the in-house administration system via the Internet, but employees based on construction sites are not able access these resources.
- Basic ICT literacy and ICT application knowledge is lacking among experienced managerial-level employees of the construction company, which poses a significant barrier to the successful adoption of mobile computing.

Based on the summary of the issues experienced in practise, the general belief was that a PDA device with a wireless Internet connection and its associated applications would be the ultimate solution to enable mobile computing on site, and would therefore allow for more effective and transparent business processes. However, as previously discussed, the technology employment is only part of the problem and other underlying social issues seem to impact on the successful adoption of mobile computing within this construction company.

The problem issues to be addressed within this research project have now been considered. The next section will provide a theoretical explanation of possible mobile computing adoption and diffusion issues as suggested by the literature survey and which were identified within this research environment.

4. Mobile computing adoption and diffusion issues: a theoretical explanation

The two sets of adoption and diffusion issues that were suggested in the literature – User and Organization Level Issues, were identified and described ion Chapter 3. Issues at organization level included: "Politics", "Training and Support", "Technology compatibility", "Company Vision, Strategy and Internal Policy". Issues at user level included: "Education Level", "Personal Belief", "ICT Literacy" and "Experience and Exposure". In this chapter the pre-conceptive issues which, we believe, impact on the successful adoption and diffusion of mobile computing within this construction company are identified and described.

This chapter differs from Chapter 2, in that the issues have been described by means of the job functions of the participants involved in this study. Sources in the literature are then used to substantiate the initial argument in this dissertation and to devise a framework to cognitively map the pre-conceptive mobile computing adoption and diffusion issues.

4.1.   Theoretical framework background

Before the author goes into too much detail, it is necessary to explain his thought process in his attempt to analyse these mobile computing adoption and diffusion issues.

He needs to consider the scenario of executing a task as part of the daily function of a particular participant identified. Let us consider the case of Participant B (Contract Manager), he acts as production control manager for a particular construction project and spends most of his time on the various construction projects that fall under his jurisdiction. If he needs to complete an administration- related task, he is faced with the choice of what office tools and applications to use before the actual execution of the task and of how to access these resources. This choice is therefore also influenced by his location – site office, home office, temporary location or head office. At head office he has all the office tools and applications at his disposal. These include a dedicated workspace, land line, LAN connectivity and broadband Internet connectivity. All these office tools and applications at head office, particularly LAN connectivity, are provided at an optimal standard,. These provide a very reliable network connection to the in-house administration system and to the company-shared hard drive. As previously mentioned, these resources are regarded as being the heart of the company and without access to

these resources virtually no administration- related activity can be executed. At his makeshift home office Participant B would be able to connect to the in-house administration system or to the company-shared hard drive, but via the use of his personal Internet connection. the simple task of remotely accessing an electronic file that resides on the company-shared hard drive located at head office might be quite frustrating because of slow Internet connectivity or the participant's ability or inability (lack of skills set) to complete the task. In this particular example Participant B has the skills and knowledge to connect to the head office LAN remotely. However, participants D (also a Contract Manager) and A (Site Agent) do not have the skills and knowledge to undertake the task of connecting to the head office LAN from a remote location. So, if Participant B needs to access an electronic file on the company-shared hard drive remotely (from his home office), he can connect to the resource remotely and access the electronic file. Participants D and A, however, do not have the ability to access the electronic file remotely. This is mainly due to their skill set. If participants D or A have to access an electronic file they would need to travel to head office and access the file from a work station directly connected to the head office LAN, whereas Participant B would be able to access an electronic file remotely as long as he has an Internet connection available.

Therefore, with reference to the author's explanation of his thought process, for the purpose of this study the situation is described in which a participant is faced with the choice of how he should achieve the administration-related task as the *task initiation* step. Figure 4.1 below provides a graphical illustration of the thought process adopted by the author.

To allow a more holistic explanation of the author's thought process, there are two additional concepts that have to be described and that have been considered in the author's attempt to identify and analyse the issues that impact on the successful adoption and diffusion of mobile computing within this construction company. The second step refers to the action of identifying and grouping all the *issues* of significance (Figure 4.1), based on their level of influence. With reference to participant's B scenario mentioned above, the issue of participant's B skill set in his attempt to access an electronic file from his home office via his personal broadband Internet connection was mentioned. His skill set presents him with the ability to connect to the head office LAN and to access an electronic file on the company-shared hard drive, whereas Participant D, who also holds the post of Contract Manager, does not have the necessary skills that

would allow him to access an electronic file directly from a head office workstation. Therefore a participant's skill set should thus definitely be considered an important and influencing issue, and should be considered in the attempt to analyse the adoption and diffusion of mobile computing in this construction company.

The third and final concept in the explanation of the author's thought process relates to a situation in which a task of a particular participant has been achieved at a pre-determined standard. This concept refers to a situation in which Participant B was able to complete the task from his home office, at the same pre-determined standard as if he had completed the task at head office. The term "pre-determined standard" refers to a situation in which Participant B is able to connect effortlessly to the company-shared hard drive remotely and is able to access an electronic file with ease. The electronic file can thus be opened without the interruption to the Internet connection and without the application failing to respond because of a slow connection, eliminating the frustration and technical problems that would hinder the completion of this particular task from a remote location. Participant B was therefore able to complete his task as if he were situated at his workstation at head office. This concept is referred to as a *meaningful achievement* (Figure 4.1). This concept is important because of the fact that any issue that might impact on the outcome of a participant's administration-related task to the extent that the participant cannot achieve the task at a pre-determined standard or may not even be able to complete the task at all, needs to be considered as an "issue" that impacts on the adoption and diffusion of mobile computing by this construction company. Issues that may pose a significant threat to the adoption and diffusion of mobile computing should thus be specifically identified and analysed.
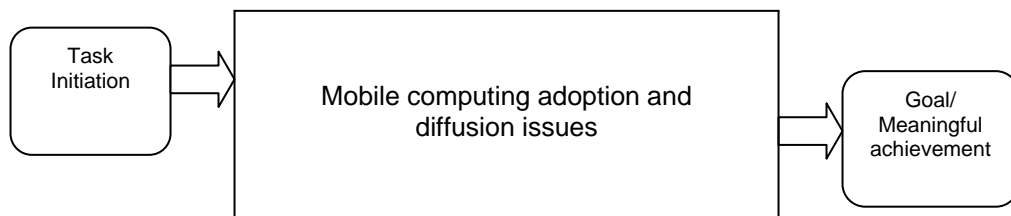
Figure 4.1:   An initial theoretical framework of the mobile computing adoption
                and diffusion analysis process

A scenario with reference to Participant B is described in this section, accompanied by a sketch (Figure 4.1), in order to allow the author to explain his thought process in the process of identifying and analyzing the adoption and diffusion issues suggested in the literature, within this particular research environment. In the next section the scenarios

that participants are faced with in terms of their daily function are described. The purpose of the next section is to identify, describe and group ICT adoption and diffusion issues suggested in the literature according to organizational and user level issues, with reference to the practical environment of the participants. This effectively forms part of the author's endeavour to formulate a proprietary framework for the mobile computing adoption and diffusion issues within this particular research environment.

4.2. Pre-conception of organization level issues

The concept "organization" level refers to a logical boundary that separates the organization from the outside world. As mentioned previously, issues defined at this level are maintained and mainly influenced by the organization. In the following section the organization level issues from a practical perspective, substantiated by references to the literature, are described.

4.2.1. Politics

Let us consider the situation of Respondent D: he is an ICT-illiterate user who has great influence on other fellow employees. His becoming more ICT literate could result in a positive spin-off on the adoption of ICT as a whole. This effect refers to the power that an employee or a group of employees has to influence other employees. For the purposes of this project it was decided that this power would be referred to as "politics". An issue that suggests the same effect was discussed in Chapter 1. Songer *et al.,* (2001: 9) identified this concept in a previous study and referred to it as corporate culture.

Although this issue might be more relevant at user level, it is considered as having a greater influence at organizational level, as the power of the politics is maintained and influenced by the employee relationship dynamics within the organization.

4.2.2. Training and Support

In this particular research environment the provision of necessary employee support by the construction company could be achieved by establishing an environment that is highly conducive to optimal productivity that would allow participants to effectively achieve their required goals. This relates specifically to dedicated IT support, by means of a department or team that would deal efficiently with technical IT-related problem

issues, allowing staff members to achieve their pre-determined company-related goals. For example, if

Participant B plans to work from his home office and is not able to access the company-shared hard drive from a remote location, he should contact an IT help centre that would assist him to resolve the issues telephonically or by means of remote support. In this construction company, IT support is managed by the IT manager, who makes use of the services of external contractors and consultants to resolve issues. The company has a Service Level Agreement for a total of 30 hours with an external IT support company. The duties of this company relate to resolution of server- or desktop-related technical problem issues. These support services are provided by weekly visits, on-site support, remote support and telephonic support.

Although no major desktop related problems have been experienced and in users are generally able to execute computer-related tasks efficiently, the author still believes that the level of support could be increased. For example, a user should not have to wait for the support agent's next site visit for when the support agent will be available again.

As previously suggested, it is also necessary to consider IT training in conjunction with support because of overlapping definitions and consequences. In this particular research environment, IT training is definitely not considered on the same level as IT support. No formal strategy or policy is in place. The issue of training is generally dealt with on an ad-hoc basis when it is necessary to introduce new administration functions or orientate users with these. However, this issue cannot be shifted to the background, a conclusion supported by Peansupap and Walker (2006: 371), Love *et al.*, (2001: 34) and Stephenson and Blaza (2001: 11) who agree on the two specific concepts that are vital to the process of ICT adoption: training and support.

4.2.3. Technology compatibility

Should the company wish to set up a workstation at a site office for Participant A (Site Agent), this work station would have to be positioned so that it could function optimally in a harsh environment, exposed to natural elements and large amount of dust, as well as being subjected to electricity issues and possible security issues. Internet connectivity would also have to be in place in order to allow Participant A to connect to the head office administration system or to the company-shared hard drive. However, in most cases the construction sites are raw, without even a fixed telephone line. This implies

that the construction company would be required to set up these services in order to allow users to connect to the Internet. However, with the delay in service delivery of this country's national fixed line operator, which installs fixed line Internet connectivity, this might pose another barrier to the setting up of a site office, as most of the construction projects within this company only have a life span of 6 to 12 months. This scenario also has a huge cost implication and would have to be considered in context of the benefits to be derived. Other options are possible, such as wireless broadband Internet connectivity and laptop PCs. However, in some areas of Gauteng reception of the wireless Internet service is not at the required level and may also be inadequate for Participant A's objective to connect to the head office's IT resources.

Bowden *et al.*,.(2006: 664) confirm the author's pre-conception and state that the technology has not yet been modified to suit the needs of the construction industry and, in particular, is exposed to extreme natural elements on a daily basis.

4.2.4. Company Vision, Strategy and Internal Policy

This particular construction company has defined a Company vision, as well as a high level strategy plan for its divisional departments. However, its policies are enforced informally and verbally, with most of its formal policy documents for business processes being outdated and there is no formal strategy in place to keep the documentation updated.

With regard to the IT Vision, Strategy and Policy, nothing has been defined in a formal way and there are no long term objectives in place. The ICT initiatives are directed by ad-hoc initiatives as new business process needs arise.
To reinforce the author's pre-conception that this issue may impact on the adoption and diffusion of mobile computing, Peansupap and Walker (2006: 369) believe that a company's vision, strategy and policy serve the purpose of a long-term plan and framework for business processes and employee behaviour. This issue is vital and can have a dramatic impact on the adoption and diffusion of mobile computing.

4.3. Pre-conception of User Level Issues

The concept "user level" allows the author to define a personal boundary for each participant which separates the user from the organization. As with the concept

"organization level", the concept "user level" allows the identification and grouping of issues that are maintained and mostly influenced by a user (participant) and not by the organization.

The following section will describe the main issues identified at a user level, from a practical perspective, as substantiated by the literature in terms of ICT adoption and diffusion.

4.3.1. Education Level

As mentioned previously, this issue could suggest the segregation of participants based on their formal level of education, as well as on the institution at which it was obtained. As part of this issue the author realised that it would be necessary to consider the date at which it was obtained, as well as the type of education obtained. This statement suggests that a user such as Participant C, who obtained his formal qualification from a tertiary institution and recently graduated, would be more open to innovative solutions and might be keener to obtain knowledge on new technologies that might impact positively on his or her daily function. On the other hand, the author believes that Participant D, who graduated in the late 1970's, would be more resistant to the adoption of new ICT technology.

In support of the author's pre-conception, Peansupap and Walker (2006: 371) and Love *et al.,* (2001: 34) consider the issue of training to be vital to the successful adoption of IT. However Peansupap and Walker (2006: 371) also highlighted the fact that the quality of training could impact on the diffusion of ICT.

4.3.2. Personal belief

This issue refers to the attitude of a particular participant has towards the concepts and components around him. For example, Participants A, B, C and E regard the new ICT technology as a possible benefit to their daily function, whereas Participant D considers it to be luxury, and that it could even be a barrier to the execution of his daily function.

The author's pre-conception regarding the issue of "personal belief" is supported by Peansupap and Walker (2006: 371) who state that the uncertainty of functions and complexity of the ICT application may lead to a lack of confidence in users' perception of its value or effectiveness and could possibly explain Participant D's belief. As mentioned

previously, the author believes that this sentiment could be changed through adoption of an effective training and support strategy.

4.3.3. ICT literacy

This issue refers to the general knowledge that a particular staff member has of commonly used ICT technologies. In this regard this would include cell phone technology, standard packaged and email software. Participants B, C and E believe that they are more efficient with the employment of commonly used packaged software in executing their daily functions, whereas participants A and D do not rely on the use of packaged software and pervasive ICT technology.

This issue of ICT literacy is particularly important, as mentioned by Love *et al.,*., (2001: 34). They consider the "lack of IT awareness" to be a great barrier that may influence the adoption of IT in the construction industry.

4.3.4. Experience and exposure

The issue of "Experience and Exposure" was suggested by Love *et al.,*.(2001: 36) and Songer *et al.,* (2001: 9). They believe that employees of a construction companies appear to have insufficient understanding of the organizational and social issues of strategic ICT adoption.

In this context, the employment history of each particular participant was taken into consideration. This issue relates to the experience and exposure of a participant in his previous positions before being employed in his present position. In this study most of the participants had not had extensive exposure with regard to innovative solutions, specifically with regard to innovative business processes within the construction industry. However, Participant B has extensive experience with regard to the application of standard packaged software such as MS Project, MS Excel and MS Outlook and has also been at the forefront in the process of adopting new innovative business processes.

Based on the author's understanding, and in an attempt to allow better deductions to be made, the interaction or overlapping between the organizational and user level issues was also investigated. These interactions on their own may act either as possible barriers or as enablers to the successful adoption and diffusion of mobile computing. The

possible interaction between the organization and user issues identified is described in the next section.

4.4. Interaction between pre-conceptive adoption and diffusion issues of mobile computing

The concept "interaction" has been defined as the connection between two underlying issues and presents a situation in which one issue is influenced by the other or they jointly influence each other. Figure 4.2 illustrates the possible interactions, which are indicated by connected dashed lines.

The next section provides the reasoning behind the identification of the interactions as observed in this research environment.

4.4.1. Interaction: "Personal belief" ←→ "Training and Support"

A particular employee's personal belief can influence his reservations regarding acceptance of the training and support structures offered within the company domain. But, from another perspective it can also be said that a staff member's personal belief could also be influenced by the endeavours of a company to provide a robust training and support environment that would allow the participant to equip himself with the knowledge and skills that would allow him to execute the task at hand more effectively.

4.4.2. Interaction: "Politics" ←→ "Training and Support"

In a situation where there is an excellent training and support platform, which provides effective training to its staff members and also presents an environment that enjoys the effective support of its staff, the interaction between these two concepts could have an influence on the politics concept within the company domain. This could be achieved by means of a key staff member who has had success with a specific issue (with regard to training and support) and who could therefore influence the rest of the workforce positively and encourage them to enrol in the specific training and make use of the support structures provided.

4.4.3. Interaction: "Personal belief" ←→ "Education Level"

It can be accepted that, based on the description of "Educational level" and "Personal belief" given in Section 4.3, it is apparent that there is some relationship between these two concepts. A staff member's personal belief with regard to the advancement of his career could inspire him or her to enrol in a formal education program. On the other hand, a staff member's personal belief could also be influenced by a formal education program that was enforced by the company.

4.4.4. Interaction: "ICT Literacy" ←→ "Education Level"

Certain modules, as part of an educational program, could specifically address a user's knowledge attainment with regard to ICT. This could help staff members to expand on their current ICT knowledge and allow for a greater degree of ICT literacy. This interaction can also be seen from a cyclical process. By this is meant that, as staff members learn more about ICT technologies, they might be motivated to enrol in other educational programs in order to learn more about ICT technologies and therefore increase their ICT literacy and awareness.

4.4.5. Interaction: "ICT Literacy" ←→ "Training and Support"

The training and support platform within the company domain could directly influence the increase in the ICT literacy of the staff member. With effective support structures and training environment, staff members can benefit greatly with regard to their ICT literacy. The ICT support team should apply an approach of not only resolving issues, but also of educating the users, a process that would promote self-empowerment.

4.4.6. Interaction: "Politics" ←→ "Experience and Exposure"

The author believes that the concepts "Politics" and "Experience and Exposure" are mutually influenced. This suggests that a staff member with certain experience who holds a certain position (Senior Contract Manager) would allow him to have greater influence on other employees.

4.4.7. Interaction: "Education Level" ←→ "Experience and Exposure"

Although a staff member's job position and function could possibly be dictated by his/her education level, it could also be dictated by the experience and exposure that he/she has gained over the years. This can also be seen from a different perspective: A new job position could present a situation in which the staff member is exposed to new situations that allow him to carry out functions that would not be considered normal practice. This specifically refers to the fact that a Site Manager / Site Agent is now more involved in administration type duties or tasks than was generally the case in the past.

4.4.8. Interaction: "Company Vision, Strategy and Internal Policy" ←→ "Technology compatibility"

This interaction refers to the company's direction in terms of ICT, strategy for implementing its vision and definition of its policies to make provision for guidelines for the implementation of ICT. Its greatest influence is on the issue of technology compatibility, as it outlines the extent to which the company will address the issue of ICT adoption, more specifically the adoption of mobile computing.

4.4.9. Interaction: "Company Vision, Strategy and Internal Policy" ←→ "Training and Support"

Although the company's vision, strategy and internal policy could influence most of the organizational and user level issues, it is believed that it has a great influence on the provision of training and support initiatives which, in turn have a significant impact on the adoption of mobile computing within this construction company.

4.5. Theoretical framework of pre-conceptive mobile computing adoption and diffusion issues

The purpose of Sections 4.3 and 4.4 was to provide a summary of the author's preliminary pre-conception of the ICT adoption and diffusion issues that may impact on the adoption of mobile computing by this construction company, as suggested by literature. The author described the organizational and user level issues as suggested in Chapter 1, from a practical perspective. The author was also able to provide some interpretation of the issues identified, from the perspective of the initial observations of

Participants A, B, C, D and E within their daily work environment. The next section will expand on the understanding defined in Figure 4.1 and propose a theoretical framework of the pre-conceptive mobile computing adoption and diffusion issues. This framework serves as a hypothesis vehicle in the process of analysing the mobile computing adoption and diffusion issues at this construction company.

With reference to Figure 4.1, the author was able to depict the thought process adopted in the analysis procedure. Figure 4.2 below is based on the foundation illustrated in Figure 4.1, but has been expanded to provide a graphical depiction of the organizational and user level issues as described in Sections 4.3 and 4.4.
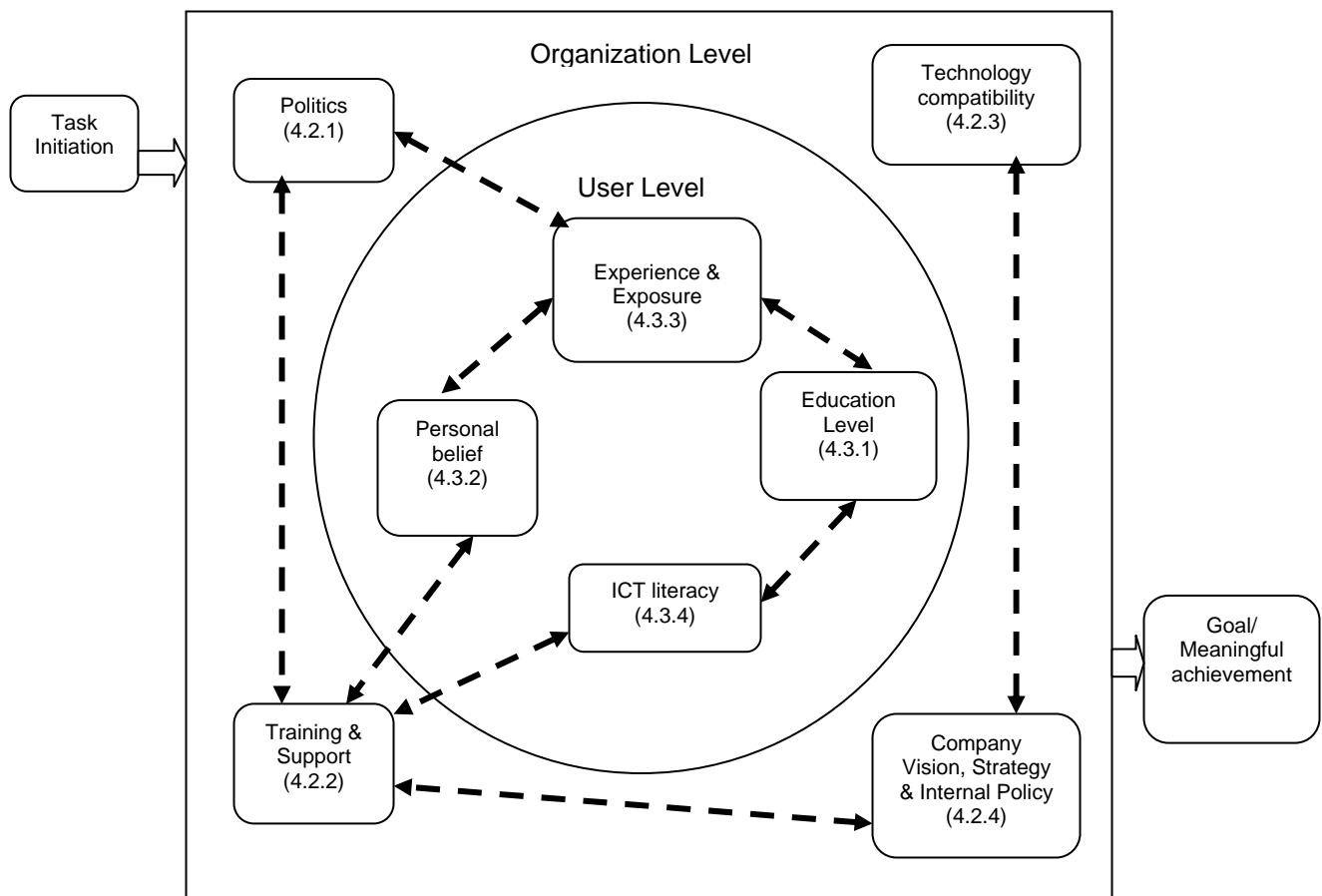
Figure 4.2:   A theoretical framework of pre-conceptive mobile computing adoption and diffusion issues at this construction company

The dynamics of the framework defined in Figure 4.2 are exactly the same as those suggested for Figure 4.1 with regard to the author's thought process. The framework (Figure 4.2) is graphically divided into four concepts: Task Initiation, Organizational Level issues, User Level issues and Meaningful Achievement.

The simple task of accessing an electronic file remotely by means of the framework (Figure 4.2) will now be described. This specifically refers to the organizational and user level issues identified during the course of this study. At the task initiation step Participant D (Contract Manager) is faced with the situation of using the company provided tools and applications and his own personal tools (skills base) to complete this task. For Participant D to be able to attain his goal of accessing the electronic file that resides on the shared company hard drive from his remote PC, the company provided tools and applications need to be in a working state, thus allowing Participant D to access the file. The first issue faced is that of IT support, which was defined within the framework as "Training and Support" (Figure 4.2). Although he relies heavily on the infrastructure provided by the company, Participant D is also faced by the fact that he should possess the necessary skills set ("ICT Literacy) that would allow him to be guided effortlessly through the operating system menus and enable him to open the applicable application so that he can access the electronic file from a remote location. At this point he is faced with the issue of "Education level" (Figure 4.2) and, more specifically, that of "ICT literacy" (Figure 4.2). If he cannot access the electronic file from a remote location or is not able to gain access to the company- shared hard drive, Participant D would then have to interact with the appropriate support structure. This statement thus suggests that Participant D has a problem that needs to be resolved in order if he is to achieve his task. At this point reference is again made to the issue of "Training & Support" (Figure 4.2) that requires him to contact IT support to resolve technical or other application-related issues or get the company-provided assistance to attain the necessary skills that would allow him to effortlessly execute his task and arrive at a state of "Meaningful achievement" (Figure 4.2).

In Figure 4.2 the issues depicted were mainly suggested by literature cited in Chapter 1, with regard to ICT adoption and diffusion. In Sections 4.2, 4.3 and 4.4, however, these issues were described from a practical perspective with the focus on adoption and diffusion of mobile computing by this construction company. This has allowed the author to compare the issues suggested by the literature, with the individual participants' scenarios in their practical environment. It also allowed the author to graphically map the issues (Figure 4.2). This figure serves the purpose of initial hypothesis for this action research project. The theoretical framework of pre-conceptive mobile computing adoption and diffusion issues (Figure 4.2) provided a platform for the author to indicate

and explain any changes to the framework as manifested in practise, as the action research project progressed.

Now that initial understanding of the issues that may impact on the adoption and diffusion of mobile computing have been depicted, we would like to focus our attention on a description of the research methodology adopted.

5. Research Methodology

5.1. Research Design

Without going into too much detail in terms of research methodologies considered, it would be beneficial to reflect briefly on these approaches as found within the IS research field. This would provide the platform for explaining the rational for the research method applied.

5.1.1. The Research Approach

In an attempt to select the most appropriate research approach, the author consulted the literature and concluded that the approaches mentioned by Myers (2007) seemed very appealing for this research project. These included ethnography research, grounded theory, case study research and action research (Myers, 2007).

In ethnography research the researcher is actively involved, participates and has social contact with all the participants and is usually limited to one field study (Kotze *et al.,* 2005). "Grounded theory is a research method that seeks to develop theory that is grounded in data systematically gathered and analyzed" (Myers, 2007). Myers (2007) states that "a case study is an observed inquiry that investigates a contemporary phenomenon within its real-life context". Myers (2007) also states that "the case study research method is particularly well-suited to IS research, since the object of our discipline is the study of information systems in organizations". Although the case study research may seem to be the most appropriate method to adopt within this study, it has to be acknowledged that case study research suggests a situation in which the researcher is removed from the research problem and mostly fulfils the position of an

observer. In this study it is clear that the researcher was actively involved and dealt with the problem domain on a constant basis. This possibly suggests that theory and practice (researcher and participant) should be combined. However, in considering a particular case study scenario, it may be difficult to identify possible social issues solely through observation of the participants. This suggested the use of an experiment to closely monitor the impact, by introducing change. However, the impact could be identified more effectively and better understood if the researcher could intervene and deliberately introduce concepts that may allow interesting discoveries.

Kotze *et al.,* (2005) believe that, by combining theory and practice through cyclical change (introducing changes into complex social process) and reflection on the problem domain (observing their effects), it would be possible to enhance the theory by focusing on what practitioners do and the effects of deliberate environmental changes.

Bearing the title and the imposed research question in mind, it is obvious that the present study focused on understanding the social context of the problem domain. Therefore, within this research study the motivation for adopting a qualitative research method has been the endeavour to understand the social context of the adoption of mobile computing in the company, as observed from Participant Activities and through interviews. More specifically the author would like to suggest an interpretive philosophical perspective and to propose the use of the action research method.

The action research approach employed allowed a platform of introducing changes into a complex social process and observing the effects. The findings should allow the researcher, as the ICT innovation champion, to implement innovative mobile computing solutions more effectively and successfully. Furthermore, this has allowed the author to enhance the theory and provided him with the ability to better understand the current literature or even to discover new concepts within this research environment.

5.2.   Action Research Framework

The next section provides an explanation of the selected action research method, as suggested by the literature. Thereafter the author will present a detailed research design that fulfils the function of the research blueprint for this project, followed by an explanation of the data collection methods employed.

Within the action research domain there are several distinctive action research approaches. However, for the purpose of this study only comments on, and characteristics of the selected applied approach will be provided.

Based on the background provided in Chapter 2 (Contextualization of the Research Problem), it is clear that the researcher is actively involved in the research domain. As described by Baskerville and Wood-Harper (1998: 94), an action researcher should be a participatory observer in determining the possible intervention strategy. In this particular research project the researcher was an equal co-worker. This scenario correlates with the concept "collaborative involvement" as mentioned by Baskerville and Wood-Harper (1998: 94). However, the researcher also acted as facilitator in providing the participants with advice, guidance and help (Baskerville and Wood-Harper, 1998: 94). In addition, because the researcher will to large extent attempt to solve the research problem and determine what interventions should be enforced, the researcher's role could also be referred to as expert involvement (Baskerville and Wood-Harper, 1998: 94). However, as mentioned by them, there are several forms of action research which can be distinguished by at least four characteristics: "process model, structure, typical researcher involvement, and primary goals". Using these four characteristics of the theoretical explanation, the author only expanded on the selected action research form.

Some considered some features of action research approaches have been considered. Table 5.1 below contains an explanation, according to the following characteristics: "process model, structure, typical researcher involvement, and primary goals" of the applied action research approach: canonical action research, as described by Baskerville and Wood-Harper (1998: 94).

Table 5.1   Characteristics analysis of action research forms (Adapted from
               Baskerville and Wood-Harper, 1998: 96)
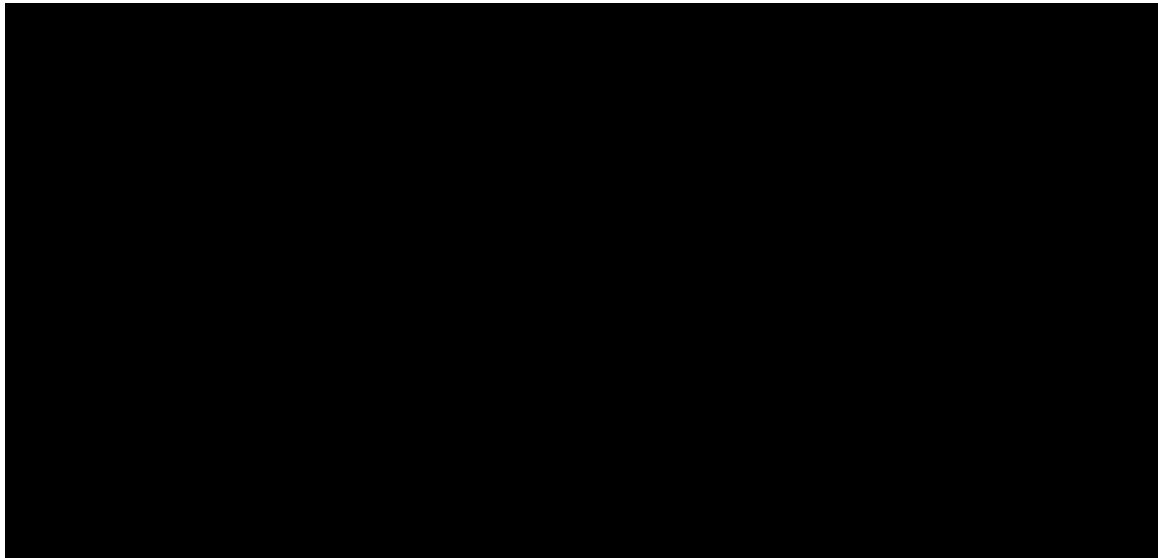
5.2.1   Process model

The research process model for this study suggests iterative cycles, with the repeat of the same set of activities for each cycle (Baskerville and Wood-Harper, 1998: 94). Figure 5.1 below illustrates the set of steps involved in each cycle.
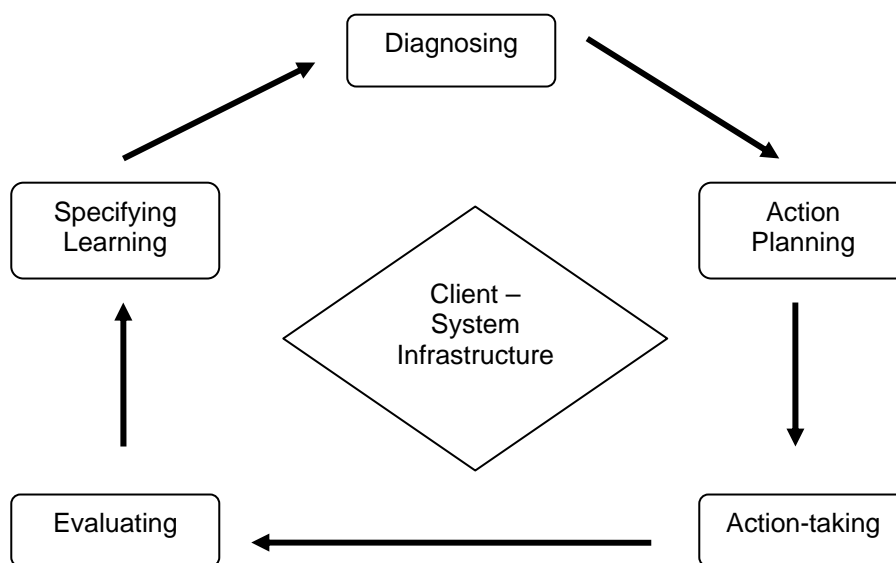
Figure 5.1:   Canonical action research process model (Susman, 1983)

As illustrated in Figure 5.1, the canonical action research involves the major activities of diagnosis, action and learning (Baskerville and Wood-Harper, 1998: 96). The idea is to repeat these cycles until the main research goal is achieved. This fact distinguishes the iterative action research from canonical action research.

Canonical action research also allows for a situation in which the competencies of the actors are enhanced. This is achieved by using data from the learning result that are fed back into a cyclical process with the aim of increasing understanding of the social situation (Baskerville and Wood-Harper, 1998: 96).

With reference to Figure 5.1, Susman (1983) provides activities or steps to be executed in a cyclical form, for each iterative cycle, to comply with the characteristics of a canonical action research form. The client-system infrastructure constitutes the research environment - "It provides the authority, or sanctions, under which the researchers and host practitioners may specify actions. It also legitimates those actions with the express expectation that eventually these will prove beneficial to the client or host organization." (Baskerville and Wood-Harper, 1998: 96).

In line with the researcher involvement dynamics mentioned previously, it should be noted that a key aspect of this structure is the collaborative nature of the researcher involvement. According to Baskerville and Wood-Harper (1998: 96) the researcher works closely with the practitioners (research participants), who provide knowledge and insight to understanding of the social anomalies being studied.

5.2.2. Structure

With reference to Table 5.1, according to Baskerville and Wood-Harper (1998: 95) the structure of a particular action research form can adopt one of two characteristics: "rigorous" or "fluid". The characteristic "fluid" refers to a situation in which the situation cannot be controlled because of its social nature and the researcher adopts a stance of observing the research environment. Although the researcher endeavours to gain understanding of the social nature of his research domain through observation, his aim is also to influence the situation, thus not only observing from a distance as in the case with "Participant observation" (Table 5.1: e.).

Canonical action research is characterized by a "rigorous" structure. This approach suggests that activities are *planned* in an attempt to address the research question and separates canonical action research from any other form of action research.

As suggested in Section 5.2.2.1 (Process Model) above, the research tasks adopted for this research project were defined as predetermined steps that were executed as iterative cycles (Figure 5.1), until the research objective was achieved. This notion refers to the research activities mentioned in Section 5.2.2.1 (Process Model) that included: Diagnosis, Action Planning, Action-taking, Diagnosis and Learning.

The same structure was adopted for this research study. The activities included in each iterative action research cycle were: the *diagnosis* of research environment at that point in time, *action planning*, *action tasks* to influence research environment, followed by a process of *evaluation of results* and the *specification of learning aspects* as derived from the effect of the planned activities implemented in the research environment (Baskerville and Wood-Harper, 1998: 96).

5.2.3. Researcher Involvement

As previously mentioned the researcher in this research project was actively involved in all the activities and stages in each iterative cycle. According to Baskerville and Wood-Harper (1998: 95) this situation implies collaborative involvement with the participants. This type of involvement necessitates the researcher being an equal co-worker with the participants (Baskerville and Wood-Harper, 1998: 95). This concept on its own distinguishes the "canonical research form" from other action research forms (see Table 5.1).

Because the researcher is a co-worker and although the tasks are shared by the researcher and the participants, the burden of solving the research problem still lies with the researcher. This could indicate a different form of involvement (Baskerville and Wood-Harper, 1998: 95). However, although the situation suggests that the burden lies only on the researcher, it has to be acknowledged that that the practitioners have an equal share in the problem domain. They were able to benefit from the outcome of the research project. Therefore, the researcher is actually only burdened with having to document and derive the scientific knowledge. The researcher and the practitioners are therefore collaboratively involved in the solution of the main problem within the boundaries of the organization.

5.2.4. Primary Goal

It was stated earlier that the focus would be on the social dimension of the problem domain. The characteristic "organizational development" as a primary goal refers to the development of social conditions, in which examples such as improved morale, greater structural efficiencies, increased effectiveness or better information flows are cited (Baskerville and Wood-Harper, 1998: 95). In the attempt to achieve the research goal, the discoveries made allowed for better adoption practises for mobile computing. This statement corresponds with explanation of the "primary goal" of canonical action research, as mentioned by Baskerville and Wood-Harper (1998: 95).

The author would also like to contribute to scientific knowledge, by contributing to the universal understanding of the problem situation with reference to the scientific literature (Baskerville and Wood-Harper, 1998: 95). These authors also stated that these circumstances imply an educational goal that allows for improved understanding of the problem situation by the researcher who is undertaking the study. This correlates with the previously mentioned goal of understanding the social dimension of the adoption and diffusion of mobile computing within a small-to-medium construction company based in Gauteng, South Africa.

5.2.5. The action research blueprint

With reference to the steps or activities involved in each cycle (Figure 5.1), the purpose and outcome of each planned activity is now briefly considered. According to Baskerville and Wood-Harper (1998: 97) *diagnosing* (Figure 5.1) is said to provide the identification of primary problems that are the possible causes of the organization's desire to change (Figure 5.1). For each cycle a set of questions was compiled, with each question being derived from the learning aspects resulting from the previous iterative cycle. This allowed the initiation of a discussion about the research topic with each selected participant.

The questions for the first cycle focused on determination of each participant's understanding, which allowed the researcher to better understand the research domain with regard to three main overlapping concepts: "participant's qualification, experience and skills", "participant's technology maturity and application", "participant's opinion on the future of mobile computing in the construction industry". After each discussion with the participants, the researcher and the participant jointly identified possible issues within

the problem domain that were considered barriers to the successful adoption of mobile computing. The second cycle questions and discussion focussed on the "mobile computing issues" in light of the knowledge obtained in the first cycle. These activities helped with the development of theoretical assumptions about the organizational situation and the problem domain for each cycle executed. Again, after each discussion the researcher and each participant jointly identified possible issues within the problem domain that are considered barriers.

The next activity, *action-planning* (Figure 5.1), involved collaborating with the participants in order to determine actions that would address the primary problem (Baskerville and Wood-Harper, 1998: 97). This activity was mainly characterized by gestures. The researcher (co-worker) asked the participants, what action should be taken from a business process perspective to facilitate the adoption and diffusion of mobile computing. Although he consulted each participant for suggestions, the researcher derived *action-planning* events with the approval of the participants. This activity was guided by a theoretical framework (Figure 4.2), which indicated possible issues that needed to be addressed and resulted in the adoption of mobile computing by the senior managers in the company.

The next step involved execution of the planned changes as suggested in the *action-planning* stage and is referred to as the *action-taking* stage (See Figure 5.1). The researcher and the participants collaborate in active intervention and in the effectively realization of planned changes (Baskerville and Wood-Harper, 1998: 97). In this particular research project the change is directive (Baskerville and Wood-Harper, 1998: 97), being directed by the researcher. Other intervention tactics included using strong willed participants as change catalysts. In practise this meant that the *action-planning* events derived by the researcher as suggested by the participants were planned, developed and implemented by the researcher over a specific time period. The activities included the establishment of an environment in which all the participants were able to associate with the concept of "mobile computing". This was achieved by ensuring that all the participants were able to work from remote locations and were able to access electronic resources from these locations.

On completion of the planned actions, the researcher and participant collaborate to *evaluate* (Figure 5.1) the outcome of the changes (Baskerville and Wood-Harper, 1998: 97). The purpose of this is to determine whether the theoretical planned effects were

realized (Baskerville and Wood-Harper, 1998: 97) and that these effects contributed to relieving the primary problem. In the evaluation of the effects, it is necessary to be cautious lest there be other non-related activities that might be considered as having contributed to the success of the planned action (Baskerville and Wood-Harper, 1998: 97). If the change were unsuccessful, the researcher should also consider some form of changes to the framework (Figure 4.2) for the next iteration (Baskerville and Wood-Harper, 1998: 97). It may also indicate that it might be necessary to modify the hypothesis. The evaluation of planned actions was achieved by informal discussions with the participants and other co-workers. The researcher also hosted planned workshops and individual interviews with each Participant and fellow co-workers, to discuss and evaluate the planned actions. After these events the planned actions outcomes were analyzed and documented by the researcher. The documented aspects of the learning activity were then used as feedback results that were fed back into the next action research cycle.

Although the activity of *specifying learning* (Figure 5.1) is described as the last activity, it was an ongoing process (Baskerville and Wood-Harper, 1998: 97) that had to be considered throughout the action research cycle activities. The knowledge gained from the outcome of a specific cycle was incorporated into the next cycle. According to Baskerville and Wood-Harper (1998: 97), the purpose of the knowledge gained can be used according to three perspectives: Firstly, "restructuring of organizational norms to reflect the new knowledge gained by the organization during the research" (Baskerville and Wood-Harper, 1998: 97); Secondly, if the change was unsuccessful "the additional knowledge may provide foundations for diagnosing in preparation for further action research intervention" (Baskerville and Wood-Harper, 1998: 97) and, finally, it is said the "success or failure of the theoretical framework will provide important knowledge to the scientific community for dealing with future research settings" (Baskerville and Wood-Harper, 1998: 97). In practical terms this was achieved by documenting learning concepts that, in the opinion of the researcher, would effectively allow the achievement of, or impact on, the main research goal of this project. This was mainly achieved by continuous exposure to the problem domain and by identification of concepts that implied a change in organizational belief with regard to mobile computing and its adoption ,or to new knowledge that forced the researcher to consider other concepts such as "peer pressure" that were not identified in the pre-conceptive framework (Figure 4.2).

The action research cycles were continued, irrespective of whether or not the *action-taking* activities had a positive impact (Baskerville and Wood-Harper, 1998: 97). As a result the organization was still able to learn its nature and environment, while the "constellation of theoretical elements of the scientific community continues to benefit and evolve" (Baskerville and Wood-Harper, 1998: 97). By analysing the research environment within each action research cycle from a scientific viewpoint, it was possible to establish a theoretical framework of expected issues that might arise. This also allowed the author either to identify with the scientific knowledge available, to reject statements in specific circumstances or to even discover new concepts that were not noted by the scientific community. Therefore, although some of the action research cycles were not as successful as originally anticipated, it was still possible to get better understanding of the organization, which contributed to the success of the research goal of this project. Figure 5.2 below provides a graphical illustration of the action research activities, within the two iterative cycles.

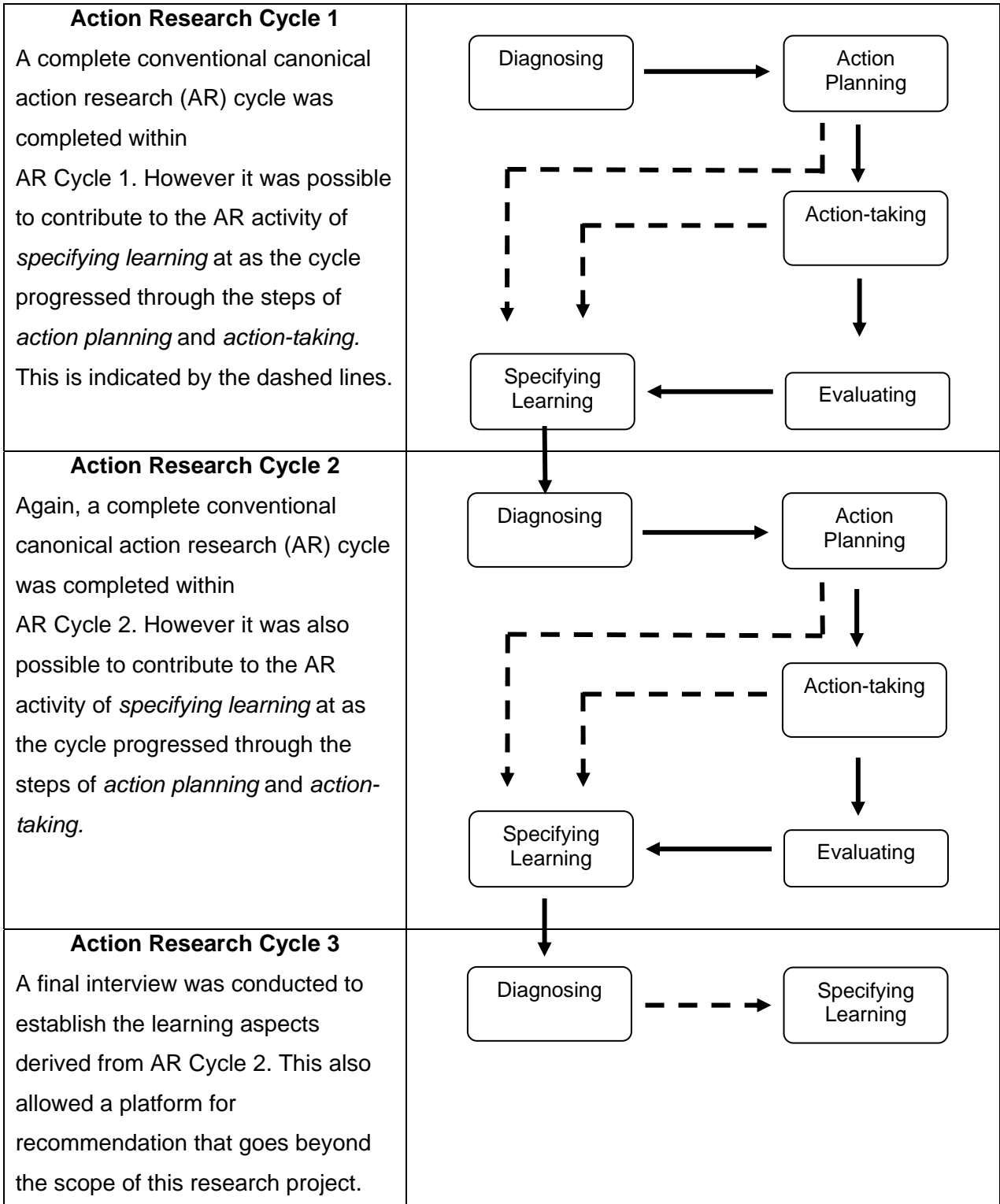| **Action Research Cycle 1**	
A complete conventional canonical action research (AR) cycle was completed within AR Cycle 1. However it was possible to contribute to the AR activity of *specifying learning* at as the cycle progressed through the steps of *action planning* and *action-taking.* This is indicated by the dashed lines.	Diagnosing → Action Planning → Action-taking → Evaluating → Specifying Learning
Action Research Cycle 2	
Again, a complete conventional canonical action research (AR) cycle was completed within AR Cycle 2. However it was also possible to contribute to the AR activity of *specifying learning* at as the cycle progressed through the steps of *action planning* and *action-taking.*	Diagnosing → Action Planning → Action-taking → Evaluating → Specifying Learning
Action Research Cycle 3	
A final interview was conducted to establish the learning aspects derived from AR Cycle 2. This also allowed a platform for recommendation that goes beyond the scope of this research project.	Diagnosing ⇢ Specifying Learning

Figure 5.2:   A graphical illustration of the action research blueprint

Because of the limited timeframe, the decision was taken to conduct the action research activity within a period of 6 months. This also meant that only a maximum of 5

participants could be used. The effective start date for this was March 2007. Interviews were scheduled, the initial plan being to conduct 3 – 4 interviews with each participant on a two monthly basis. However, as the cycles progressed, the researcher had to reduce the interviews in the data-gathering processes to 2 cycles, which effectively resulted in 3 interviews with each participant. This could mainly be attributed to the slow progress with regard to the implementation of "action-planning" events.

5.3.   Data gathering and reflection

The task of collecting empirical information that would be valuable to the actual outcome of this research project was heavily dependent on the selection of the most appropriate participants. This implies that, although some employees manifest great qualities in terms of ICT literacy and innovation, participants from the other end of the scale also had to be included in order to allow for a more accurate reflection of the adoption situation of mobile computing in this construction company. As mentioned previously, because of the collaborative nature of the action research form, the background of each participant was also important. The intent was to gather the bulk of the information through conducting one-on-one interviews and by means of workshops.

However, if only feedback provided by the participant was used, this could possibly provide an unfair reflection of the actual social situation. It was thus decided to employ monitoring tools to gather data of the implemented "action-planning" activities – in order to provide some justification for the findings presented. This was mainly achieved by monitoring log information of systems being employed, as part of the action plan activity.

An informal networking feedback process was also employed. This mainly involved approaching colleagues who had close working relationships with the selected participants and engaging in informal conversations with them in terms of the sociological implications of the changes as provided by the action-planning stage, from the perspective of the relevant participant. This also fulfilled the purpose to provide empirical information obtained from a perspective differing from that of the researcher or the selected participants.

This chapter described the action research blueprint (Figure 5.2). Chapter 7 provides details of the action research activities within the two AR cycles, as well as an explanation, analysis and interpretation of the research results.

6. Reporting the Action Research Cycles

This section presents the results of the action research activities, based on the research blueprint illustrated in Figure 5.2., The events and the analysis of these for each of the action research cycles are presented, followed by a discussion of the practical learning results, the practical contribution of the action-taking activities and the theoretical contribution.

6.1. AR Cycle 1: Baseline Analysis

The goal of the research project was to identify and understand the social issues that may impact on the successful adoption and diffusion of mobile computing in a small-to-medium construction company in Gauteng, South Africa. The first actions were to ensure that the appropriate technology was employed at the observation points. This was done to ensure that the technology was not considered as the primary barrier, so that the focus would only be on the possible social issues.

The first cycle was intended to prickle the participants' "thinking" with reference to the use and application of mobile computing as part of their daily function. Participants A, C and E have used mobile computing devices with a wireless Internet connection, whereas Participants B and D had not had any real experience the use of mobile computing devices with wireless Internet connectivity.

Although the literature suggested that the diagnosing stage should be completed as the last step in the action research cycle, in this research project the researcher thought that it would be more meaningful to identify the main problems with regard to mobile computing upfront, provided that the researcher was an employee of this company and had noticed the problems in previous observations.

6.1.1. Diagnosing

At initial glance, it seemed that participants B and D were not equipped with the appropriate technological devices to allow this research to be meaningful. It was decided therefore that this issue would have to be addressed by providing all participants with at least a laptop (notebook), a Smartphone or a PDA device which could be connected to

the Internet wirelessly or could connect to head office IT resources from a remote location.

Although the company was able to provide all the participants with the appropriate technological devices and it would be meaningful to use these technological devices as part of their daily function, participants A, B and D did not seem to be very confident in applying the technologies available to them or to be very sure of how to apply the technology. Initial observations indicated that the users would definitely need training, particularly with regard to the application of the technology in their daily function. They also indicated that they did not have the appropriate technical support should a technical problem arise. This, however, contradicts the researcher's initial belief that the IT support structures in place were fairly effective.

The method and process adopted in the attempt to derive the set of planned activities executed in the AR Cycle 1: Action-planning phase are discussed in Section 6.1.2.

6.1.2.   Action Planning

Interviews with each individual participant were held over a period of 2 weeks. This seemed to be the appropriate route to follow, seeing that politics and rivalry might influence the true manifestation of each participant's perspective. Also, the author felt that, because of the disparate technology maturity among the participants, the older generation participants might feel threatened by the younger generation.

Bearing the research objective in mind, it was decided to determine the current application of technology in the work environment of each participant and, by introducing planned changes, to attempt to establish an environment that would allow the successful adoption of mobile computing. With AR Cycle 1 the researcher was also interested in learning each participant's actual technology maturity.

The author interviewed all the participants individually and focused on three main concepts:

1. Participant's current application and use of the mobile computing technology available to them;
2. Participant's technology maturity; and

3. Participant's opinion of future application of mobile computing technology in the construction industry.

Each participant was presented with a set of questions, the intention being to have open-ended discussions. The questions posed to the participants in each interview, together with the purpose of the question, are listed in Table 7.1 below

Table 6.1:   AR Cycle 1: Action-planning questions and intended purpose

AR Cycle 1: Action Planning Questions	Purpose of question
1. How long have you been in your current position and what is your highest formal qualification?	The purpose of this question was to determine whether there was any correlation between the level of formal education and the individual's mobile computing adoption rate.
2. Do you have a computer at home with an Internet connection?	The purpose of this was to establish the pervasiveness of technology in the lives of the participants, especially with regard to Internet connectivity.
3. How would you rate your computer literacy? 4. How much time do you spent on average reading and compiling electronic messages like sms's or emails?	These questions were intended to establish what the daily application were in using, assumed to be pervasive, electronic communication tools available to the participants.
5. What kind of mobile computing technology do you have to your disposal?	The purpose of this was to document the mobile computing technology used by each Participant At this specific point in time.
6. Do you believe that a mobile computing device like a laptop, Smartphone or PDA with an Internet connection, and the ability to access to the head office LAN, would allow you to be more effective in your daily function?	The last question was intended to capture the participant's belief in terms of the future of mobile computing devices in the construction industry, especially in this particular construction company.

By examining the response to the questions mentioned above, and considering the general feedback from the interviews, the social issues of significance could be grouped in three categories: qualification, experience and skills; user technology maturity and application; and opinion of future roadmap for mobile computing in the construction industry. These interviews also allowed for a platform that allowed the researcher and the participants to establish action-planning events. Although it was stated that the first and foremost action-planning strategy for AR Cycle 1 was to ensure that all participants had the necessary technology available to them, which justified their involvement in this research project; the researcher also identified other action-planning events that were derived from the interviews with the participants. The action-taking events for each participant are described in Section 6.1.3.

6.1.3. Action-taking

6.1.3.1. Participant A

Participant A was supplied with a PDA device four months before the initiation of this research project. This device is able to connect to the Internet wirelessly and was set up to receive all email and calendar items over-the-air via the cellular service provider's infrastructure. It synchronizes with the email server at the head office via wireless Internet connectivity. However, Participant A also asked to be supplied with a laptop because of the limitations posed by the size of the screen and email applications on his laptop that would enable him to be more productive in his daily functions on site. These would include updating progress sheets for the particular project using spreadsheet technology. This task is currently executed with the use of paper reports and, according to Participant A, this has always been an administration nightmare. The other requirement was to use and access an email application from his PDA or laptop wirelessly which would allow him, as mentioned previously, to communicate more effectively and formally with the Project Manager of the specific projects specifically regarding "snagging"-related issues.

6.1.3.2 . Participant B

Participant B was supplied with a laptop at the start of his employment by this company. However, he did not have a wireless Internet connection device, but did have a broadband Internet connection at home. It was jointly decided that being equipped with a

wireless Internet connection device was not essential at this stage. He was able to connect to the office network from home using a secure connection (Virtual Private Network) via his personal broadband Internet connection.

6.1.3.3.   Participant C

Participant C was supplied with a laptop and a wireless broadband Internet connection device at the start of his employment by this company. He appears to have been using the technology successfully for the last 2 years. His main concern was the slow connectivity from the site office to head office using the wireless Internet connection device. Unfortunately the company is dependent on the wireless Internet service provider, a problem that is beyond the scope of this research project. It was therefore decided to focus on the employment of technologies and services available within the constraints of the company's internal network, which would allow faster access to electronic resources located on the head office computer network. These technologies included an FTP site that would allow Participant C to access subcontractor information (mostly electronic spreadsheet files) on the shared company hard drive from a remote location more efficiently and effectively. . Once the technology was operational, Participant C was informed and trained on a once-off basis on how to use the facility.

6.1.3.4.   Participant D

Participant D was supplied with a laptop (notebook), but eventually came to dislike it and said that he felt more comfortable using a desktop workstation. Participant D has been using the desktop workstation successfully for about 15 months, but it seems that his skills were limited to viewing reports, finalizing purchase orders on the in-house administration system and viewing email communications received. During the first workshop held Participant D agreed to exchange his desktop computer for a laptop to allow him more flexibility in terms of performing his daily functions from remote locations (site office). However he later again refuse to have a laptop. He said that he would rather prefer to have training to address his skills shortage in terms of computer literacy and would revisit the idea at a later stage.

Participant D said that he had a skills shortage in terms of basic electronic file management, electronic communication tools such as email software and electronic fax service. It was then decided to deal with these skill shortages by conducting weekly one

hour one-on-one training sessions, for two months for Participant D. It was also decided that the focus would be on enabling him to use these applications in his daily functions.

6.1.3.5 . Participant E

In his position as Managing Director, Participant E had been supplied with all the mobile computing technology available to this construction company. He had a desktop computer at his disposal, which effectively functions as his default workstation at head office. He also had a laptop with a wireless Internet connection device; a PDA with wireless Internet connectivity, as well as a desktop computer at his home which was set up to connect to the head office LAN via his broadband Internet connection.

As no clearly defined action tasks were identified in the interview with Participant E, he provided direction and approval for the action-planning tasks suggested for Participants A, B, C and D. This was one of the main reasons for the inclusion of Participant E. In the case of Participant E, the intent was also to establish a platform to foster support from senior management within the company, for this research project.. He was constantly provided with feedback from the research project and also used this channel to lobby support from other members of the senior management team.

6.1.4. Evaluating

After the successful completion of the action tasks discussed in Section 6.1.3: Action-taking, the stage was reached at which the findings from AR Cycle 1 could be described and analysed .

The questions for this cycle focused on determining each participant's understanding and on allowing the researcher to better understand the research domain with regard to the three main overlapping concepts considered in AR Cycle 1: "participant's qualification, experience and skills", "participant's technology maturity and application" and "participant's opinion on the future of mobile computing in construction industry". Section 6.1.4.1 describes and analyses the feedback from the participants for "AR Cycle 1: Baseline Analysis".

6.1.4.1.   Evaluation: Participants' qualifications, experience and skills

Based on the feedback from Participants A, B, C, D and E (documented in Appendix A), it appeared that most of them held degrees from well-known tertiary institutions. Participant A was the only one without a formal tertiary qualification. It was expected that the barriers to the adoption of mobile computing would be particularly manifested by the older generation participants and by those without a tertiary qualification. The older generation (Participants A and D) seem to have had extensive practical experience in terms of project management and site activities and function. According to Participants A and D, practical experience is more vital in their daily function to successful execution of their particular job functions. The younger generation, Participants B and C, seemed to be more eager to implement the new concepts that mobile computing technologies offer. It should also be noted that only Participants A and E had the knowledge of how to use a PDA device to receive email via wireless Internet connectivity. All the other participants had only recently heard of the technology or were introduced to this technology when they joined this research project.

Participant A did not have any formal tertiary education but was able to use a PDA device in his daily activities. Although Participant D held a degree he did not have the skill even to send an email from his desktop email communication application. The researcher had the pre-conception that a university graduate would have an attitude to constantly enrich himself and that, consequently, the generally accepted skill in sending and receiving mail messages would already have been gained.
Participant E believes that people need to constantly enrich themselves to allow for progression in their career endeavours. He has completed a number of courses at various non-tertiary institutions, constantly enriching his knowledge. He believes that this has allowed him to achieve above-average enrichment and has narrowed the knowledge gaps that he experienced during the course of his career.

Section 6.1.4.2 provides background with regard to Participants A, B, C, D and E's "technology maturity and application thereof".

6.1.4.2.   Evaluation: Participants' technology maturity and application

The general feedback from all the participants in this research project indicates that there is a definite administration component in terms of their daily function that requires

them to spend some time at the head office. In some cases up to 50% of their duties are administration-related. It could be argued that this might be because the particular participant is not as efficient in executing administration-related tasks or that he lacks the computer literacy that allows another participant to be more efficient. For example, Participant B said that he spent 30% of his time executing administration -elated tasks at head office and that he rated himself in terms of computer literacy as a level 4 on a scale of 1(bad) – 5 (good). On the other hand Participant D, has a similar position in this company, spends 50% of his time on administration-related duties but rated himself in terms of computer literacy as a level 2.

With the focus still on Participant D, let us now consider his application of the ICT technology that he has available. Participant D's current cell phone is considered a Smartphone, but he does not use or apply any of the functionalities of a Smartphone, such as sending or receiving emails from his cell phone, or even browsing the Internet. He states that:

> "… I only know how to send an SMS, because my daughter showed me how…. She showed me about 10 times before I was able to do it myself… I do not understand how something works if it is explained in a book… someone will have to show me: click here, and then there and then click there… I will have to be shown physically how to go about…"

He believes that he could or would use the email functionalities of the Smartphone, if he had the appropriate training. Although he has been provided with a standard user manual (provided by the Smartphone manufacturer) in terms of these functions, he has not made any progress in terms of knowledge attainment on his own. He said that he would like to receive training in terms of electronic communication tools in the form of practical demonstrations and application within his daily function. He also wanted to know if the company's IT support department would be available to provide support if he should experience a problem with a particular functionality or needed to ask a question. Although Participant D made the above statement, he still uses an email application connected to the Internet to view and read email messages. He was offered a wireless Internet connectivity device and laptop when he started at this company, but declined because he felt he did not have the necessary knowledge to use and apply these technologies. Although the company's software policies in terms of a desktop and laptop computer within this company are exactly the same, it seems that Participant D believes that desktop and laptop computers do not operate in the same fashion, particularly in

terms of the email application and standard office application software. The author had to explain to him that there was no real difference between these two types of device, in terms of software applications and the only difference between these two devices relates to their physical dimensions and to the fact that that a laptop computers allow for mobility.

Participant A did not have a laptop, but asked that he be supplied with one laptop so that he could execute some administration-related tasks from the site office. He specifically asked for a laptop with a long battery life. As the company's IT budget did not allow this request to be serviced immediately, it was decided, as temporary solution, to provide him with a second-hand laptop. However, this laptop was 5 years old and its battery was not functional. This was a major frustration for Respondent A as, in most cases, construction projects do not have electricity on site. Electricity is usually only connected about one month before completion of the project.

With the above in mind the reader is referred to the statement made by Participant B:
> "… I believe that there is a need to access tools like an email application, the in-house administration system and electronic files stored on a centrally located company shared hard drive from a remote location".

In this particular research project the remote location, in most cases, refers to the site office, where most of the decisions are made and actions are initiated with regard to a specific construction project. He further states:
> "… In many cases there is the issue of urgency…"

This statement by Participant B refers to a situation in which the productivity of a construction site may be influenced, for example, when the Site Manager on a construction site, requested building material for a particular delivery date but does not receive the material at the time requested, but only two weeks later. This delay could be ascribed to the red tape process involved with regard to a purchase order that needs to be approved by the Contract Manager, in this case by Participant B. It could be that the supplier only has a limited amount available of the requested building material and, because Participant B may not be near an Internet connection, which would allow him to connect to the in-house administration system and approve the order requested for action, the purchase order might only be sent to the supplier at a later stage, resulting in

the requested building material no longer being available and the supplier only deliver two weeks later.

Participant C's statement complements the statements made by Participant B above. Participant C said:

> "… I believe that a device that allows the use of an email application remotely, will allow me to provide quicker feedback with regard to the process of approving purchase orders, and the receiving and compiling of emails that contains vital information".

In most cases the clients and external project managers for a particular project use email communication as a formal channel to provide instructions or to get feedback on specific problem issues. It can be agreed that this channel of communication is vital and could have a negative impact on the project if instructions or feedback do not reach the intended recipient in time. The opposite, however, is possible, allowing a positive spin-off as stated by Participant C:

> "…I think there is a need to receive emails on a Smartphone or PDA type device that will enable me to provide quicker feedback, or allow me to attend to problem issues in a more efficient manner".

To substantiate Participant C's statement above, it should be noted that Respondent C's job description requires him to spend 50% of his time on site.
Participant C also said:

> "...If I was aware of a new email received with regard to a problem issue [snagging], I can resort to it immediately, instead of travelling back to head office and only learn about the problem then".

At present it is only when the client or external project manager notifies or discusses the problem issues with Participant C telephonically, that he would be able to react to them. If he is not notified telephonically, but only via an email notification of a problem issue on site, he would only become aware of the issues once he is able to connect to the email server to view his emails.

Participant C also said that he believed that there was a need to access and view electronic documents stored on the shared company hard drive from remote locations. At present he is not able to view these electronic resources, because of the slow connectivity speed of the wireless Internet service in the areas in which he operates.

These electronic documents contain budget-related information to which Participant C, as a junior Contract Manager needs to constantly refer.

He stated:

> "…If I was able to open an Excel spreadsheet remotely or maybe capture information on a spreadsheet document on a PDA device, I will be able to save a lot of processing time…"

To elaborate on the above statement, let us consider the tasks involved with regard to the administration of progress payments to subcontractors. This function requires Participant C to physically confirm the progress that a particular subcontractor has made on site, with regard to the work that he has been contracted to do. It is necessary for Participant C to certify only a payment amount that is equal to the agreed cost of the actual work completed. To resolve discrepancies, he might need to view information from the site offices to compare the actual rate or subcontractor's contract amount with the budgeted rates to ensure that the project is still within the required allowance. Without the ability to access the electronic documents from the site, subcontractor payment issues could only be dealt with when Participant C is back at head office and has access to the company shared hard drive. This situation suggests inefficiency and it can be agreed that remote access may have a positive impact on this process.

With regard to technology pervasiveness, it seemed to be at a fairly moderate state among the participants. This is based on the fact that Participants A, B, C and E use some form of mobile computing device as part of their daily activity and that all the participants use the Internet on a daily basis, not only for work-related purposes but also for personal use. Participants B, C, and E use a laptop, which can at least connect to the Internet, as part of their daily functions. Participant A only has a PDA with wireless Internet connectivity, and uses the email functionality on a daily basis. At this stage Participant D only has a Smartphone with wireless Internet connectivity, but he only uses it for telephony.

The pervasiveness of email communication technology is quite interesting. All the participants use the email facility provided by the company on a daily basis. It was also noticed that they depend on this facility. This observation is based on the fact that all the participants spend at least 30 minutes per day reading email (or sms) messages and that some of them spend up to 4 hours per day reading and sending email messages. It should also be noted that email communication is used as a formal communication tool,

which is indicative of its importance. Bearing this and the scenarios depicted above regarding delayed email communication response or receipt of an email that contains vital information in mind and the mobility aspect of the participant's job function, it is clear that there is a need to receive emails on a Smartphone or PDA type device that will enable Contract Managers in particular to provide quicker feedback to the client or external project manager. It should also allow Contract Managers to attend to problem issues more efficiently. This is suggested by the time wastage factor when commuting between the construction sites and head office.

6.1.4.3. Evaluation: Participants' opinions on the future of mobile computing in the construction industry

This section deals with the issue of the participants' personal beliefs in terms of the future of mobile computing in the construction industry and whether the relevant participant would benefit from it.

Participant A said:

> "… I would like to use a laptop on site, to capture work schedule information through the use of spreadsheet application software".

To elaborate on this statement, Participant A plans to capture and monitor the progress of the construction activity on site with the use of the spreadsheet application software. He can execute this administration tasks electronically, allowing him more easily and formally to distribute the progress information to the client or to the Contract Manager who needs to track the progress of the project. Although he believes that access to the company's internal network and in-house administration system, with the use of a wireless Internet connection, would be a great benefit, he does not see this functionality as a necessity from his perspective. He believes that the email facility enabled by mobile computing can have a positive impact on his daily administration related tasks. He said:

> "…With the email facility I can query site requisitions by sending email requests to the procurement officer or to the Contract Manager…. I could also use email to communicate directly and formally with my subcontractors that have email".

Participant B supports the notion of the importance of email communication from remote locations, but places more emphasis on the "urgency" concern of the communication methods required in business. This is substantiated by the following statement:

> *"…it doesn't matter in which industry you are in, everyone is expected to receive information faster, process the information more efficiently and also be able to react on it more efficiently…with the intensity of communication every professional within this industry expects a response from you within two hours of time they sent the email. A three day delay in response is unacceptable, one should at least respond within one day".*

It is clear that Participant B believes that there is a need to react or respond more promptly to information received from external project managers, clients, suppliers and subcontractors. He also believes that there is a need to be able to disseminate information more efficiently. He therefore believes that it is more important to be able to receive and send emails from remote locations with the use of a mobile computing device than to be able to connect to in-house administration systems and to other electronic resources that are available only on the company's internal network (head office LAN).

Although the use of a mobile computing device such as a PDA or laptop with a wireless Internet connection allows the user to access the company's project related information while on site, enabling him to react to budget-related issues immediately, Participant C also believes there is a greater need to enable access to an email facility via the mobile computing device such as a Smartphone.

He said:

> *"…if I had a PDA that can receive emails, and I need to be on site in any case to do my progress payments, and an email is delivered reporting an issue for that particular site I can react on it immediately…"*

As implied by Participant C's response in Table A3 in Appendix A, with regard to the impracticality of setting up a dedicated desktop on site, Participant C believes that site staff should rather employ laptops. He also said that he would use other applications on a PDA device that would allow him to be more efficient. This notion is substantiated by this statement (Table A3 in Appendix A):

> *"…I believe that, if I had a PDA, I would also use the mobile spreadsheet software application installed on the PDA to capture information while I'm on site,*

and then later when I'm at the head office, download the information from the
PDA to my laptop".

Although Participant D could not provide the researcher with a valid statement regarding his opinions on the future of mobile computing, he did mention some aspects that suggested that he believe that technology could actually enable him to be more efficient in his daily activities. This is based on the following statement from Participant D:

> *"…I am wasting time to write details out on a site requisition form and then*
> *taking it to the procurement officer for action, can't we do this*
> *electronically?"*

Participant E considers the technology to be a possible barrier, but believes that any tool or technology (in this case mobile computing), that would allow the Contract Managers to be more involved in site activities by physically operating from the site office, would be beneficial to the company. He stated (See Table A3 in Appendix A):

> *"…when you consider the common problem issues that arise during the*
> *construction phase of a project, Contract Managers should be more*
> *involved in site activities and should execute their daily function from a site*
> *office to provide better supervision".*

He believes that there should be a paradigm shift in the perceptions of older generation Contract Manager that would allow them to acknowledge the benefit of employing mobile computing within their daily function. He suggested that, as a starting point, training sessions with regard to IT literacy should be initiated. He would then also make Contract Managers more aware of the reporting tools available within the in-house administration system so as to foster a notion of support and encouragement by the executive management team, through the use of innovative technologies.

He also made the following bold statement:

> *"…technology may enable the older generation Contract Manager to be more*
> *efficient, but it would not necessary impact on their project management abilities."*

This statement suggest that Participant E would also need to change his mindset regarding IT and see it as an integral part of the organization, whether it is in head office workspace or in the harsh circumstances of the site office.

Participants A, B, C and E seem to agree that mobile computing devices such as laptops or PDA devices with wireless Internet connection modems would definitely benefit them in terms of their daily productivity. Although it was assumed that most of the participants,

particularly the Contract Managers, would want access to all the internal resources available on the company internal computer network as a first priority, the primary requirement seemed to be the ability to access email applications wirelessly or receive and respond to company-related emails from remote locations. Other requests that could be beneficial to the participants in their daily function were made, such as the provision of spreadsheet application software and of access to the internal shared drive to view vital budgetary information, but these did not seem to be necessities.

6.1.5. Specify Learning

The *learning* activity described in Chapter 5 as part this research project's AR framework (Figure 5.2) took place throughout the cycle's activities and included the *action planning, action-taking* and *evaluating* activities. This section provides a summary of the aspects learned, the practical contribution that the *action-taking* activities presented and the substantiation or contradiction of the proposed theoretical framework (Figure 4.2), followed by the interpretation of the most influential issues that would be incorporated in AR Cycle 2.

Table 6.2:   Summarized learning aspects for AR Cycle 1

Summary of Learning Concepts	Practical Contribution	Implication on the Theoretical Framework: Figure 4.2
The eagerness displayed by Participants A, B and C regarding implementation and learning new innovative technologies suggested that better adoption and diffusion scenario may exist for mobile computing among the younger generation participants.	In the attempt to make mobile computing technology available to the participants, possible new ways in which the technology could allow efficiency were identified. There are major benefits in using mobile computing technology in the daily function of Site Managers and Contract Managers of this construction	Although the pre-conceptive issue of "personal belief" plays an integral part in the eagerness of Participants A, B and C, it is also necessary to be aware of the "stage of their career" and their "motivation" level, which may also be important issues.

	company.	
There was no distinct correlation between participants' formal "education level" and its impact on the adoption and diffusion of mobile computing. Participant E has a strong belief in the importance of "training" and, given the pervasiveness of mobile computing in his daily function, "personal belief" and "training" are vital to the success of mobile computing adoption and diffusion.	The participants in this study have been positively influenced regarding mobile computing adoption and diffusion. They have influenced their direct peers with regard to the use of mobile computing in their daily function.	Although the participants' formal "education level", was believed to have a significant impact, it seems that the issues of "personal belief", "stage of career", "motivation" and possible previous "experience and exposure" will have a greater impact on his "ICT literacy".
Mobile computing devices present the ability to use email application software has and offer significant benefits in terms of formal communication and the auditing of communication between the professional construction management team.	Email communication seems to be the most important communication between the members of a professional construction management team. The ability to access and send emails wirelessly via mobile computing devices has positively impacted on the efficiency of the communication channel users between this construction company and external professional team members.	"Technology compatibility" cannot be considered the main barrier in the adoption and diffusion of mobile computing, but should also be taken into consideration in the attempt to implement an innovative initiative as in some cases required service delivery cannot be provided to the required standard.

Technology cannot be excluded from the attempt to focus only on social issues. Technology that enables mobile computing (wireless Internet) poses an influential adoption and diffusion barrier.	The available technology offered by a service provider who provides wireless Internet connectivity is considered a possible issue in the deployment of innovative solutions. Participants and users in this construction company have acknowledged this issue and seek designated areas on a construction site that will allow efficient wireless Internet connection reception.	This refers to "technology compatibility". The methods employed to allow wireless Internet connectivity, and possible other technological issues, such as the robustness of computer hardware, need to be considered in the attempt to successfully adopt and diffuse mobile computing on the construction sites of this company.
Limited awareness of the functionalities and IT technology provided by this construction company, suggests revision of the company's computer literacy training policy may be necessary.	The training policy with regard to IT literacy and mobile computing needs attention. The general IT literacy proficiency suggests that it has an effect on the adoption and diffusion of mobile computing. The need for a plan has been formulated, as well as an implementation policy to define the IT training methodology to be employed at this construction company.	This construction company's "Company Vision, Strategy and Internal Policies" have a great influence on the objectives of this IT department. This issue also has an impact on "Training and support" as it provides direction. The issue of "Training and support" also has an influence on the "ICT Literacy" in this construction company, as it has a positive impact on the adoption and diffusion

		of mobile computing.
Users' lack of awareness of the steps to be followed to obtain IT support, inadequate IT support structures and revise delivery method of IT support.	Participants and other users in this construction company have been made aware of the course of action to be followed in the event of computer-related issues. Issues are being reported in a more formal approach via email to the correct parties.	This also substantiates the significance of the pre-conceptive issue "support".

Although many of the pre-conceptive mobile computing and adoption issues were substantiated, there were also several new discoveries and contradictions.

The following issues were substantiated as suggested in the theoretical framework (Figure 4.2) in AR Cycle 1:

Organization Level:
- Training and support;
- Technology compatibility;
- Company Vision, Strategy and Internal Policy;

User Level:
- Education Level;
- Personal belief;
- Experience and Exposure; and
- ICT literacy.

The newly discovered issues of significance included:
- Stage of career (User Level)

This issue refers to the situation in which a particular participant is at a later stage in his career and does not necessarily envisage the benefit of learning new concepts with regard to ICT technology. He does not see the benefit of, for example, a training course that provides insight in using email to its full capacity.

On the other hand, it also refers to Participant C's "Personal belief". He has just started his career and is keen to learn about new innovative technologies that would allow him to be more productive. This issue considered to be inherently owned by   the user, and is therefore considered at user level.

-        Motivation (User Level)

The meaning of this concept is derived from the personal perspective of a particular participant. In this case it specifically refers to Participants A, B and C. It refers to the situation in which participants follow a pro-active approach in the execution of their daily functions. It refers to the degree of innovation that has been noticed in the feedback results documented, derived from the interview with these participants. It can therefore be concluded that this issue would influence the "Personal belief" of Participants A, B and C in the adoption of mobile computing. These participants are considered to be highly motivated and their constructive feedback on the employment of mobile computing in other scenarios suggests that they "believe" that technological innovation does have a positive impact on their daily work functions.

Figure 6.1 below is a revision of the theoretical framework illustrated in Figure 4.2 of the substantiated issues around the adoption and diffusion of mobile computing that were identified in AR Cycle 1, as well as their interactions. The interactions are indicated by means of dashed and solid lines. The dashed lines indicate t pre-conceived interactions and the solid lines indicate both the previously confirmed as well as the newly discovered interaction of issues in AR Cycle 1. The issues highlighted in grey represent the new issues that were discovered in AR Cycle 1.
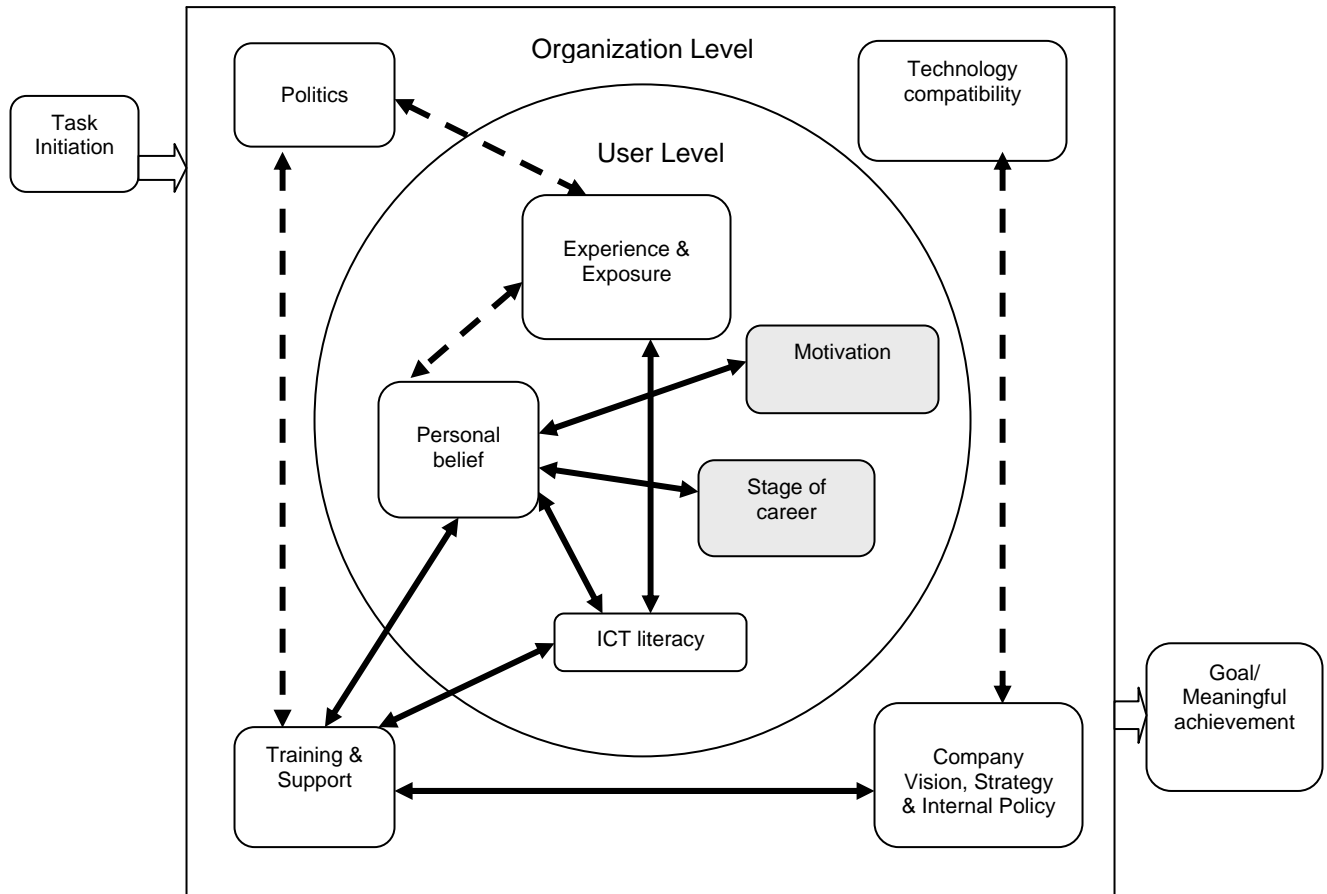
Figure 6.1: A theoretical framework of pre-conceptive mobile computing adoption and diffusion issues as observed in AR Cycle 1

The summary of the *learning* specified within AR Cycle 1 allowed the impact of many of the pre-conceptive issues suggested in Figure 6.1 to be substantiated. Although most of the pre-conceptive issues were identified in the work environment of the participants in this construction company, issues such "Education Level" did not seem to have had a great impact on adoption and diffusion of mobile computing. Some new issues and interactions were also found among the issues identified and are illustrated in Figure 6.1. In addition, it was also noticed that that were several specific issues that were considered as having a great impact with regard to the adoption and diffusion of mobile computing in this construction company. These main issues will be highlighted in the next section and will provide the justification for their inclusion in AR Cycle 2.

Technology ("technology compatibility") is still regarded as a significant barrier to the successful adoption of mobile computing within this company's environment. This particular case refers to ICT technology, which provides the ability to connect wirelessly to the Internet via the infrastructure of a cellular service. The cellular service providers who offer wireless Internet are not yet able to provide the quality of service that will allow users to connect efficiently to the company's internal computer network (head office LAN) from all remote sites within Gauteng, South Africa and to use the electronic resources available to them as if they were located at head office. If the costs of other options for setting up a site office connected to the head office computer network via devices fixed to the site office building were taken into account, these may be found to be unjustifiable, even if the issues of theft and exposure to the natural elements were excluded.

Another issue realized was the fact that the most of the participants were not aware of the available functionalities or technologies that would allow a user to connect to the company's network from a remote location. They were also not aware that, with the use of this functionality, they would have all the administration facilities at their disposal just as if they were situated at head office. These facilities include an email application, shared drive, fax services and access to the internal administration system. Resolution of this meant that it might be necessary to inform the participants of the technologies that are available to them in a more effective manner. There is also a need to train users to acquire the skills required to enable them to employ these common functionalities, such as accessing email applications, the company shared hard drive, fax services and the in-house administration system from remote locations as part of their daily function. The company thus needs to address "training" and the lack thereof as a significant issue that could impact on the pace of adoption of mobile computing in this construction company. Such training should include topics that specifically address a user's "ICT literacy". This may be achieved by hosting training sessions that deal with standard office applications such as the standard layout of a desktop PC, Microsoft Outlook, Microsoft Excel and Microsoft Internet Explorer. The training initiative should also consider training employees in mobile computing technologies as part of their daily function. There is also a need to be aware of the vehicle used to provide this training. The training should be executed in an intimate manner, whereby delegates can openly and freely ask questions to allow effective knowledge transfer. These training sessions should also be repeated, which would also complement effective knowledge transfer. There is also a need to communicate the benefits of mobile computing technologies effectively and to ensure

that users are aware of how the technology operates and of the benefits that may be derived by employing the applicable technology.

IT "support" structures need to be in place to allow users to get prompt and efficient response if they have technical or application issues that need to be resolved. This poses a dilemma, in that the current resource allocation of one part-time support consultant, may not allow for the provision for the intended support. There is also a need to communicate to users what action should be taken when specific computer problem issues are reported. A possible solution is to employ a more structured approach to reporting these computer issues by capturing them on an intranet portal website so that feedback (progress comments) and possible resolution dates can be captured and communicated.

Another significant issue identified was in terms of basic computer literacy ("ICT Literacy"). Although Participant D mentioned that he had a below-average computer literacy rating, from observations of him while he was executing some of his daily functions, it appeared that he was definitely not below average, but that it was more likely that he felt threatened by the idea of using new technology. It also seemed that Participant D was threatened by the abilities of the younger generation Contract Managers.

In summary, the following issues are considered significant and will be used to derive the *action-planning* activities for AR Cycle 2:
- Technology compatibility;
- ICT literacy; and
- Training and Support.

Based on what was learned in AR Cycle 1, these findings will now be used and incorporated into AR Cycle 2. The activities and findings of AR Cycle 2 are described in Section 6.2.

6.2. AR Cycle 2: Strategic Planning

The goal of this research project was to identify possible social barriers to the successful adoption of mobile computing within a small-to-medium construction company in Gauteng, South Africa. As mentioned in AR Cycle 1, the purpose of the researcher's

initial actions was to ensure that the appropriate technology was employed at the observation points, in an attempt to eliminate the technology issue as a possible barrier to the successful adoption of mobile computing. This is based on the assumption that the wireless Internet technology used by Participants A, C and E allows an acceptable connection speed. In this research project, an acceptable connection speed was assumed to be a situation in which a participant would be able to connect to the company's internal computer network (head office LAN) wirelessly and access the internal electronic communication, in-house administration and other application tools, as well as the connectivity speed is reliable and does not result in frustration.

During "AR Cycle 1: Baseline Analysis" participant interviews, it was realised that the technology, specifically the Internet connection allowing access to the company's internal network, would have to be considered as a possible factor presenting a barrier to the successful adoption of mobile computing in this construction company.

6.2.1. Diagnosing

During AR Cycle 1, several initiatives were undertaken to allow for an environment in which all the participants would be able to use some form of mobile computing as part of their daily function. AR Cycle 2 was therefore intended to determine the participant's "experience" in the use and application of mobile computing as part of their daily function.

Based on the findings from the AR Cycle 1's interviews, three overlapping adoption and diffusion issues were derived and will be concentrated on during AR Cycle 2:
- Training;
- Technology application; and
- Support.

The concept *training* refers to events that would provide a platform to more effectively transfer skills and knowledge in terms of mobile computing technologies. The significance of this issue was again realised after a request from a fellow colleague, an older generation Contract Manager who has the same function as Participant D, but who was not included in this research project. This colleague requested one-on-one training sessions in order to address his skills shortage in terms of general computer literacy. It seemed that the request came after this colleague had noticed the change in Participant

D's computer literacy skills and became aware of their benefits. This was after the initial one-on-one training sessions with Participant D. Although the computer literacy sessions with Participant D only included electronic file management, email software application, electronic fax services and document-scanning technologies; they appear to have made a difference in the productivity of Participant D. This led to the belief that effective training could be achieved either by conducting one-on-one training sessions or by having small intimate training sessions with not more than 4 attendees. It is also important to group attendees together on the basis of their knowledge and their particular job function. For example, the older generation Contract Managers and the younger generation junior Contract Managers should be grouped in their own separate training groups. This would allow for a more conducive knowledge transfer environment, eliminating possible rivalry between the older and younger generation participants. This approach would also allow the older generation to be more confident in interacting and asking questions among an audience with the same knowledge gap.

From the findings of "AR Cycle 1: Baseline Analysis", it is clear that technology still poses a possible barrier to the successful adoption of mobile computing. As mentioned before, in this particular case technology refers to wireless Internet technology offered by cell phone service providers and a top-of-the-range mobile computing device that can establish a broadband Internet connection wirelessly. Although there was a noticeable difference in the wireless Internet connection speed between final and initiation stages of this research project, it is still not possible to establish a reliable wireless secure private connection to the company internal computer network with the use of this technology in all the geographical areas in which the participants operate. A reliable wireless secure connection refers to a situation in which the user is located at a construction site office in an urban area and has to be able to access all electronic information resources as easily as if he were located at head office and connected to the head office LAN.

The top-of-the-range PDA device that is offered by most cell phone network service providers has also presented a set of barriers. One of these is that the PDA device has a limited screen size, making it impossible to display this construction company's internal administration system in its standard format. The Internet Explorer functionality on the mobile device is also limited and in many instances cannot display a standard Internet Explorer page that could otherwise be viewed with ease on a laptop workstation. This indicates that web pages that have to be displayed on mobile computing devices such as PDAs will have to be modified to allow the content of that particular page to be

viewed. If the intention is to view the web page on a mobile device, a web site would have to be designed specifically for viewing and accessing its contents on a cell phone or mobile type device. These drawbacks were identified and based on the preliminary assumption that a PDA-type device would present the ultimate solution in enabling mobile computing within this construction company. Although PDA or Smartphone devices are still very powerful tools, the author had to revise his assumed *technology application* policies because of limitations posed by the standard handset device available on the market. The email, calendar and contacts synchronization facility that this type of device presents is still considered very valuable to the participants who use it. The purpose of this technology is to make the user aware of all formal email communications and calendar invites delivered to his email inbox and to notify the user on the PDA or Smartphones wirelessly of any new email communication items. This resulted in the concept being derived whereby a set of technologies works in conjunction so as to allow a more suitable environment for the successful adoption of mobile computing within this construction company. For example, a Contract Manager would need at least a Smartphone with a wireless Internet connection and software that allows receiving and sending email wirelessly, a laptop with a wireless Internet connection modem with email application software and a company network that allows an environment that is conducive to mobility and allows the workforce to connect to the company internal computer network from a remote location. Email application software is said to be the most important tool, within this environment as identified in AR Cycle 1, enabling the concept of mobile computing. It was also found that email communication in conjunction with SMS technology could provide a solution that would be very conducive to the adoption of mobile computing in the operating environment of this particular construction company.

The concept *support* refers to internal company structures that both enables and is conducive to innovative concepts such as mobile computing. This particularly includes technical support that would provide users with assistance that would allow the efficient resolution of technical issues that may arise. Although the focus is on mobile computing, this support needs to be expanded to include any technical computer issue to allow a situation conducive to confidence building in computer literacy, particularly in the case of a user such as Participant D who has a large skill's gap as regards general computer literacy. It should also be noted that support also refers to the situation in which all employees understand the benefits offered by mobile computing. Towards the end of "AR Cycle 1: Baseline Analysis", Participant B decided that he would also like to use a

cell phone that would allow email inbox synchronization wirelessly. It was also decided to provide him with a wireless broadband Internet connection modem that could be used with his laptop. However, this process took almost 4 months. If management parties dealing with the task of acquiring the modem had been aware of the benefit and had fully supported the use of the particular technology, this might have been a different scenario.

6.2.2. Action Planning

In "AR Cycle 1: Baseline Analysis" the approach used was that of interviewing the participants individually. However, because of their limited availability and the time it took to complete "AR Cycle 1: Baseline Analysis", it was decided to group certain participants together, based on their technology maturity and job description. It was therefore decided that the younger generation participants, who included Participants B and C, would be grouped together and that Participants A, D and E would be interviewed individually. Participant A was interviewed separately because of his position – his job description requires him to function from a construction site office. Participant D was interviewed separately because of his limited computer literacy level and Participant E was interviewed separately because of his position of Managing Director, providing direction for the research project. It was interesting to note that other fellow employees also wanted to be included in these sessions. A group session was then scheduled that included Participants B and C, as well as two colleagues who held the position of junior Contract Manager (same job description as Participant C) and who wanted to join the session.

Although it was initially intended to have three AR cycles, the timeframe and the slow progress with regard to the action-taking activities did not allow the third and final AR cycle to take place. It was therefore decided at least to have interviews with all the participants after the action-planning events of AR Cycle 2 had been successfully implemented. The purpose of this was to get at least some feedback with regard to the action-planning events in AR Cycle 2, which should contribute to the scientific learning obtained from this research project.

6.2.3. Action Taking

Based on the discussion presented in the previous cycle, in Section 6.2.1: Diagnosing, three main concepts that influence the participant's experience with regard to the mobile

computing technology tools available within this construction company were identified. These three concepts were *training, technology application* and *support.* The *action-taking* activities were based on these three concepts and the focus of the interviews was also on these three concepts, in an attempt to show how these concepts contribute or pose barriers to the adoption of mobile computing in this construction company.

The first set of interviews and group sessions were conducted over a period of two weeks to compile the action-taking events for AR Cycle 2. Group sessions were conducted with Participants B and C and with two of their colleagues who had the same function as Participant C and individual interviews were held with Participants A, D and E. The researcher travelled to Participant A's workplace and conducted the interview on the construction site where he is currently employed as Site Agent and the interviews with Participants D and E were conducted at their offices in the head office buildings. Although it was not possible have a group session with all participants at one time, the consensus between the different sessions was interesting. In most of the sessions it seemed that all the participants agreed to a certain extent, that the main issue with regard to the participants' experience of mobile computing technology, as identified in Section 6.1.5: Specify Learning, could be grouped into the concepts: training, technology application and support.

Based on the feedback from the all the participants, it was clear that these three concepts (training, technology application and support) were definitely the main issues of concern. There was also general agreement regarding the action-planning activities to be undertaken within this cycle.

These activities included intensive *training* events that focused on the use and application of email communication software on a mobile device such as a Smartphone or PDA and a laptop workstation. The participants also wanted to be educated in the application and use of the email synchronization employed on a laptop or desktop workstation in conjunction with a Smartphone or PDA device that can connect wirelessly to the Internet. Training sessions were scheduled in which employees were grouped together based on their function and their computer literacy level. These training events focused on email communication software, and specifically the Microsoft Outlook 2003 package. The topics in these training events covered general management techniques available within this software. This included email inbox management, email folder management, follow-up tools, calendar management, task list management, email archiving, automatic rules for sorting emails and inbox synchronization used in

conjunction with a PDA or Smartphone. Although the training events initially included only the participants within this study, most of the head office employees in this company wanted to join these sessions and the training plan had to be revised to include most of the head office workforce. The training sessions were conducted over a period of two months, with a maximum of four attendees per session.

With regard to *technology application*, as stated in Section 6.2.1: Diagnosing, the participants agreed that there was a need to consider an environment in which technologies could be used in conjunction with each other, in which mature technology could be used with newer technologies to enhance business processes. The site requisition requests entailed the ordering of material, initiated by a Site Agent or Site Manager. According to Participants B and C this process takes on average 3 days to complete, because of the red tape involved in approving an order. The author proposed the use of SMS and email technology in conjunction to make this process more efficient. This could be achieved by informing the Contract Managers via an SMS message that a site requisition request had been captured and needed to be approved. Only when the Contract Manager has approved the order, would the purchasing officer be able to forward the request to the relevant supplier. However, if the Contract Manager is not at head office, and do not have a laptop with a wireless Internet connection, he would not be able to view and approve the order details via the traditional way. However, the functionality and benefits of email software introduced a possible solution. The author introduced a process whereby the details of the order to be approved are emailed to the Contract Manager. The body of the email is text based and can be delivered with ease over a wireless Internet connection in an area with below-average reception. The email was defined in such a way that it would allow the Contract Manager to view exactly the same information as that displayed on the in-house administration system webpage. The body of the email was also defined in such a way that it allowed the information to be viewed on a Smartphone or PDA device. This technique also allowed the email to be delivered to the relevant Contract Manager's Smartphone or PDA device if he had that functionality. The author went one step further and implemented a process whereby any employee with the proper authority would be able to send an SMS message with a predetermined action request to an SMS message receiver device connected to the in-house administration system, which allowed approval of the order. Once the order was approved, the purchasing officer would be automatically notified via email and could therefore process the approved order.

Another concept identified that was employed as part of the drive behind *technology application*, was the use of standard office application spreadsheet software in a disconnected fashion. A spreadsheet application worksheet (VBA programming in Microsoft Excel 2003) was developed to allow users to complete a Site Requisition Form electronically. However, the user did not necessarily have to be connected to the Internet or the company's internal computer network to compile this Site Requisition. However, if the user were connected, he would be able to access information stored on the in-house administration system and therefore be able to complete the Site Requisition form more effectively. Again, the approach was adopted whereby the information was transferred in a text-based format, allowing the application to function more efficiently in situations with low wireless Internet connection speed. The information to be provided would include dates and quantities of items previously ordered , price history and details of the supplier of the particular item. It is important to note that users would have the choice on how to complete the Site Requisition form; they could use the Site Requisition Book and write out the request and submit it by having it delivered manually, by faxing it to the purchasing officer or, if they have access to a computer, they could use the Electronic Site Requisition Form and compile and save it electronically and submit it to the purchasing officers via email. This would allow the user to choose the most appropriate method in each particular situation.

With regard to the concept of *IT support*, it seemed that the approach in terms of IT support that was adopted on the basis of the results obtained from AR Cycle 1 was more effective. An approach was adopted that allows IT support on a more personal level and responds to any technical issues instantly and resolves the particular issue as efficiently as possible. However, there was a need for more formally documentation and management of any issues that may arise. This was due to the limitation of IT human resources available within the company. In some cases several problems were reported at the same time, but the IT staff could only attend to the most urgent issues. In some instances an entire working day would be spent on the urgent issues,. The less crucial issues would then only be attended to, but only after the user had again requested assistance from the IT staff. The participants were in agreement that a formal approach to reporting, documenting and tracking the progress of reported IT issues was needed. With this in mind an intranet web portal: "IT Help Desk" was introduced. Users were now able to report any IT issues formally. The web portal allows the user to document the particular issue experienced. Once the user has completed the form, the IT support resources staff would be notified via email and would attend to it as soon as they were

available. All issues reported would be assigned a progress status based on their state, as well as a priority status. All issues that had not been marked as "Completed" would stay open until resolved. A technique was also developed whereby all the IT support resources staff would be notified on a daily basis, via an automatically generated report, of all the outstanding issues.

The concept of *executive management support was also identified* as being a barrier or enabler with regard to the participant's experience of mobile computing within this environment. This concept refers to a situation in which the executive management team supports the employment and use of mobile computing in this construction company. In his interview with Participant E, the researcher shared the views and statements arising out of the interviews held with Participants A, B, C and D in terms of training, technology application and support. He found it enlightening and, based on this feedback, agreed that email software training was a great idea. He also agreed with the proposal in terms of technology application, where a set of technologies, such as SMS and email, could be used to enhance a business process. He also stated that it would also be necessary to empower the Contract Manager and Site Agents by providing the facilities that would allow them to become more efficient in the execution of their administration duties from remote locations. Although at this stage only Participants A, B and E had mobile handset devices and laptops that supported the technology of email synchronization functionality, a policy was proposed and accepted by the executive management team that all Contract Managers and Site Agents would be supplied with company-specified Smartphones or PDA devices with wireless Internet connectivity, as well as laptops with a company-defined standard operating system and a wireless Internet connection modems.

6.2.4. Evaluating

After the successful implementation of the initiatives as described above, the researcher was in a position to analyze the research situation, bearing in mind the effects of the new initiatives in terms of the adoption and diffusion of mobile computing.

Within this section the researcher did not, as in AR Cycle 1, pose a set of questions to evaluate the impact of the action-planning tasks implemented. Instead he approached the evaluation by dealing with issues around the main concepts identified within this cycle, i.e.: *training, technology application, IT support* and *technology application.* The

questions for this cycle focused on extracting the participant's opinion on the experience of mobile computing within this company, based on the initiatives implemented.

The following section describes the participant's feedback for "AR Cycle 2: Strategic Planning" action-planning events.

The first issue that was addressed was *training*, specifically the standard "ICT literacy" training events for Participant D and the email software training sessions conducted for the entire personnel in head office. The author wanted to determine the opinion of the participants in terms of the effect of the training sessions on the overall effect of the adoption of mobile computing in this company. Participant E was the first to comment and gave his comments in amore general fashion. He said:

> *"Training is cardinal for an organization and will always be a necessity, not only in terms of mobile computing but also in terms of how our business processes function. Previously we assumed by appointing the correct people that they would have the adequate skills to do what is expected of them. However, the company has a standard in terms of how we go about in terms of our daily processes and there should be adequate training sessions to allow employees to benefit from this and at the end of the day achieve our end goal from a company's perspective. One can also notice a change in certain employee's approach, as an effect of adequate training… "*

Participant D then stated that:

> *"Anything new to anyone will be threat, until you can see the benefits thereof."*

Participant E also said:

> *"Although something new will always be a threat, we should address it by providing constant training that would allow the users to be able to trust the new technology and employ it in their daily activities."*

Participant D then said that:

> *"Training in terms of new technology needs to adopt an approach as to where it may be applied or implemented. It should actually not just be suggested but also shown exactly how to apply the technology. If it is pie in the sky I will not be able to make sense of where to apply the specific technology or new tool…If I consider the situation where I was in when I joined the company. I had very basic computer literacy, while today I will not be able to function without it at all...*

> *I had to accept that I had a skill shortage and I had to make an effort to address this skill shortage… And the training events that were hosted have definitely helped me to overcome this threat, and acquire the necessary skills."*

Participant B also said that training event agendas should be drawn up in such a way as to cater to the audience. This confirms the author's viewpoint in terms of modifying the *training* agendas and basing them on the users' maturity levels. Some Site Agents have computers at home and would not need to be trained in terms of basic "ICT literacy", whereas users who are not at all computer literate would need extensive training in basic computer skills that would enable them, at a later stage, to use email functionality on a laptop and PDA or Smartphone. Participant E also stated that employees should be trained with the objective to enabling them to communicate formally through the use of email software and electronic faxing software. However, all the participants agreed that there was also a need to be able to process standard business process forms, such as Site Requisitions, electronically. The idea, however, should be to equip them with templates so that they are not faced with the task of designing forms to be able to complete these functions electronically, which is not their primary function and which may cause frustration on their side and also raise the issue of company time being spent on the execution of tasks that do not form part of the employee's primary function. Participant D added to this by stating that Site Agents and Site Managers should be aware that their roles and functions are changing. They are now expected not only to execute the physical site work, but also to be able to execute administration-related duties. This suggests that they would need the tools to allow them to achieve this objective. However, it also suggests the necessity for the provision of formal communication facilities to allow effective communication between the Site Personnel and the Contract Manager.

The researcher then guided the participants to the next concept: *support*. He then stated that he had changed the *IT support* approach and had seen that there was a difference in terms of the general feeling of the state of IT within the company, but that he also believed that the employees were more receptive to the idea of mobile computing. Participant B made the first comment and stated that, with regard to the *IT support* initiatives implemented as part of the action-taking events:

> *"Although the response time and the manner of support are acceptable, need to be aware that there are resource restraints. We are all aware that effectively there are only two employees that provide IT support within the company. But users need to be made aware that in some instances "IT support" will not be able*

to attend to their problem immediately because they are required at a different function at that specific time. So, yes, I agree that the support should be efficient, but users need to be made aware of the fact that there is a resource constraint because of the size of the company."

Participant B suggested that, because of the culture of human behaviour, users tend to demand immediate action. However, as this company falls into the small-to-medium-sized category, the IT function is not considered to be as significant as that of a large enterprise.

Participant E added to this and made the following statement:

"When we consider the history of IT in the organization, I think we have accepted that IT is vital to the organization's success and survival. I can also see a difference in terms of the state of IT in general and impact it has had on the business processes since you [this researcher] joined the company. I agree that the benefits of mobile computing to involve   site personnel on a more formal level and to train them to be more computer literate would allow more efficient decision making. But I do not think we can do more in terms of support. I do not have a problem with regard to the IT support provided. I think it is now more a case of informing and training the users so that they understand that we can have hiccups or that we may be faced with IT issues at a particular point in time, but will address and resolve the issues as efficiently possible."

The comments from the participants above support the notion that the concepts within the topics of "*training"* and "*support*" should be considered thoroughly in order to establish an environment that enables mobile computing. These concepts specifically refer to "ICT literacy" "training", "IT support" and "executive management support".

The researcher then asked for the opinions of the participants in terms of the new initiatives implemented to address the issue of *technology application*. He wanted to know if the new functionalities were actually employed and if the functionalities had had any impact on the process of mobile computing adoption within this company.

Participant D believes that the new process of incorporating SMS technology to notify Contact Managers of new Orders has impacted positively on the communication network. He can now approve Orders more efficiently from anywhere, which effectively

allows faster delivery of material to the construction site. He stated that the delivery of emails via Smartphone was also a great benefit.

Participant B said that the company should go one step further and adopt a policy of providing laptops and PDA or Smartphone devices to all Site Agents and Site Managers. He said that:

> *"These okes* (an Afrikaans slang term for "guys" or "chaps") *are our first line of communication, and are also in charge of any work variations or tasks that need to be executed on site. In most cases the professional management team communicates via email. If these okes can be included in the communication chain, they can immediately, on receipt of a communication item, respond by mentioning their viewpoint and provide more efficient and formal feedback to all the professional management members. Or on receipt of action tasks requested, act more efficiently. Currently, I receive communication and then I phone the Site Agent or Manager to discuss the contents… The fact that it is verbally communicated is also an issue. This can result in communication breakdown issues."*

Participant D added to this and said that:

> *"… Snag lists should be addressed to the Site Manager or Site Agent directly with only the Contract Manager overseeing and managing the process. We had a situation where a snag item for a particular unit was provided on an informal piece of paper and was not executed. If the developer knows that we employ the method of only accepting snag lists via formal email communication, we would not be in an embarrassing situation and the developer would not be in a position to say that he has provided the list to the Site Manager that can negatively impact the relationship."*

Participant E stated the following in response to the comments from Participants D and B:

> *"We need to define the communication line between the developer or client and the Site Agent. We need to be aware that, if the Site Agent has a direct line of communication, the developer or clients can address him directly, which can pose a new set of issues in terms of communication breakdown. It should be made clear that Instructions should only be issued by the Contract Manager or that the Contract Manager should at least be well informed about it. Site Instructions should still be a formal process but, with the use of email or electronic fax communication, the process could be more efficient."*

With regard to the new initiative to employ a set of technologies (matured and new) to improve a business process, the response was better than expected. All the affected users were aware of the new functionalities and seemed to be employing it regularly. Participant B said that:

> *"The new SMS finalize process works very well, but you should note that we will only use it in situations when we are under pressure in terms of the providing material on the construction site. In such a situation we would like to get the order approved as soon as possible. I have not been in those situations since lately. But, I must say: the few times I used it, it has definitely helped me process the orders more efficiently. This new functionality is definitely a great benefit."*

Most of the Contract Managers and junior Contract Manager now employ the new electronic Site Requisition form on a daily basis. However, it was noticed that additional formal training would have to be provided so that users can avail themselves of the full extent of the functionality. The new functionality allows the users to access material price details on the central administration system. Users are still unsure about how this functions and only seem to use it to draft electronic material requisitions.

In response to the feedback from Participants B and D, Participant E said that he would like to seriously suggest the implementation of an internal policy that would a allow common platform among all employees of what is intended with mobile computing in this company. This policy should explain what the executive management would like to achieve with regard to mobile computing. He stated that the company should start by adopting a policy of supplying Site Agents with laptops and PDAs or Smartphones with wireless Internet connection modems.

Participant E said that the researcher should consider new initiatives. He said that the process of capturing information on the construction site should be examined. It is Participant E's opinion that this could decrease the bottleneck experienced at head office when delivery notes are captured.

6.2.5. Specify Learning

As mentioned previously, it was the author's intention to focus on social issues that created barriers to the adoption and diffusion of mobile computing within this construction company. This was substantiated by the literature, which suggested that barriers to the successful adoption of ICT could mostly be attributed to social issues rather than to technological issues. However, in AR Cycle 1 it was found that technology within the South African context can still act as a possible barrier to the successful adoption and diffusion of mobile computing. On the basis of this deduction the author found three main concepts that in his view should be considered as the most important issues to consider in terms of the successful adoption of mobile computing in this construction company. He found that these three issues had a direct impact on the process of mobile computing adoption.

As confirmed by evaluation of the participants, *training* and *IT support* are vital cognisance should also be taken of the platform for the provision of these two concepts. All the users agree that the provision of personal, more hands-on *training* and *IT support* is definitely the best approach and that *training* and educating users in the process of providing *support* could also be successful. However, care should be taken to ensure that users are informed of the formal process for reporting problem issues and they should also be made aware that the IT support staff will not always be able to tend to their problems immediately.

With regard to *executive management support* (lobbying), the executive and top management are behind the drive to adopt mobile computing more effectively in this company. As observed during the AR Cycle 2 evaluation, Participant E was excited when the findings were shared with him, and Participants B and D have already experienced the benefits of this at first hand. Participant E went as far as to suggest other possible scenarios in which mobile computing technology can be employed (a suggestion regarding the capture of delivery notes on site via wireless connection). Although he was excited about the possibilities of mobile computing within this construction company, Participant E warned that the IT section should not get ahead of itself and allow the implementation of certain initiatives to create other issues. The IT section would have to be very thorough in implementing mobile computing initiatives and provide clear policies in terms of the implementation and the use of mobile computing.

Although not formally considered as one of the possible issues within AR Cycle 2 that impacts on mobile computing adoption, *internal policy definition* has also been

suggested as one of the vital issues. According to the participants, internal policy definition should provide structure and guidelines for the implementation of a mobile computing initiative. On reflecting back on the literature and AR Cycle 1, which stated that "Company Vision, Strategy and Internal Policy" should be considered as an ICT adoption barrier, these instruments should be properly defined so as to provide a platform and direction in terms of driving the concept of mobile computing and that the "Company Vision, Strategy and Internal Policy" should be clearly defined and communicated.

The company's initiative in employing new mobile computing functionalities, by making use of a range of technologies was successful, as suggested by Participants B and D. The use of SMS technology in combination with mobile email delivered wirelessly to laptops, PDAs or Smartphones suggests that, by merging mature and newer technology, it will be possible to improve the efficiency of a business process. The concept of *technology application* can thus definitely have a great impact on the process of mobile computing in this company.

The next section provides a tabulated summary of the aspects learned, the practical contribution made by the action-taking activities and the substantiation or contradiction of the proposed theoretical framework (Figure 4.2), followed by the interpretation of the most influential issues that impact on the adoption and diffusion of mobile computing in this construction company.

Table 6.3: Summarized learning aspects for AR Cycle 2

Summary of Learning Concepts	Practical Contribution	Implication on the Theoretical Framework: Figure 4.2
Influential employees such as Participant D inspired other employees to seek the same type of ICT literacy skills.	Many employees who were not directly involved in this study have also benefited from the drive among influential participants to learn new concepts specifically with regard to the email application software	The issue "politics" has been substantiated and has had a positive impact on the adoption and diffusion of mobile computing in this construction company.
Although "Technology" was considered to be a barrier, this issue has been resolved by changing the perspective in terms of the "technology application".	The use of technology in conjunction with SMS and email, or changing the perspective of the application of the actual technology has allowed for more efficient business processes. This also refers to the VBA Excel application, which allows the material requisition request to be submitted electronically and can access the requested building material efficiently.	The issue of "technology compatibility" has previously been considered. However, the technology available still allows for mobile computing functionalities and users simply need to apply it correctly. Therefore, although technology compatibility is also an issue, the issue of "technology application" is more relevant in this research project.
Training, and the platform of provision, is vital to the successful adoption and diffusion of mobile computing.	The training provided has enabled users to become more efficient in approving orders. Users who attended the email application software	As previously substantiated, the issue of training is vital to the success of mobile computing adoption and diffusion.

	training have acknowledged that the training had made a positive impact on their communication skills.	
With regard to IT support similar concepts apply. The platform of IT support provision and the structure organizing the discipline are vital to the successful adoption and diffusion of mobile computing.	A more structured approach in terms of IT support has allowed the IT support resources section to be more effective in its endeavours. Users have also benefited, as IT related problems are resolved in a more efficient and effective manner.	In AR Cycle 1 we considered e "training and support" as co-dependent issue. However, because of the extent of their impact on mobile computing, the author would like identify "IT support" as a standalone issue in his theoretical framework.
Support from management has an impact on the research objective and, as noticed in the testimonials of Participant E, provides direction and drive by means of the company strategy with regard to mobile computing adoption and diffusion.	Senior Site Managers will benefit from the drive to provide all of them with laptops and Smartphone devices that can connect wirelessly to the Internet. This should allow them to access an email application wirelessly and to compile an electronic material requisition – a more efficient approach than the paper-based process.	"Executive management support "- this is a new issue stemming from the "training and support" issue that was identified in the pre-conceptive theoretical framework.
Internal policy definition is vital to support the drive of adopting mobile computing within this construction	Users are guided by policies that are derived from the vision and strategy defined by the	Although "internal policy definition" was specifically identified in AR Cycle 2, it serves as an

company.	executive management. Policies communicate the executive management's vision and strategy with regard to mobile computing deployment.	implementation vehicle for the company's vision and strategy. In this research project the vision to allow on-site applications, a policy has been adopted to issue users with the appropriate technology, which may include a laptop, PDA or SmartPhone and wireless internet connection device. Therefore the issue of "Company Vision, strategy and policy" has a vital impact on the adoption and diffusion of mobile computing.

In AR Cycle 2 the author was again able to substantiate many of the pre-conceptive mobile computing and adoption issues that were identified and illustrated in Figure 4.2. This particular AR Cycle did not result in any new discoveries, but it was more a case of a paradigm shift in terms of the meaning associated with the pre-conceptive adoption and diffusion issues. The issue of "training and support" that were considered co-dependent was split in AR Cycle 2.

The issue "training and support" was excluded and the following division of this issue applies (indicated in dark grey in Figure 6.2):

- Training (Organization Level);
- IT Support (Organization Level); and
- Executive management support (Organization Level).

There was also a change in perspective with regard to "technology compatibility". The new term to be incorporated in the theoretical framework (Figure 4.2) is:

- Technology application (Organization Level).

The following issues were substantiated in AR Cycle 1, as was suggested in the theoretical framework (Figure 4.2):

Organization Level:

- Training and support;
- Technology compatibility;
- Company Vision, Strategy and Internal Policy;

User Level:

- ICT literacy.

It was also possible to expand on the confirmation of interactions that exist between the certain issues. Again the confirmed interactions are indicated by s solid lines in Figure 6.2.

Therefore, in line with his research objective and research blueprint the author again revised his theoretical framework of mobile computing and adoption issues. Figure 6.2 below illustrates the revised theoretical framework of the substantiated mobile computing adoption and diffusion issues that were derived in AR Cycle 2. The issues highlighted in grey are new issues that were discovered in AR Cycle 2.
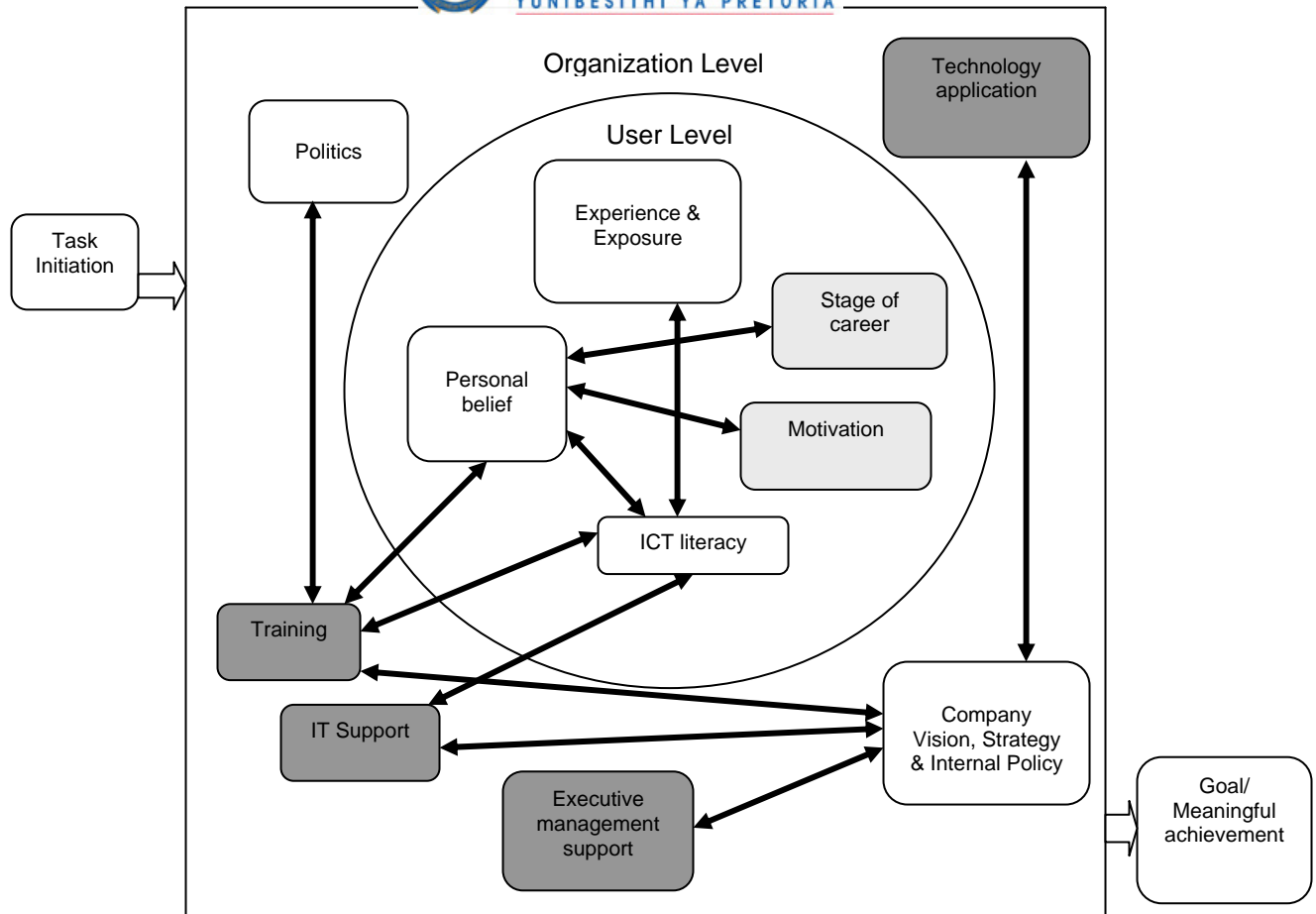
Figure 6.2:   A theoretical framework of pre-conceptive mobile computing adoption and diffusion issues as observed in AR Cycle 2

6.3.   AR Cycle 3: Realised benefits

The learning aspects presented in AR Cycle 1 and AR Cycle 2 allowed of pre-conceptive adoption and diffusion issues that were suggested in the literature to be substantiated. "Stage of career" and "motivation" were identified as newly discovered issues, and the "training and support" issue was divided into "training", "IT support" and "executive management support" because of their individual significance and, as the perspective of the impact of technology has changed, it was therefore decided to adopt the term "technology application". In addition, it was established that the "company vision, strategy, internal policy" provide the drive and structure of the adoption and diffusion of mobile computing.

In AR Cycle 3, as suggested by the research blueprint, the intention was to have a final interview with all the participants in order to derive the effects determined from the action-taking and learning aspects from AR Cycle 2. The interviews were conducted in

the form of informal discussions with Participants A, B, C and D. Guidance was obtained from Participant E, to whom all learning feedback was provided.

Section 6.3.1 provides an explanation of the issues that are still perceived as influencing the process of adoption and diffusion of mobile computing, followed by the learning aspects for AR Cycle 3.

6.3.1. Diagnosing

In AR Cycle 2, Participant E proposed a policy in terms of which senior Site Managers and Site Managers would be provided with mobile computing technologies. These included laptops with wireless Internet connectivity and PDAs or Smartphones with wireless Internet connectivity or, at least Smartphone with wireless Internet connectivity and the functionality to receive and send emails. Although the policy was adopted and enforced the budget did not allow the selected employees to benefit. Budgetary constraints thus pose a barrier to the adoption and diffusion process. However, this situation actually refers to the "company vision, strategy, and policy"

The process of a adopting a policy to provide all senior Site Managers and Site Agents with mobile computing devices was also affected by service delivery of the supplier of the Smartphones and wireless Internet connectivity modems. Towards the end of AR Cycle 2, Participant B asked to be supplied with a wireless Internet modem. However, this device was only delivered 4 months after his initial request.

Wireless Internet technology has improved greatly since the initiation of this research project. During the course of our AR Cycle cellular service providers introduced broadband wireless Internet connectivity. Although this suggests that it the wireless Internet connectivity from site should improve, this technology has only been rolled out to certain urban areas.

In AR Cycle 2, as part of his action-taking activities, the researcher made use of an extensive ICT training strategy that involved most of the employees at the head office. Although this endeavour was very successful, queries were constantly posed by users who had received this training. This suggests that training at this construction company should be provided in the form of regular training sessions.

6.3.2. Specify Learning

This section can be considered as a logical extension of AR Cycle 2. However the purpose of this third cycle has allowed a new reflection on the effect of the action-taking activities implemented and derived in AR Cycle 2. This was mainly due to the slow implementation of planned activities and to the identification of vital action-taking activity of implementing a policy that states that all senior Site Managers and Site Agents should be supplied with mobile computing technology. The real consequences of this action-taking activity were therefore only observed during AR Cycle 3.

A tabulated summary of the aspects learned, as derived in AR Cycle 3 is given in Table 6.4.

Table 6.4:   Summarized learning aspects for AR Cycle 3

Summary of Learning Concepts	Practical Contribution	Implication on the Theoretical Framework: Figure 4.2
A policy has provided the drive with regard to diffusion of mobile computing among site employees. Although the process is slow, it seems to be effective.	A more efficient formal communication channel is available to senior employees on site.	The "company vision, strategy, and internal policy" is vital to the drive towards the diffusion of mobile computing.
Training should be provided on a regular basis and in an intimate manner to allow the successful acquisition of knowledge.	Senior Site Managers and Site Agents are attaining new skills with regard to ICT literacy.	"Training" is vital to the success of mobile computing technologies.
Wireless Internet technology has improved during the course of the research project, but its extensive benefits are not perceived by all participants.	Certain urban locations allow users to access the Internet at true broadband Internet throughput.	The application of technology is significant and should always be considered in the endeavour to extend business processes to site employees within this construction company.
Mobile computing devices have not been fully adapted to function optimally in the daily construction site situation, but may still be applied in such a way that benefits can be derived.	More affordable mobile computing devices (Smartphone) available from cellular service providers, that allow the same functionality as a PDA type device, can be supplied to users.	PDA devices are not the ultimate technology device to enable the diffusion of mobile computing. Smartphone technology can be applied in such a way that it offers the same benefits as those offered by PDA devices.

In AR Cycle 3 the author was not able to derive extensive substantiation of the pre-conceptive issues, but he was able to identify and stress the importance of the following

theoretical issues that are significant in the adoption and diffusion within the construction company:

Organization Level:

- Company Vision, Strategy and Internal Policy;

- Training;

- Technology application;

- IT Support;

- Executive Management Support;

User Level:

- ICT literacy.

In conclusion, the revised framework that that was derived in AR Cycle 2 did not change. The only aspect learned within AR Cycle 3 was that the issues of "company vision, strategy and internal policy", "training" and "technology application" were significant in the process of successfully adopting and diffusing mobile computing in this construction company. Figure 6.3 below illustrates the final version of the theoretical framework of the issues and the underlying interactions as derived from the AR Cycles in this project.
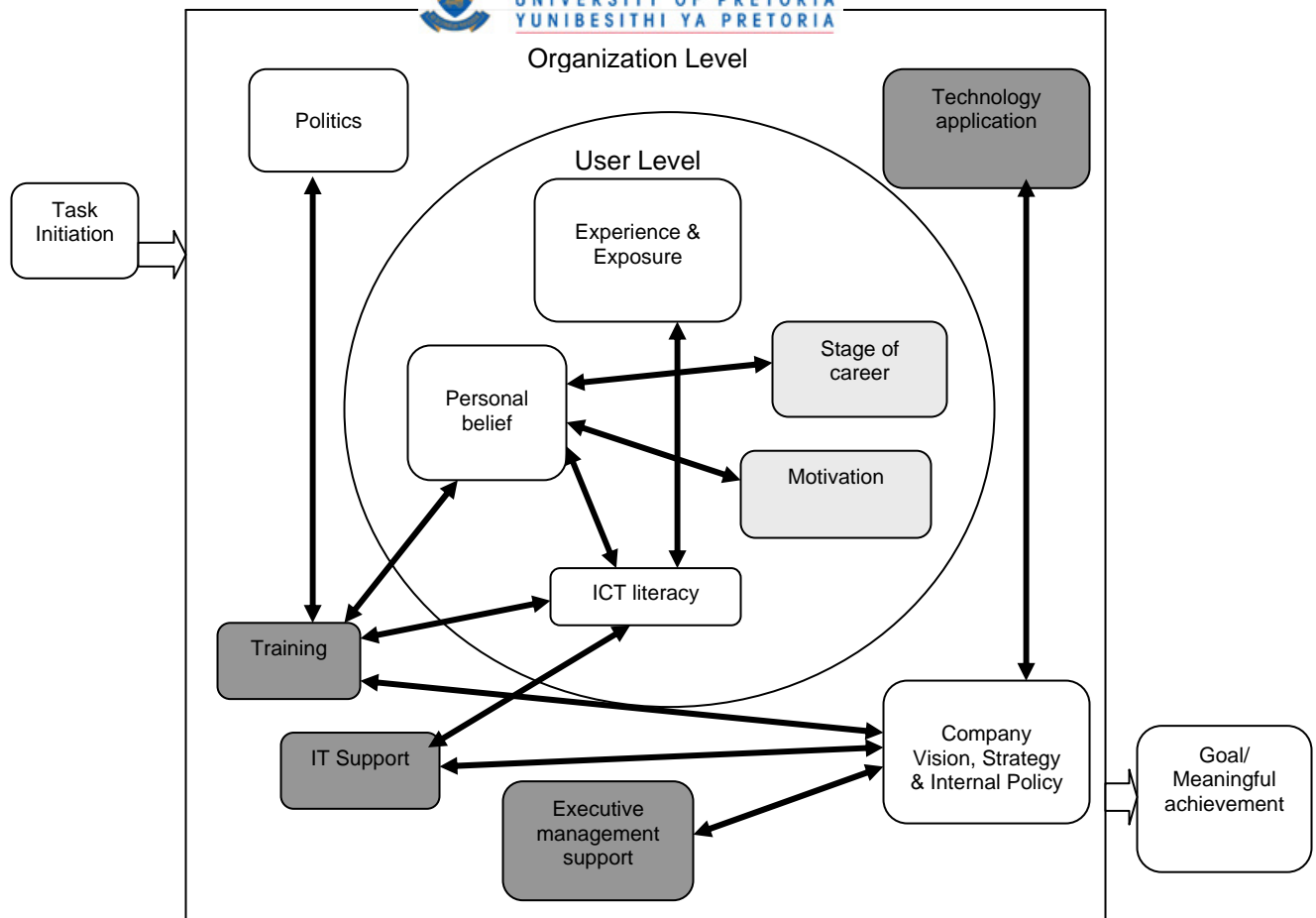
Figure 6.3:   A theoretical framework of the mobile computing
               adoption and diffusion issues in this construction company

6.4.   Summary

The AR project delivered its goals in three dimensions. Firstly, the researcher was able to learn and understand the dynamics of the technology and was also able to create an awareness of the technologies available to this construction company that would facilitate the employment of mobile computing. Secondly, through the cyclical approach of the AR method applied, the author was able to understand the operating environment of the Contract Managers and Site Agents and other employees involved in this project. This goal paved the way to achievement of the next goal. Thirdly, the author was able to identify and understand issues that may act as barriers to the successful adoption of mobile computing in this construction company. The author also found new issues that had not been suggested in previous literature. The author also found possible solutions that could be implemented and could create an environment conducive to the successful adoption of mobile computing in this construction company.

It can be agreed that many of the issues suggested in the literature were identified in the AR cycles. Most importantly, however, the author was able illustrate clearly the significance of the issues of training, support and internal policy definition. He was very surprised to have identified new concepts that may be conducive to the adoption of mobile computing in this construction company.

7. Conclusion

As stated in the introduction a need was identified to establish the feasibility of successfully adopting mobile computing technologies within a small-to-medium South African construction company, based in Gauteng. In this research project, we specifically considered the implication of this on professional workers was specifically considered in an attempt to identify barriers to their adoption by users, as well as the impact of technology.

The literature available was very limited because of the research location (South Africa) and the research topic. However, literature suggested the organizational and user level issues that provided the foundation for the initiation of the action research cycles to produce the theoretical framework. The organizational issues included: Politics, Training and Support, Technology compatibility and Company Vision, Strategy and Internal Policy.. The literature also suggested user level issues that included: Education level, Personal belief, ICT literacy and Experience and exposure.

The process of adoption of mobile computing was facilitated by the introduction of planned changes within the research environment, which allowed the researcher to identify and analyze the issues suggested in the literature that should be considered in the planning for the extensive adoption of an ICT technology such as mobile computing in this construction company, particularly at management level. This objective was achieved and is represented by a theoretical framework highlighting the significant issues that should be considered when attempting to promote the extensive adoption of mobile computing in this construction company.

Throughout the action research cycles the researcher was able to substantiate the significance of most of the above-mentioned issues suggested in the literature, except for the issue of "Education level" (according to the author's definition) which was excluded in AR Cycle 2. It was also possible to identify newly discovered concepts, including "Stage of career" and "Motivation", as mobile computing adoption issues in the attempt to adopt and diffuse mobile computing in this construction company. In the final AR Cycle the author found that he had to reconsider our understanding of certain issues and, consequently, the definition of certain significant adoption and diffusion issues. Initially it was assumed that "Training and Support" should be seen as a combined concept. However, because of the extent of the individual significance of these two

concepts they had to be separated into "Training", "IT Support" and "Executive management support". These three issues were highly significant in this research project, particularly if the provision platform that was employed for "Training" and "IT Support" is taken into account. It was found that "Training" at this construction company needs to be provided in an intimate manner and that the facilitator (training provider) should focus on the concept of "*How to apply the technology?*" in the trainees' daily function. The significance of support and especially the method of providing structured and efficient "IT support" is vital to the adoption process. Another significant issue that underwent a definition transformation was "Technology application". Although the wireless Internet technologies were not as expected, the application of particular technologies can still enable the pre-imposed efficiency of extending critical business processes to the field to be increased. It was also found that the PDA devices available on the South African market should not be considered the ultimate technology for facilitating the adoption and diffusion of mobile computing, and that the combination of technological devices and technologies that include laptops and SMS technology is needed. Finally the "Company Vision, Strategy and Internal Policy", as suggested by the consulted literature, manifests its significance in the process of adopting and diffusing mobile computing by providing the vision, method statement and implementation parameters.

In conclusion it was found that the following issues were the most significant in facilitating the extensive adoption and diffusion of mobile computing in this small-to-medium-sized construction company based in Gauteng, South Africa:

-   Company Vision, Strategy and Internal Policy;
-   Training;
-   Technology application;
-   IT Support;
-   Executive management support; and
-   ICT literacy.

To illustrate the success of this action research project the author would like to share some of the mobile computing adoption and diffusion statistics of this construction company. At the initiation phase of this project only 3 users (10% of management workforce – includes contract management team, site agents and site management, Figure 3.1) were able to receive and send emails via their mobile computing devices. Currently all members of the Contract Management Team can send and receive emails

via their Smartphones. With regard to the site management team, the company's policy has recently been revised and implemented, allowing Smartphones and/or laptops to be supplied to senior site agents and site management employees so that they can send and receive emails or access administration system resources from remote locations. This applies to a total of 5 employees (or 30% of the site management team). The company is in the process of providing laptops to two other senior site management employees. This meant that the company wide statistic with regard to the diffusion of mobile computing technologies among the management workforce has increased from 10% to 40%. This is a clear indication of the increase in the adoption and diffusion of mobile computing.

The researcher was thus able to contribute to the current scientific knowledge by providing the company with the findings of issues perceived as barriers, with the aim of enhancing the process of adopting mobile computing within the South African context. He was also fortunate enough to identify new issues of significance and re-define existing issues that may be applicable in similar research environments. However, it will be necessary to take note of the limitations of this research project. The research environment referred to in this project related only to a single medium-sized construction company based in Gauteng, South Africa. Although other wireless Internet technologies were available in this research environment 3G technology considered was that offered by MTN. With regard to the technological devices, only the HTC TyTN PDA, i-mate JasJam, Nokia N80 and the HTC S710 were considered.

In future research endeavours the author would like to consider other handsets and wireless Internet connectivity. In South Africa, with the increase in wireless Internet connectivity speed and the broadening of the wireless Internet product spectrum, it may be necessary for the author to revise his position in terms of the technology available that would allow more reliable wireless connectivity and mobile computing enablement. It should also be noted that the current users are also evolving constantly. This suggests that their experience and belief (that ICT literacy and technology employment is essential) will also have an influence on future research outcome. As a result of this, therefore, a revision of the author's position with regard to the current mobile computing diffusion and adoption issues may be viable.

The author would like to close off by sharing a few thoughts mentioned in a paper published by the IDC (Drake and Perry, 2008: 10). Mobile deployment, enabled by

mobile computing, is significant in the endeavour to "business process problem-solving, worker and organizational efficiency improvement" (Drake and Perry, 2008: 10). The foresight of this construction company in initiating the rollout of mobile computing could be the starting point for widespread deployment of LOB (Line-of-business) applications that could extend the administration systems and key functionalities of the head office to a larger number in the professional construction management team and not only to a select few.

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Appendix A

Table A1:   Participants' feedback with regard to their qualification,

experience and skills

Qualification, experience and skills:	
1. How long have you been in your current position?	
2. What is your highest formal qualification?	
Participant A	Participant A has held the post of Site Agent for the last four years and was previously employed as a Site Foreman. He has completed a project management course at a well known South African institution. He does not have formal tertiary education and his knowledge and skills are mainly based on practical experience.
Participant B	Participant B has held the post of Contract Manager for the last ten years. He obtained his degree in construction management in 1995. He has also recently completed a course on project management at a private institution. He is also planning to start with his Masters degree in construction management 2008.
Participant C	Participant C obtained his Honours degree in construction management at the end of 2006, and has held the post of junior Contract Manager for the last year (as at the date of the interview). He was previously employed as Site Foreman at his previous company for about 1 year. He is not planning to enrol in any formal course in the near future, but would like to focus on his career and obtain as much practical experience as possible.
Participant D	Participant D obtained his degree in construction in 1977. As he did not complete an Honours degree course, this is considered to be his highest formal qualification. He held the post of Site Foreman in previous positions, but has acted as Contract Manager in his career. Participant D has been appointed as a Contract Manager at this construction company and has been employed by this company for the last two years (as at the date of the interview).

| Participant E | Participant E obtained his degree in 1979. Since then and has mainly held the position of Contract Manager in his previous positions. For most of his career he worked for a well known construction company in South Africa. After leaving that company he joined a small-to-medium-sized construction company based in Gauteng, South Africa, where he worked until 12 years ago, when he and then a colleague founded their own construction company – the construction company that is the subject of this study. |

Table A2:   Participant's feedback with regard to their technology maturity
            and application

Technology maturity and application:
1. Do you have a computer at home? 2. Do you have an Internet connection at home? 3. On a scale of 1(bad) – 5(good), how would you rate your computer literacy? 4. How many minutes do you spent on average reading electronic messages like sms's or emails? 5. What kind of phone do you have? 6. How many emails or sms's do you sent on average per day? 7. How many emails or sms's do you receive on average per day? 8. How many hours per day do you spent on average on the Internet? 9. Do you have a laptop? 10. Do you have wireless Internet connectivity? 11. What percentage of your time do you spend at the office dealing with administration duties?

Participant A	Participant A has a computer at home, which is connected to the Internet via his PDA device that can be used as a wireless broadband Internet modem. He rates himself as a level 3, with regard to computer literacy. Provided that he has been using a PDA phone with a wireless broadband Internet connection and email communication software, over the four months prior to the date of the interview he spent roughly 15 minutes per day on reading emails and about 2 hours per day on average compiling and sending emails wirelessly. He does not use the Internet for any other purposes except banking and states that he only uses the Internet on average for 30 minutes per month. At this stage Participant A did not have a laptop but asked to be supplied with a battery-operated laptop. Budgetary constraints did not allow for this request to be serviced immediately and it was decided, as temporary solution, to provide him with a second hand laptop. This laptop was 5 years old and its battery was no longer

	functioning. This was a major frustration for Participant A as, in most cases, construction projects do not have electricity on site until about 1 month before completion.
	As a Site Agent, Participant A said that he spent about 20% of his average day on administration duties.
Participant B	Participant B does not have a desktop computer at home but both he and his wife possess laptop computers. During this cycle Participant B installed a broadband Internet connection at home, allowing him to execute some of his functions from his home with the use of a secure private Internet connection to the company's internal computer network. In terms of computer literacy Participant B rated himself a level 4. Although Participant B did not have a Smartphone or PDA at this stage, he considered the possibility of getting one. However, he did not consider it to be an urgent need for a Smartphone or PDA at this stage. This was because the company had set up a secure private Internet connection on his laptop, allowing him to connect to the company's internal computer network from any location using only the Internet connection and a laptop. At the time of the interview Participant B had only used the secure Internet connection (VPN) about 4 times, but was very happy with the quality of service. With regard to his electronic communication behaviour, Participant B said that he spent about 60 minutes a day reading and compiling electronic messages and sent about 5 messages per day and received about 10 messages. In most cases Participant B uses email as his default formal communication tool. Although Participant B stated that he spent only 30% (3 hours of a 10 hour working day) of his time executing administration -elated duties, he was connected to the Internet on average for 5 hours per day. However, this is mostly job related in the sense that it allows him to access his email application, look up products or to make product enquiries. He also employs the Internet for the purposes of online banking.
	Participant B stated:

	"… I believe that there is a need to access tools like an email application, internal administration system and electronic documents stored on a centrally located server from a remote location". In most cases these remote locations include site offices, where most of the decisions are made and actions are initiated with regard to specific construction projects. He said: "… In many cases there is the issue urgency…" This refers to a situation in which the productivity of a construction site may be influenced if the building material requested is not received as soon as possible. However, in such situations a purchase order would have to be approved by Participant B, but he may not be near an Internet connection that would allow him to connect to the internal administration system through the use of the secure private Internet connection and to approve the order requested for action.
Participant C	Participant C has held the post if Contract Manager at this company for a year (as at the date of the interview). He was employed as Site Foreman by his previous company for about 1 year. As mentioned previously, Participant C recently obtained his Honours degree in construction management. Although Participant C does not have a computer at home, he has a laptop at his disposal with a wireless broadband Internet modem that was issued to him when he started with this company. Participant C rates himself a 4 on the scale of 1 -5 mentioned in terms of computer literacy. With regard to his electronic communication behaviour Participant C stated that he spent about 1-2 hours per day reading electronic messages, and sent and received on average about 10 electronic messages per day. Participant C also said that he spent between 50% -80% of his time on administration duties which, in his opinion, indicates that he needs to be at the office for about 50%-80% of his time. In the early phases of a project he would spend 80% of his time on administration duties and only about 50% of his time on administration duties in the later phases. This is because in

these later phases he would be more involved in site activities ensuring that the finishing quality is up to standard.

Participant C does not have a Smartphone or PDA device.

Participant C stated:

"… I believe that a device that allows the use of an email application remotely, will allow me to provide quicker feedback with regard to the process of approving purchase orders and the receiving and compiling of emails".

In most cases the clients and project managers for a particular project use email communication as a formal channel to provide instructions or get feedback on specific problem issues.

Participant C stated:

"…I think there is a need to receive emails on a Smartphone or PDA-type device that will enable me to provide quicker feedback, or allow me to attend to problem issues in a more efficient manner".

In many cases Participant C is on site, executing his daily function.

He added:

"...If I was aware of a new email received with regard to a problem issue [snagging], I can resort to it immediately, instead of travelling back to head office and only learn about the problem then".

Currently, it is only when the client or principal agent notifies or discusses the problem issues with him telephonically, that he will be able to react to it. If he is not notified telephonically he would only become aware of the issues once he is able to connect to the Internet and view his emails. Participant C said that there was also a need to access and view electronic documents stored on the internal computer network from remote locations. Currently he is not able to view these electronic resources, because of the slow connectivity speed of the wireless broadband Internet facility in the areas in which he operates. These electronic documents contain budget-related

	information to which Participant C, in his position as Contract Manager, constantly needs to refer. He stated: "…If I was able to open an Excel spreadsheet remotely or maybe capture information on a spreadsheet document on a PDA device, I will be able to save a lot of processing time…" When he processes subcontractor progress payments, he might need to view information from the site offices to compare the actual rate with the budgeted rates to ensure that the project is still within the required allowance.
Participant D	Participant D has held his present position for 1 year (as at the time of the interview) at this construction company. Participant D has held the post of Contract Manager since 1980. He has obtained his degree in Construction Management in 1977. As he did not complete an Honours degree course, this is considered to be his highest formal qualification. Although Participant D has a computer with an Internet connection at his home, he does not use it and it is mainly used by his wife and children. Although he said that he had some knowledge of spreadsheet software application and project management application, in terms in computer literacy he nevertheless rated himself as a 2 on a scale of 1 -5. In terms of electronic communication, Participant D spends on average 30 minutes per day reading electronic messages such as emails and sms's. He said that he did not send any emails and stated: "...I do not know how to send an email". Fortunately, Participant D has a personal assistant who has access to his mailbox and carries out the duty of sending emails on behalf of Participant D. He stated that he had only recently (as at the time of the interview) started to use the sms functionality. However, he understands the sms functionality and sends on average 10 sms per day and receives on average 15 sms's and emails per day.

Although Participant D's current cell phone is considered a Smartphone, he does not use the functionalities of a Smartphone, such as sending and receiving emails from his cell phone or for browsing the Internet via his Smartphone.

He stated:

"… I only know how to send an sms, because my daughter showed me how…. She showed me about 10 times before I was able to do it myself…"

He also said:

".. I do not understand how something works if I read it from a book… someone will have to show me: click here, then there and then click there… I will have to shown manually how to go about…"

He believes that he could or would use these functionalities if he had the appropriate training. Although he has been provided with a user manual in terms of these functions, he has not made any progress in terms of knowledge acquisition on his own. He would like to receive training and support in terms of electronic communication tools, in the form of practical demonstrations and practical application within his daily function.

Participant D stated:

"I spend 0 hours using the Internet".

Although he made the above statement, he still uses an email application connected to the Internet to view and read email messages. Although he was offered a wireless broadband Internet modem and laptop when he started with this company, he declined because he felt that he did not have the necessary knowledge to use and apply these technologies. Although the software policy in terms of desktop and laptop computers within this company is exactly the same, Participant D seems to believe that desktop and laptop computers do not operate in the same fashion in terms of email application and standard office application software. It had to be explained to him that there is no difference between these two types of device in this construction company and that the only difference between

	these two devices is the fact that a laptop allows for mobility. Participant D believes that he spends about 50% of his day on administration duties. However, he also stated that at the early phases of a project he spent more than this average 50% of his time on administration duties.
Participant E	As mentioned previously, Participant E is Managing Director of this construction company. At various times he has held all the posts currently held by all the participants involved in this study. He has held his current position for the last 12 years and his highest qualification is a degree in construction management, which he obtained in 1979. He has also completed several business administration related courses at various institutions. Participant E has a computer at home and regularly connects to the company's internal network via his broadband Internet connection. Participant E rates himself a 3 on the scale of 1 - 5 in terms of computer literacy. He believes that he spends about 4 hours a day on average reading and managing emails within his email inbox. He stated that he received and sent about 30 emails and sms's per day on average. As previously mentioned, Participant E has been using a PDA since 2005 but only started to use its functionality to receive and sent emails about 12 months ago. Participant E also has a laptop with a wireless broadband Internet connection modem and has used the technology in the past with ease. His position as Managing Director does not necessitate his being able to connect to the company internal network wirelessly from site offices, although he receives his emails wirelessly on his PDA. Participant E believes that he spends about 1 hour per on the Internet solely to do Internet banking and for product enquiries. As Managing Director, and because of his responsibility for the financial and administration functions in the company, he believes that he spends about 80% of his time at the office dealing with administration-related tasks.

Table A3: Participants' feedback with regard to their opinion on the
future of mobile computing in the construction industry

Opinion on the future of mobile computing in construction industry:	
1. Do you believe that a mobile computing device such as a laptop or PDA with an Internet connection and access to the work's internal network would allow you to be more effective in your daily functions?	
Participant A	Participant A believes that he can be more effective with the use of a laptop. He stated: "… I would like to use a laptop on site, to capture work schedule information through the use of spreadsheet application software". In his particular case he is expected to capture and monitor progress of the construction activity on site. With the use of the spreadsheet application software he can execute this administration electronically, allowing him to distribute the progress information more easily and formally to the client or to the Contract Manager who needs to track the progress of the project. Although he believes that access to the company's internal network, together with the use of a wireless broadband Internet connection in order to access the internal administration system, would be a great facility, he does not regard this functionality as a necessity from his perspective. He also said: "… I believe I will use 3G [wireless broadband Internet] for the sole purpose to access my emails. This is more vital to me at this stage… With the email facility I can query site requisitions by sending requests to the procurement officer or to the Contract Manager…. I could also use email to communicate directly and formally with my subcontractors that have email". He therefore requested to be supplied with a laptop with an ample battery lifetime, so that he could use it specifically for this function.

Participant B	Participant B stated:
	"…it doesn't matter in which industry you are in, everyone is expected to receive information faster, process the information more efficiently and also be able to react on it more efficiently". He added:
	"…with the intensity of communication, every professional within this industry expects a response from you within two hours of the time they sent the email. A three-day delay in response is unacceptable; one should at least respond within one day".
	It is clear that Participant B believes that there is a need to react or respond more promptly to information received from the project managers, clients, suppliers and subcontractors. He also believes that there is a need to be able to distribute information more efficiently. The response to his "opinion on the future of mobile computing in the construction industry" is clearly based on the urgency issue of the information being distributed or requested. In conclusion, he believes that the ability to receive and send emails with the use of a mobile computing device is more important than the ability to connect to internal administration systems and other electronic resources that are available only on the company's internal network.
Participant C	Although the use of a mobile computing device such as a PDA or laptop with a wireless broadband Internet connection allows the user to access the company's internal computer network and allows access to project-related information while on site, enabling the user to react immediately to budget-related issues, Participant C believes it is more essential to have access to an email facility via the mobile computing device. This belief is based on the fact that he operates from head office (Silverton,

	Pretoria) and the building sites at which he is involved are on average 60 km away (Sunninghill, Johannesburg). The average travelling time between his sites and the head office is 60 minutes. He said: "…if I had a PDA that can receive emails, and I need to be on site in any case to do my progress payments, and an email is delivered reporting an issue for that particular site I can react on it immediately. Whereas, if I were to travel back to head office and only then receive the email once it gets delivered on my laptop after I connect to the Internet, this causes a major delay in response and resolution of the issue." He believes that, because of the natural elements factor on the construction sites, it is very difficult to set up a space that would allow him to use his laptop. It should also be borne in mind that, in most cases, electricity to the construction sites is only connected, on average, 1 month before practical completion of the project. Therefore, with the currently issued laptop, its battery life is only 3 hours, implying that Participant C would only be able to work on his laptop for a maximum period of 3 hours on site without having to recharge the battery. Participant C also stated: "…I believe that, if I had a PDA, I would also use the mobile spreadsheet software application installed on the PDA to capture information while I'm on site, and then later when I'm at the office download the information from the PDA to my laptop". This, he believes, may eliminate the issue of duplication or the time wastage factor. Currently he has to capture the information on paper and manually transfer the information to his laptop when he arrives back at the office.
Participant D	Participant D was not able to provide us with his "opinion on the future of mobile computing in construction industry". He was not even sure how to operate standard software applications that include email communication software and spreadsheet application software. He did however make some comments

	that were considered interesting. He stated: "…I am wasting time to write details out on a site requisition form and then taking it to the procurement officer for action. Can't we do this electronically?" He also said: "…manual faxing is a frustration, especially because the fax machine is very slow. I am wasting valuable time in manually compiling a fax cover letter or typing something out on Word and then printing it out, walking over to the fax machine and faxing it."
Participant E	Participant E believes that the technology itself poses the greatest barrier to the successful adoption of mobile computing. He stated: "… 3G [wireless broadband Internet connectivity] is great, but it is still too slow in various areas to support the full extent of the company's standard business processes". He also said: "…when you consider the popular problem issues that arise during the construction phase of a project, Contract Managers should be more involved in site activities and should execute their daily function from a site office." He believes that Contract Managers should be more involved in the planning activities on the building site and should do physical supervision of construction work by spending most of their time on site in order to address the problem issues more effectively when they arise and not 2 months later when subsequent trades are affected. In contrast he said that if a site office was set up with all the available technology that would enable the necessary business administration environment, for example by installing a wireless broadband Internet connectivity satellite dish and an electricity source via the use of solar panels, there would still be the issue of security and safeguarding the equipment that would have to be permanently fixed on site.

| | He believes that, from a Contract Manager's perspective, there are great benefits to be gained in employing mobile computing devices with wireless Internet connectivity in his daily activities. However, he stated:
"… These employees need to be made aware of the benefits in employing this technology to change their general mindset and culture". He believes that, in an attempt to achieve this, the company should start by hosting formal training sessions on topics that would facilitate changes in mindset and culture.
He also believes that the availability of a personal assistant to the Contract Manager contributes to the lack of computer literacy among the older generation. However, he also said that the older generation Contract Managers had the benefit of more practical experience in terms of site activities and project management, whereas the younger generation would be more successful in employing the current available technology available to them but who lack the practical experience. He also made the bold statement that: "…technology may enable the older generation Contract Manager to be more efficient, but it will not necessary impact on their project management abilities."
He said that he had noticed that employees do not use the custom developed internal administration system's reporting portal and that they did not use the standard office application software to its full potential. Based on this fact, he decided that he would start to employ the use of this reporting tool in the company's monthly management meetings. This endeavour, in his opinion, should foster awareness of this type of company tool and of the benefits that it may provide them in their position as Contract Managers it should establish a belief that the executive management encourages and supports the use of these technologies and tools. |
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