Visual Information and Knowledge Representation in Organisations

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By

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ABSTRACT

The construction industry's environment is continually changing. Employees are now more geographically widespread and diverse, both culturally and educationally, than ever before. A great deal of research has been carried out on knowledge acquisition and storage, but there is still a distinct lack of research into knowledge presentation and communication. Information and knowledge presentation play a significant role in daily decision-making processes, when inappropriate decisions may result from inaccurate or poorly communicated information. The simplified, filtered coherent presentation of explicit knowledge can be instrumental to a successful, profitable and safety conscious business.

Wates Construction is a major construction company and employs around 1300 people directly, as well as various subcontractors on different projects. Their current turn over is around £1billion, they are based in the UK and have branches in Ireland and Abu Dhabi. Wates realised their existing information system was inefficiently conveying information to its employees and the need to provide a simplified system, to assist staff's decision-making processes. Earlier IT professionals' attempts to make the system more usable had made no significant difference to its performance.

The aim of this research is to 'Develop a framework that facilitates presentation and re-use of organisational and personal knowledge within and between people and businesses run by the sponsoring company, with a view to reduce information redundancy and encourage information uptake.'. The objectives are to evaluate existing problems and current practices in information and knowledge presentation and communication, and provide the means for the user to access vital information and knowledge with less effort. This includes communicating safety information on construction sites to employees who may be disadvantaged by language or cultural barriers. Recognising the diversity of the targeted people, after initial observations two distinct groups were identified, representing the majority of the employees. In each group users' needs were systematically identified by conducting workshops, one-to-one interviews, questionnaires and observations. The findings enabled the researcher to methodically develop two tools, which were positively verified by the users, one for each group. The first tool, designed for staff in management roles, comprises software which uses graphical imagery and outstanding words and phrases, using of series of hyperlinks leading the user to the required information. The second tool, catering for site-based employees, also uses visual images and graphical effects to present and aid the transfer of essential safety information for their day-to-

day needs. It also gathers information about the users which can be used and analysed by the company to facilitate better and safer design of the future projects, safeguarding users' anonymity. Both tools were subjected to pilot studies and results were encouraging. The uptake of the first tool, directed at management roles, although slow in the beginning seem to improve exponentially. The second tool directed at the site based manual workers had an immediate effect and although time will tell if it had a significant effect on reduction in accidents, the initial surveys proved that the targeted people were a lot more informed. The tools are going through the process of being incorporated into the sponsoring company's network. Feedback so far has been positive and favourable. There is a need for future research to focus on analysis of the activities of those using the new system. This would enable better understanding of how, why, when and where employees obtain the information they seek. This in turn will allow the company to ensure that the information their employees seek on the system are easily accessible and laid out to their needs. Further analysis of the data gathered from the activity on the system could also provide an insight into employees' ability to resolve issues.

Keywords: Information presentation, Visual information and Knowledge transfer in construction, tools for visual knowledge transfer, case study

PREFACE

The Engineering Doctorate (EngD) research programme run by the Centre for Innovative and Collaborative Engineering (CICE) at Loughborough University is a relatively new and challenging research programme, set up to address significant and challenging problems in industry under the guidance and supervision of academia.

This research was undertaken with Wates Group, one of the leading construction companies in the UK. The research is primarily intended to simplify information and knowledge presentation in the group. The seven chapters of the thesis comprise:

Chapter One	Outlines the background and introduction to both the sponsoring company and the research.
Chapter Two	The Aims and Objectives and justification for the research.
Chapter Three	Explains the methods used in the subject matter and provides justification for their use and the tools which have been utilised
Chapter Four	Evaluates the primary problem i.e. the presentation of information to those who have problems finding it, using surveys, case studies and interviews to identify the shortfalls.
Chapter Five	Explores alternative methods of information presentation, leading to research and development of a new system to address the needs of the first objective. This is followed by the implementation and fine-tuning of the new system to ensure the outcome satisfies the objectives.
Chapter Six	Evaluates the second problem, i.e. the presentation of explicit information and knowledge to those who have difficulty understanding it in the conventional format, and the follow-up research and deployment of a new process to address the problem.
Chapter Seven	Draws conclusions from the research and offers justification for the results. It also includes a critical view of the research, highlighting its achievements and implications for the building industry.

Further to Chapters One to Seven, the Appendices contain two conference papers, two journal papers and a number of additional elements referred to in the body of the thesis.

These papers are presented to provide a more in-depth perspective on the specific issues considered in this thesis and should be read in conjunction with it.

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GLOSSARY OF ABBREVIATIONS

App	Appendix
ASP	Application Service Provider
CAD	Computer Aided Design
CCIM	Conference on Construction Culture, Innovation, and Management
CE	Concurrent Engineering
CP	Collaborative Prototyping
CPE	Construction Project Extranet
CBPP	Construction Best Practice Programme
CICE	Centre for Innovative and Collaborative Engineering
CITB	Construction Industry Training Board
EDM	Electronic Data Management
Eng D	Engineering Doctorate
EPSRC	Engineering and Physical Science Research Council
EU	European Union
FM	Facilities Management
ICT	Information and Communication Technologies
IKMN	International Knowledge Management Network
ISO	International Standards Organisations
IT	Information Technology
KM	Knowledge Management
KMO	Knowledge Management in Organisation
KMS	Knowledge Management System
M4i	Movement for Innovation
M&E	Mechanical and Electrical

O&M   Operation and Maintenance

OOD   Object Orientated Design

PFI   Private Public Partnership

RAM   Random Access Memory

LIST OF PAPERS

REFEREED CONFERENCE PAPERS

1. **PAPER 1 (SEE APPENDIX A)**

   Nowbati B, Hassan T, and Pasquire C (2006): *"Are we getting the best out of our Intranet System?" A Practical Case Study,* presented in "The Joint International Conference Culture , Innovation and Management (CCIM 2006)"9th – 11th September, 2006, at The Conference Centre, Knowledge Village, The British University in Dubai (Ref 97).

2. **PAPER 2 (SEE APPENDIX B)**

   Nowbati B, Hassan T, and Pasquire C (2007): *Information and Knowledge Visualisation: Can it help with the crisis in the UK Construction Industry***?** Presented in The Joint International Conference in Knowledge Management in Organisations (KMO 2007) 26th – 29th September, 2007, at the Ecotekne Campus in the University of Lecce, Lecce, Italy (Session 3).

3. **PAPER 3**

   Nowbati B, Hassan T ,and Pasquire C (2008): *Knowledge Management in Organisations: A Constructive Case Study***,** presented in the "8th International Conference on Knowledge, Culture and Change in Organisations" 5-8th August, 2008, at Cambridge University, Cambridge , United Kingdom. (Ref : M08P0460).

JOURNAL PAPERS

4.   PAPER 4 (See Appendix C)

Nowbati B, Hassan T, and Pasquire C (2008): ***Knowledge Management in Organisations: A Constructive Case Study***, Following the presentation of Paper 3 in the "8th   International Conference on Knowledge, Culture and Change in Organisations", the organisers were invited to publish an extended version of Paper 3, which was published in the "International Journal of Knowledge Culture and Change Management 2008", Volume 8 , Issue 6 , pp 33-40.

5.   PAPER 5 (See Appendix D)

Nowbati B, Hassan T, and Pasquire C (2008): "***Knowledge Visualisation and its application in the Construction Industry***". Under second round of review by the "Journal of Information and Knowledge Management" World Scientific publishers.

CHAPTER ONE: INTRODUCTION

1.1 INTRODUCTION

This chapter sets out the background and context of the research in both the Construction Industry and the sponsoring company (Wates Construction).

1.2 BACKGROUND TO THE RESEARCH

The last decade has presented many challenges to businesses competing in their respective markets to maintain and further their competitive edge. Poor knowledge management and knowledge reuse has contributed to many companies' lack of progress and in some cases resulted in their demise. The Construction Industry is no exception, and by its very nature it has been slow to adopt new technologies. The industry has been criticised for being too slow to take advantage of new technologies and methods of working and has been accused of failing to employ more innovative approaches (M. Abadi & D.Moore, 2005), (Egan, 1998).

Construction companies can no longer be judged solely on the level of their past performance: they also need to examine how they manage their knowledge and expertise. This can in part be done by utilising any available means that help them maximise value for their customers, and by ensuring that their employees receive optimum support. This, in turn, increases profits for their shareholders and investors alike and encourages repeat business.

It has become accepted fact throughout the UK Construction Industry that firms must realise the full potential of the intangible resources available to them in order to remain competitive. In particular, knowledge is increasingly being recognised as a vital organisational resource offering competitive advantage (Egbu & Botterill, 2001). KM deals with the organisational optimisation of knowledge through the use of various technologies, tools and processes to achieve set goals (Kamara et al., 2002).

1.2.1 KNOWLEDGE MANAGEMENT IN THE CONSTRUCTION INDUSTRY

The UK Construction Industry accounts on average for about 10% of UK's GDP, employs over 1.8 million people, and was valued in 2003 by the Department of Trade and Industry at £93,284m (DTI 2005). The industry has attracted the attention of successive governments to invest a substantial amount of money to improve its performance. Government reports, including "Rethinking Construction" (Egan,1998) and "Accelerating Change" (Egan, 2002), and Latham's earlier report in 1994, "Constructing the Team", have identified two obstacles to implementing change in the construction industry:

- The highly fragmented nature of the construction industry
- The lack of prominent and experienced repeat clients.

There have been calls for change from the academic profession. Anumba et al (2000) found that: 'Competitive pressures from within the industry as well as external political, economic and other considerations are now forcing the industry to re-examine and improve its modus operandi'.

The construction industry is struggling to implement techniques to reduce project time and cost, and improve productivity and performance and growing trends of integration and decentralisation in the industry. This has been largely manifested through adopting the design build and partnering approach, which has added to these challenges. (Bouchlaghem et al. 2004)

The Construction industry, like other industries, is exposed to considerable advances in Information Technology. Investment in new hardware and software is crucial to gain a competitive edge, but this investment needs to be justified, by demonstrating how the company will benefit from it. Often, as was proved in this case, extra investment can in the long run make a difference in winning new business between competing companies.

In the Construction Industry mistakes are often very costly because of the high cost of materials and labour, tight profit margins, the economic environment and the possibility of

litigation. 'The importance of managing information and knowledge to generate commercial advantage is becoming increasingly clear.' (Carrillo and Chinowsky, 2006)

'Construction firms in particular are extremely knowledge-intensive and can be characterized by their use of a high degree of tacit knowledge, resulting from the need for high levels of problem solving and technical ability.' (Anumba *et al,* 2005; Robinson *et al*, 2005)

Knowledge gained in construction projects should be recorded and stored. This is vital for ensuring that the hard work and expense invested in capturing it can benefit future projects, encourage continuous improvement, and avoid 're-inventing the wheel'.

Knowledge is increasingly recognised as a vital organisational resource that provides competitive advantage (Egbu & Botterill, 2001). This is particularly useful for construction companies undertaking Private Finance Initiative (PFI) projects, such as the sponsoring company, where they are responsible for the design, construction and maintenance of buildings over long periods of time.

KM practice in construction is mostly informal and people-centred, although there is a growing trend towards the development of formal KM strategies in construction firms (Kamara et al, 2002).

Gold *et al* (2001) illustrate the necessity for effective KM by explaining that a successful KM initiative enables an organisation to become more innovative, better co-ordinate its efforts, rapidly commercialise new products, anticipate surprises, become more responsive to market change and reduce the redundancy of knowledge and information available to it.

Construction companies have always managed to utilise knowledge they have gained but the increased awareness that knowledge should be managed in a more structured manner is new to the industry (Carrillo,2004). Anumba et al (2005) confirm that construction firms are knowledge intensive, characterised by their use of a high degree of tacit knowledge.

By using practical case studies, this research in part examines how one of the UK's largest privately owned construction companies provides information and knowledge gained over the past century to their employees. It also explores what the employees feel about the systems in place and whether the company gets maximum return for their efforts. It also investigates new ways of making information and knowledge more accessible to users who for a variety of reasons struggle with finding, reading and/or understanding what is provided.

1.2.2   EXTENT OF THE PROBLEM IN THE UK

It can be argued that the UK Construction Industry has always lagged behind other industries in keeping up with advances in information technology. The need for effective mobilisation of knowledge in sourcing expertise quickly, and providing clients with confidence in a firm's competence in specific areas of work, is a longstanding goal in the construction industry (Carrillo, 2004).

The UK government identified the knowledge driven economy as one where the generation and exploitation of knowledge is a major contributor to the creation of wealth in the economy (CIC, 2003).

The importance of knowledge to a construction firm to improve its ability to innovate, increase its competitive advantage, and contribute to project success has meant that UK construction firms have become increasingly interested in implementing various KM solutions (Carrillo and Chinowsky, 2006; Robinson et al, 2001).

At a time when free movement of labour in communities and countries is becoming immensely popular, UK industries are experiencing an unprecedented influx of migrant labour from Eastern European countries and other parts of the world, a good proportion of which work in the construction industry. Their performance and health and safety can be compromised by deficiencies or their inability to communicate in a common language, and may therefore require different means of KM and information presentation.

 The majority of migrant workers occupy the more physical, high-risk jobs, working in the hazardous sectors. They often cannot read and/or write in English and in some cases

cannot speak or understand it. They therefore rely on their fellow workers to keep them informed on the safety briefs and method statements which are essential to their safety and performance.

On the other hand, the demand for delivery on tight programmes puts increasing pressure on contractors to speed up their operations. Consequently employers tend to neglect or overlook the new workforce's shortcomings and in turn may expose them to unnecessary risks in a hazardous environment.

There have been a number of fatalities involving migrant workers employed in the UK because of the difficulties highlighted above. 'Deaths are on the increase and there's a danger that we could soon start to see more fatalities and serious injuries at work as language barriers mean safety messages are not getting to the people involved.' (Salt and Millar, 2005)

The extent of the problem in the UK can also be deduced from some of the headlines appearing in the newspapers and other media, such as '*UK workers outnumbered by foreigners on London sites, MPs heard that 40% of construction workers in London were migrants in 2006 - up from just 21.5% in 2001.*' and '*It's possible that it has now topped 50% in London, although it's impossible to get totally accurate information.*' [a UCATT (Union of Construction, Allied Trades and Technicians) spokesman].

There are concerns that migrant workers are not given crucial health and safety training in a form they understand and may not be able to carry out their work with optimum performance. In part, this is explained by employer's unwillingness to provide information and knowledge in any format other than written language. This has prompted the Health and Safety Executive (HSE) and the Trades Union Congress (TUC) to direct 'the industries involved producing new safety information to be translated into 21 different languages!' (HSE, 2004)

Corvalan (1994) studied 1,211 cases of work-related fatalities among people from 51 nationalities working in various sectors in Australia and concluded that the fatality rate was higher amongst non-English speaking workers than that of indigenous Australians. This

case study argued that language and duration of residence are important determinants of safety at work in Australia.

Employers have a duty under the Health and Safety at Work Act to provide all employees with appropriate safety training to enable them to do their jobs without risk of illness or injury (TUC, 2004). In some cases, without the practical means to transfer information and knowledge, this task will prove extremely difficult, if not impossible. Furthermore, if an employer refuses to take on new employees because of a low level of understanding in English, the company may be accused of discrimination with attendant legal implications.

1.2.3   THE SUBJECT DOMAIN IN THE GLOBAL MARKET

The global market and economy dictate closer collaboration between nations and people. With the provision of free movement of labour in the European Market, and the need for migrant labour from the rest of the world, better means of communication and information and knowledge transfer are now essential if companies are to provide acceptable safety conditions and enhance employees' performance. Global involvement dictates closer co-operation, and language may be a barrier and a stumbling block hindering this closer involvement.

Swan *et al*. (1999) emphasises that despite the apparent enthusiasm from numerous recent publications for people and managerial-orientated KM solutions, many articles continue to focus on IT-based methods. They also recommend that organisations must not neglect the human issues, and should aim to achieve a people-centred implementation of KM.

This research focuses on some of the problems generated by the need for effective communication with an increasing migrant labour force, and the difficulties in communicating in a common language in a typical medium to a large construction company. It draws on surveys and interviews to understand some of the difficulties encountered by the construction industry in the twenty-first century. This research also suggests ways to improve information and knowledge presentation, regardless of language and educational background.

1.2.4   BACKGROUND OF WATES GROUP "THE SPONSORING COMPANY"

The majority of the following sub-sections under the headings 'History' and 'Facts and figures' are from the publicly available official Wates Construction literature.

HISTORY (WWW.WATES.CO.UK)

'In 1897 Edward Wates and his three brothers set up the first Wates Company.
During the 1920s and 1930s Edward's sons, Norman, Sir Ronald and Allan, expanded the Company by pioneering speculative house building and then extended their activities into general contracting.

During the Second World War, the company built aerodromes, army camps, factories and most notably, developed a speciality in constructing pre-cast and in situ reinforced concrete barges and floating docks. The company supplied major parts of the Mulberry Harbours that were towed across the channel after D-Day.

After the War the company used this knowledge of pre-cast concrete to develop high-rise and low-rise industrialised housing systems and built over 60,000 houses and flats using these techniques. Property development was also added to the core housing, contracting and plant businesses.

The company is currently owned by the fourth generation of Edward Wates' family.
Wates Group consists of five national businesses: Living Space (affordable homes), Construction (education facilities, commercial premises and public buildings), Interiors (office fit-out and refurbishment) Retail (retail premises fit-out and refurbishment) and Developments (enhancing land value and strategic joint ventures). The Group has shown record performances across all divisions with the most successful results in Wates' 100+ years history.'

FACTS AND FIGURES

'2,200 people were employed by the company. In 2007 the Group had a turnover of £949m, a 10% increase on 2006. Profit (before exceptional credit) increased 20% from £31.4m to £37.7m on turnover 10% higher. This consistently improved business performance has led once again to a strong balance sheet.

Alongside financial improvement, the Group also achieved significant progress against its key corporate responsibility programmes:

- *80% of the value of work in 2007 came from repeat customers, bringing us closer to our 2010 objective of managing 90% of business within strategic partnerships and frameworks.*
- *The Group's output of waste to landfill has been further reduced with 80% diverted from landfill keeping us clearly on track to eliminate non-hazardous waste to landfill by 2010, an improvement of 12%.*
- *There was also further improvement in safety performance with 83% of Wates' sites being injury free.*
- *The Group's Building Futures Programme, which enables long-term unemployed adults to get back into work, provided places for 110 individuals in 2007, of whom 65% secured permanent employment in communities where we work.*

With a forward order book of £2bn, a strong pipeline of business across each of the Group's strategic businesses is in place for 2009.

80% of the value of work in 2007 came from repeat customers.

Wates is ranked by the BITC as one of the Top 100 companies in the UK with regard to corporate responsibility.

In 2006 Wates' Accident Incident Rate (AIR) was half the industry average.

In 2007 83% of Wates' sites were injury free.

The company has built or restored many landmark buildings, including:

- *London Transport Museum*
- *The Stratford Ete*
- *The Queen's Gallery at Buckingham Palace*
- *London Academy*

- *Birmingham Town Hall*
- *The National Gallery*
- *Phase 1 regeneration of Paddington Basin*
- *Leeds Railway station.'*

(WWW.WATES.CO.UK - 03/04/2008)
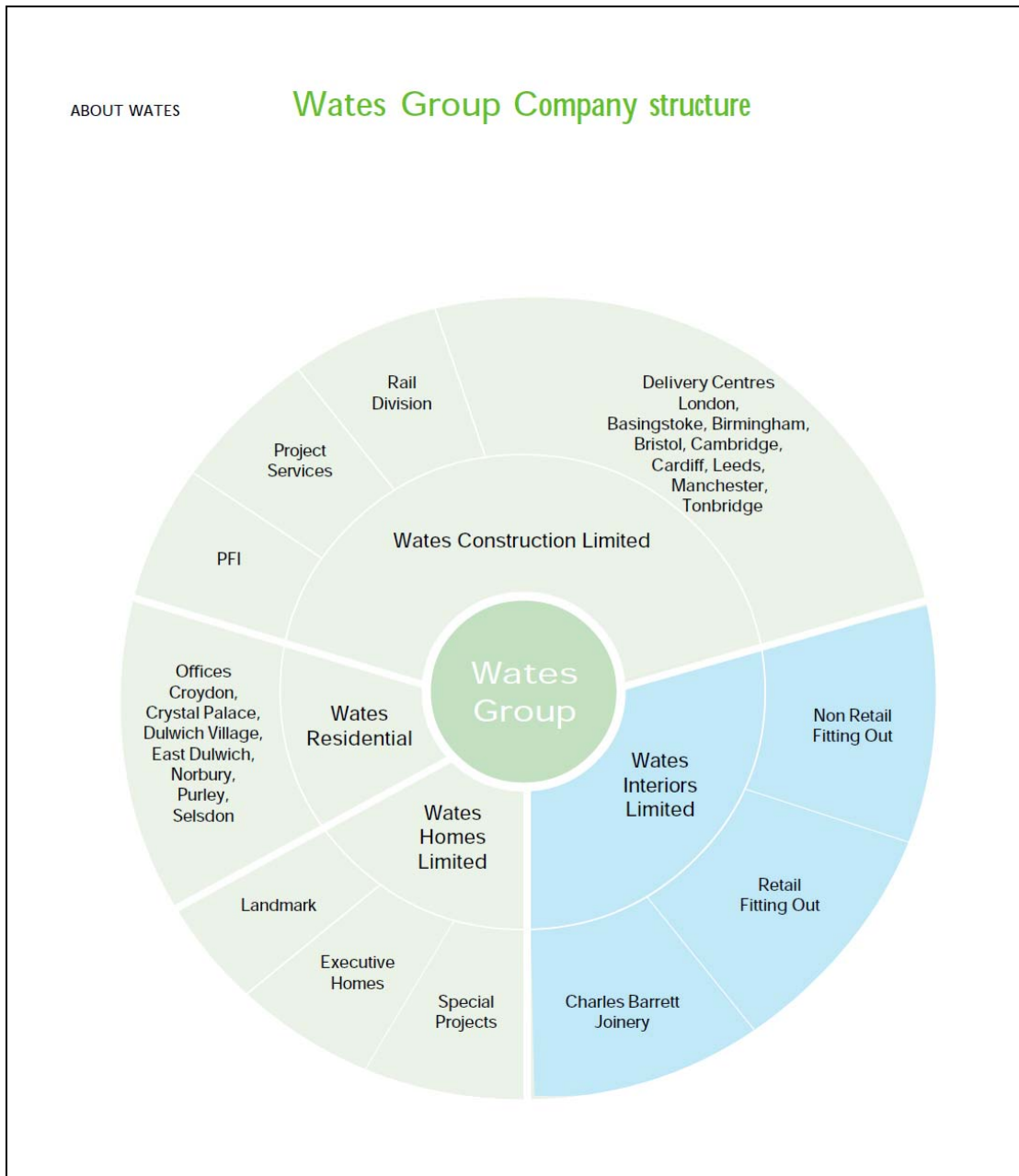
Figure 1- Wates Group
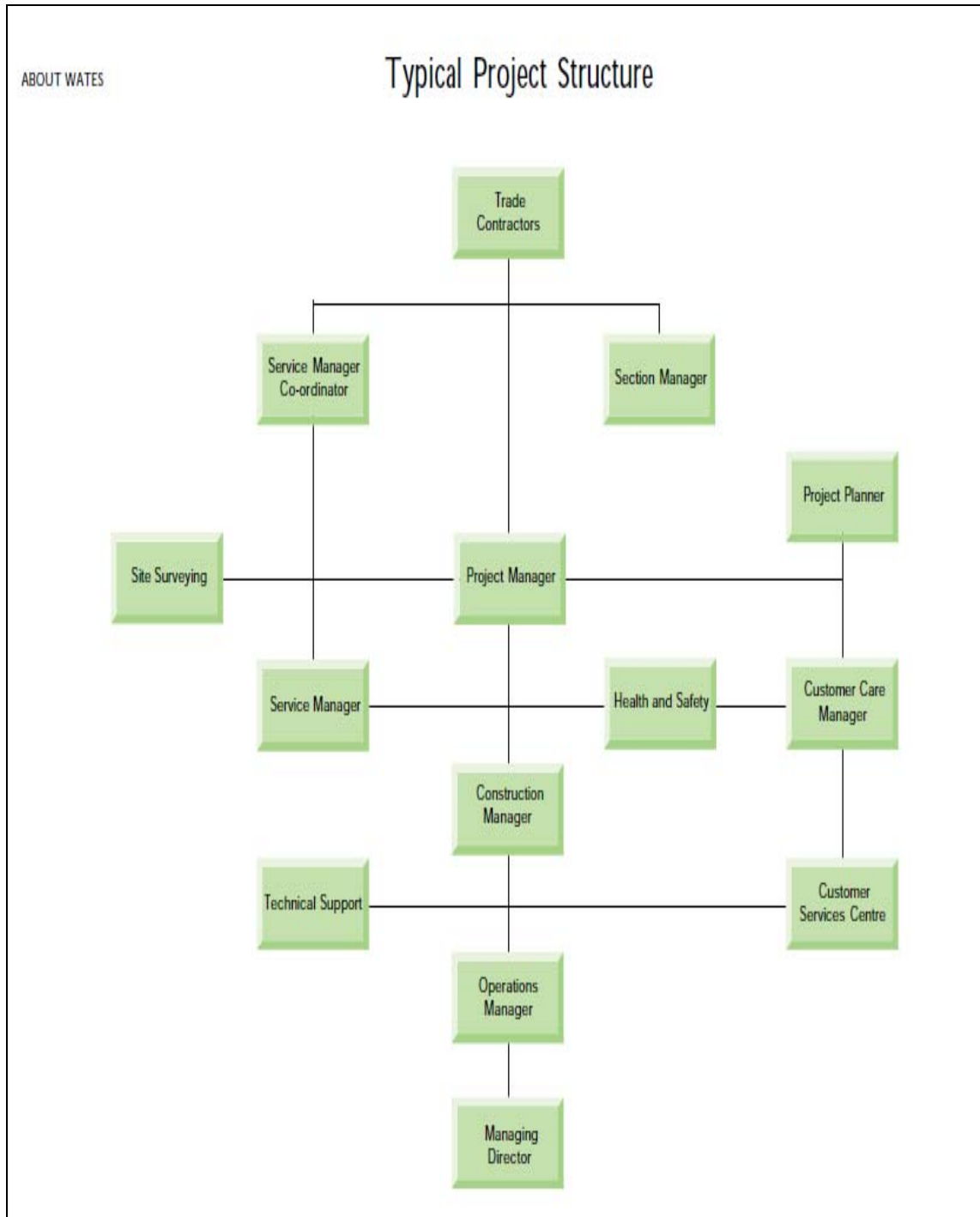
Figure 2- Project structure
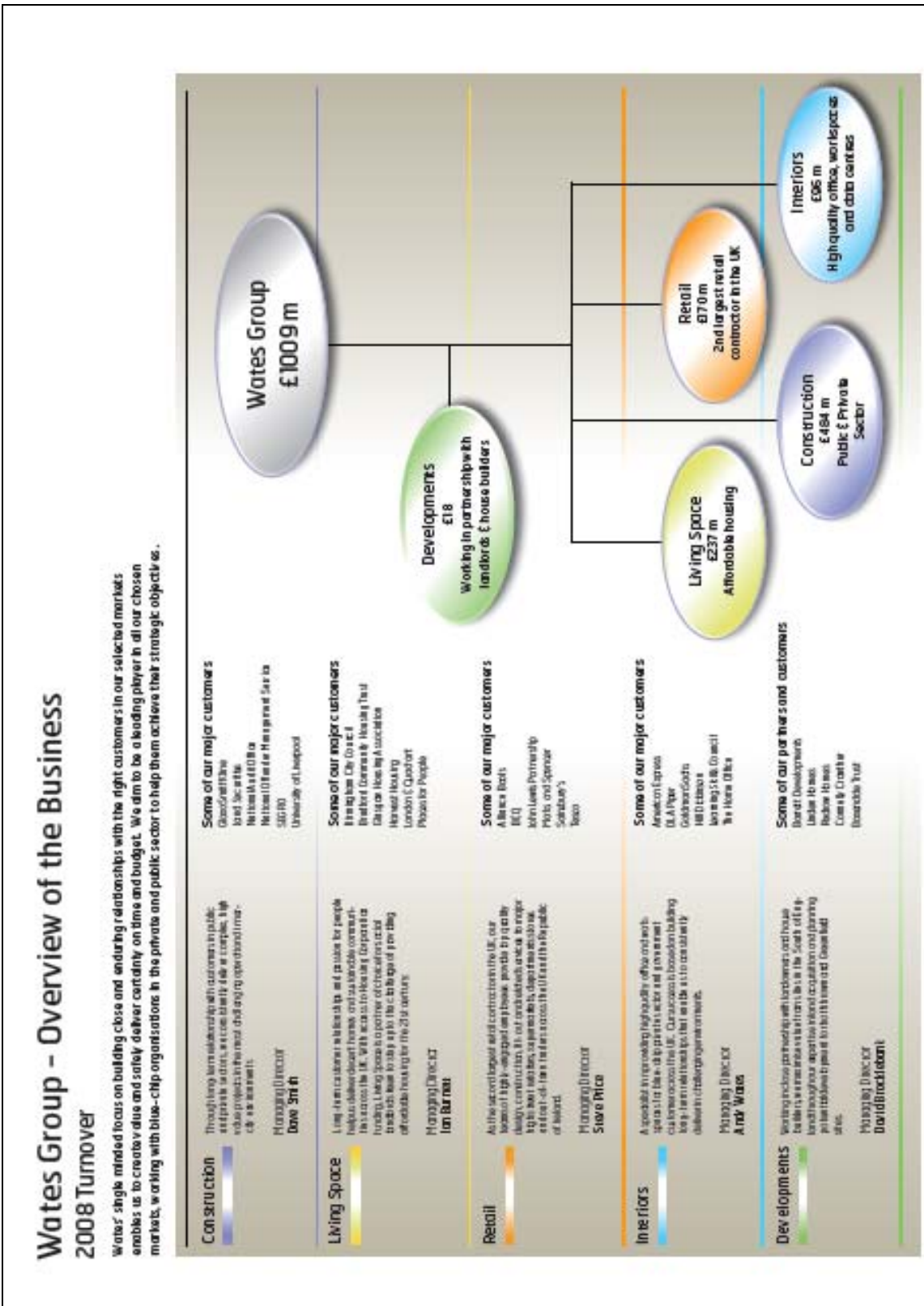
Figure 3- Overview of the Business for 2008

1.2.5   PROBLEM FACING THE SPONSORING COMPANY

The information and knowledge provided by the sponsoring company and other external sources in the group are held in the company's intranet system, buried in hard to access pages of text. Generally users require training and considerable time to search the database for relevant information. Volume of work and lack of time may prevent successful retrieval of information, which may lead at best to making unqualified decisions and at worst to making the wrong decision, with attendant potential time and cost implications.

The preliminary research also concludes that few contractors can take advantage in a comprehensible structured way of knowledge and information gained from previous contracts.

This research categorises the sponsoring company's workforce into two distinct groups who can benefit from change:

1. **Group 1** need a simpler way to find and access the information and knowledge on the company's database. For the purposes of this research, this group is classed as needing "High Level Information and Knowledge Presentation" (HLI KP).
2. **Group 2** Although information is provided for this group, for various reasons they fail to understand it. This group, therefore, is classed as needing "Low Level Information and Knowledge Presentation" (LLIKP).

1.3   INTRODUCTION TO THE RESEARCH

Shortage of time for decision-making is placing greater demands for having information "on tap". There is a need for a simplified method of information and knowledge management in order that useful information is not too cumbersome to explore and use. With the vast amount of information available, the major barrier to gathering useful information is not only finding what is available but finding what is available to satisfy our needs. Despite twenty-first century technology, a great deal of time is expended on

searching for useful information because of the various systems, processes and techniques used. The user has to be highly trained and/or spend much exploratory time to successfully find the anticipated results. Carty (2005) observes,

> 'A major overlooked cause of many IT project issues is that the technology tool set is not the correct one for that particular project. However, many IT professionals valiantly try to make it work since management likes the economics of using what you already have. Yet, ultimate success often depends on knowing when it's time to stop and re-evaluate the technology direction before its too late.'

Demain and Fruchter (2009) emphasise that, 'Improving and supporting the process of design knowledge re-use can increase productivity, improve the quality of designs and lead to corporate competitive advantage.' They also point out that "external knowledge" (re-use of knowledge from an external digital or paper archive) often fails.

The construction industry typically generates two types of information and knowledge:

- **Project based** – knowledge, other than what has previously been or is currently being produced in offices prior to its use on site, which is usually tacit and can easily be lost if it is not quickly captured.
- **Office based** - more structured and mainly recorded knowledge, which can be classed as explicit, but could be buried in pages of text and therefore not easily accessible to everyone.

There are huge variations in the types of knowledge a typical project can generate. Egbu (2005) states that 'decisions on what type of knowledge a construction organisation needs or the knowledge intensity depends on the context of the business environment.' He emphasises that there are three types of knowledge to manage in a typical construction firm:

> 1) *People - this relates to skill and problem-solving capabilities. The skill base increases depending on the complexity and innovative qualities of the projects. Often the people involved with these projects are more creative*

and experts in problem-solving. The type of knowledge associated with them is therefore mainly tacit.

2) ***Process*** *– this relates to the technical and management systems required for the project, so the technical process is heavily reliant on explicit knowledge, whereas the management process may be either explicit or tacit.*

3) ***Product*** *- refers to the end product, so the type of knowledge needed is associated more with clients, end-users and market characteristics and may be classed as mainly explicit knowledge.*

Egbu (2004) also argues that construction companies need to become more innovative and to maximise the use of their resources, which renders knowledge a significant organisational asset. Kamara (2000) emphasises that formulation of a knowledge management strategy involves an examination of a number of interrelated concepts and factors. McLaughlin (2004) suggests that during the development of KM solutions, people-related factors typically remain neither acknowledged nor discussed.

New hardware and software technologies are now necessary tools which provide ease of access for the user. The better these tools are, the higher the edge over competitors, but investment in them needs to be justified by ensuring that the business is benefiting from them.

Increasingly company employees, frustrated by not being able to access their information needs from company's system, rely on the internet for extracting information. This is normally done in a haphazard and unstructured way. Surveys (Chapter 4) demonstrate that the success rate in finding answers to users' queries in this way proved higher than finding it in the company's intranet system, indicating that more than a hundred years of information and knowledge-building by the sponsoring company is not fully utilised and often ignored. (See the outcome of the questionnaire in Chapter 4.)

Swan et al (1999) emphasise that research is limited, examining the specific factors which affect the willingness and co-operation of people to contribute to KM initiatives. Furthermore, the vast amount of information on the internet means it may take employees much longer than necessary to find the information they need.

'Information growth on the net is still accelerating at a rate of about 7.3 million pages per day, doubling every eight months, indicating that the Internet has not yet reached its highest period of expansion, buried in this vast, rapidly growing collection of documents lies information that is of interest and use to almost everyone.' (Murray and Moore 2000)

'*Making knowledge visible so that it can be better accessed, discussed, valued or generally managed is a longstanding objective in knowledge management.*' (Sparrow,1998)

The use of visual presentation as a medium to obtain, supply and exchange ideas, information and knowledge in a coherent and usable manner could be the key to training and educating people, regardless of educational background and to some extent language ability. This could prove to be not only a viable supplement, and in some cases an alternative to language, but also essential in certain circumstances.

 It has been said that a picture speaks a thousand words; in addition, it can also be argued that "a picture speaks a thousand words in any language".

Architects have successfully used visual methods for centuries to create and transfer knowledge among individuals from different cultural, social, economic and educational backgrounds.

Lengler (2007) describes a working definition for visualization: 'Visualization method is a systematic, rule-based, external, permanent, and graphic representation that depicts information in a way that is conducive to acquiring insights, developing an elaborate understanding, or communicating experiences.' Kosslyn (1980) and Shepard and Cooper (1982) share this vision, adding that visual recall seems to be better than verbal recall.

Gallagher (1995) observes: 'Rapid growth of visualisation application in the field of engineering results in large part from its tangible benefits within the design process.' Haber and McNabb (1990) agree, adding that 'Computer visualisation methods have emerged as the most effective tool for rapidly communicating large amounts of information to scientists and engineers in a format that enhances comprehension and deepens insight.'

Damian and Fruchter (2009) have done similar research into effective visualisation; they prefer the use of Storytelling for design re-use. They divide knowledge re-use into two categories:

- Internal Knowledge Re-use - knowledge from personal experiences
- External Knowledge re-use - knowledge from an external knowledge repository.

Damian and Fruchter (2009) also observe that research studies on knowledge re-use are based on either cognitive or computational aspects. They emphasise that the computational aspect of visualisation focuses on knowledge representation and reasoning. These values are prominent in this research and form the bases of its findings.

1.4   STRUCTURE OF THE RESEARCH

The theme of the research is *'to ease the information and knowledge transfer by streamlining the process within the sponsoring company'*. Following the findings of surveys, questionnaires and one-to-one interviews, the domain was widened to take account of not only the simplification of the knowledge provider system for indigenous employees but also to ensure that it caters for everyone involved with the company. This took account of individuals' educational background and understanding of English. The company is expected to expand into overseas markets, hoping to capture a large proportion of its works in the Middle East, so the new system needs to cater for employees from these countries.

The outcome of this research was primarily perceived as the analysis and modification of the existing information and knowledge provider system, but as the research progressed further needs became evident. These proved to be within the brief and parameters of the research and of immense importance to the sponsoring company, namely to provide essential information to people who may struggle with reading pages of text or have limited understanding of English, thereby also helping with future Middle East operations. These groups' needs were also addressed as far as possible within the remit of the research.

CHAPTER TWO: AIMS AND OBJECTIVES

2.1 INTRODUCTION

This section sets out the background to and description of the aims and objectives, and the justification for the research. It also includes a guide to this research, and describes how it has been developed and carried out. The different stages of the research have been split into objectives and further broken down into tasks.

There follows a description, explanation and justification of the objectives. The objectives are set out in the order in which they appear in this thesis. Each objective has been defined in a separate chapter to clearly emphasise its outcomes.

2.2 AIMS OF THE RESEARCH

The foundation and drivers for any successful company is dependent on its technical knowledge, expertise, experience and the management skills of its workforce. The explicit technical knowledge is usually embedded in the organisation's repositories and information retrieval systems. Any deficiency in the system can affect optimum performance and may result in wasted time and effort, in areas that have already been explored. This research primarily deals with the presentation of information and knowledge and its overarching aim is to:

'Develop a framework that facilitates presentation and re-use of organisational and personal knowledge within and between people and businesses run by the sponsoring company, with a view to reduce information redundancy and encourage information uptake.'

2.3 OBJECTIVES OF THE RESEARCH

To achieve the aim of this research three key objectives were established: two at the outset and one during the first phase of the research.

2.3.1   OBJECTIVE ONE

Evaluate the existing information retrieval system used by the sponsoring company. This objective is further divided into three tasks:

1   Investigate the cause of current poor performance

2   Evaluate the strengths and weaknesses of the existing system

3   Develop an understanding of the users' wants and the company's needs.

2.3.2   OBJECTIVE TWO

Research and development of an alternative system which would address the weaknesses identified in Objective One Therefore Objective Two contains the following tasks:

1   Research and analysis of available software to simplify the system and encourage the user to make better use of it

2   Development and deployment of an alternative system that is user-friendly, logical and would provide maximum effectiveness with minimal training in transferring information and knowledge to targeted users.

3   Feedback and fine-tuning of the new system.

2.3.3   OBJECTIVE THREE

Evaluate the need to provide vital information and knowledge to employees who have difficulty reading pages of text, and address the requirements of those who cannot read, write and or understand a common language (Group 2-LLIKP), and devise an easy process which provides the necessary safety messages, method statements and risk assessment in a format comprehensible to this group. This should also give the sponsoring company an insight into the problems and hazards this group encounter, to ensure steps are taken to prevent accidents.

This objective has been sub-divided into the following tasks:

1   Qualify the extent of the problem

2   Establish the end-users' views and how they have managed so far

3   Explore the potential fields of graphical and visual presentation of information and knowledge in the Construction Industry and whether they can be used to address the shortcomings highlighted in Objective Three

4   Evaluate the advantages and disadvantages of using such a system

5   Research and develop alternative forms of information and knowledge presentation to address the needs of this group of employees.

2.4   BACKGROUND TO THE AIMS AND OBJECTIVES

The research aims and objectives had to both address the industrial sponsor's needs and achieve the degree of the scrutiny, structure and rigour associated with academic research. The direction and areas on which the research was initially based evolved as the various priorities, expectations and concerns of those involved in the different aspects of the research were fully appreciated and realised. As a consequence, although the aim remained as the brief, the objectives were steered in different directions. The research had its fair share of changes and challenges, but there were also surprises and unexpected successes in emerging new areas, uncovered by probing into day-to-day practices and processes.

The first two research objectives concern the company's information and knowledge provider system. The first objective explored the system's strengths and weaknesses and how it was perceived to perform by the users. There followed the second objective, the research and development of a new system to address the shortfalls identified in Objective One.

Whilst gathering data for Objective One, it became clear that users' needs varied according to their role, so the research had to find a common theme for information and knowledge presentation that applied to groups of employees with similar needs. The decision was made to split the workforce into two groups:

Group 1 largely consisted of people who were office-based and/or in managerial roles on construction sites. The information and knowledge they sought is mostly explicit and to some extent structured. This group was classed as needing 'High Level Information and

Knowledge Presentation' (HLIKP). Concern for this group initiated this research, so Objectives One and Two focus on their needs.

The third objective, however, became apparent whilst gathering data and information for the first two objectives. It can be best described as a tool to provide essential information to site-based manual workers who mainly carry out the physical work. This group also included people with a lower educational background than Group 1, who often struggled to read pages of text and in some cases were unable to read, write and/or understand English. This group was classed as Group 2, identified as being in need of 'Low Level Information and Knowledge Presentation' (LLIKP).

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                    ┌─────────────────────┐
                    │   Information       │
                    │  and knowledge      │
                    │  Presentation       │
                    └─────────────────────┘
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Information and knowledge Presentation

<u>High Level</u>
Information and Knowledge Presentation (HLIKP)

<u>Low Level</u>
Information and Knowledge Pransfer (LLIKP)

<u>GROUP 1:</u>
Architects, Engineers, Planners Managers, Estimators, Surveyors, Design Managers etc.

<u>Group 2:</u>
Carpenters, ground workers, plumbers, electricians, Machine drivers, Roofers, plasterers, labourers, etc.

<u>Requirements</u>
- Minimise the use of jargon
- Use out-standing words& phrases
- Graphical presentation
- Logical reasoning
- Minimise training

<u>Requirements</u>
- Graphical presentation
- Avoid words and sentences
- Use sketches, diagrams, images, objects, and storytelling principals
- Encourage logical thinking

Information and Knowledge Presentation –

Figure 4- Summary of specification for targeted group

2.5 JUSTIFICATION OF THE OBJECTIVES

The justification of objectives can be summarised as follows:

- Evaluation of the mindset of the employees working for a typical construction company and its partners, which to a degree represents the industry in general, by understanding their strengths and weaknesses in finding and using information and knowledge that is provided for them by the sponsoring company and the wider market.

- Explore the means in presentation of information and knowledge to Group 2 within the company in particular and industry in general.

- Investigate the principals of communicating information and knowledge simply and efficiently with minimal need for training, reading, and the user's educational background and command of English language.

Figure 5 encompasses the research aims and objectives, including tasks for each objective and the papers related to them:

AIM:
To improve the transfer of corporative, organisational and personal knowledge within and between construction businesses with a view to reduce information redundancy.

OBJECTIVE 1

Evaluate the existing information retrieval system used by the sponsoring company

Primary investigation for performance of the system

Users view on the current system

Explore the potential of information and knowledge visualisation to improve the system

Establish the need for an improved system

Paper 1

"Are we getting the best out of our Intranet System?" A Practical Case Study

High Level Information and Knowledge Transfer

Group 1

OBJECTIVE 2
Research and development of an alternative system that would satisfy the weaknesses identified in Objective 1 for group 1

Search for and investigate available software.

Research and development of an alternative system

Pilot study, feedback and fine tune

Paper 2

Information and Knowledge Visualisation : Can it help with the crisis in the UK Construction Industry.

Low Level Information and Knowledge Transfer

Group 2

OBJECTIVE 3

Research and development of an alternative approach that would address the needs of Group 2

Qualify the extent of the problem

Establish the end users views

Explore the potential fields for information and knowledge Visualisationvisualisation

Evaluate the advantages and disadvantages of using Visualisation concept

Feedback and fine tune

Paper 3

Knowledge Management in Organisations: A Constructive Case Study

Paper 4

Knowledge Visualisation and its application in the Construction Industry

Figure 5 - Summary of the work done

CHAPTER THREE: ADOPTED METHODOLOGY

3.1 INTRODUCTION

The purpose of this chapter is to explain the methodologies available for undertaking an academic research project in a working environment. Effective research methodology is critical to achieving good results. The success and validity of any research critically depends on the selection of research methods (Steele, 2000; Fellows and Liu, 2003).

This chapter also discusses the research design and methodology, including their strengths and weaknesses. The choice of research methodology an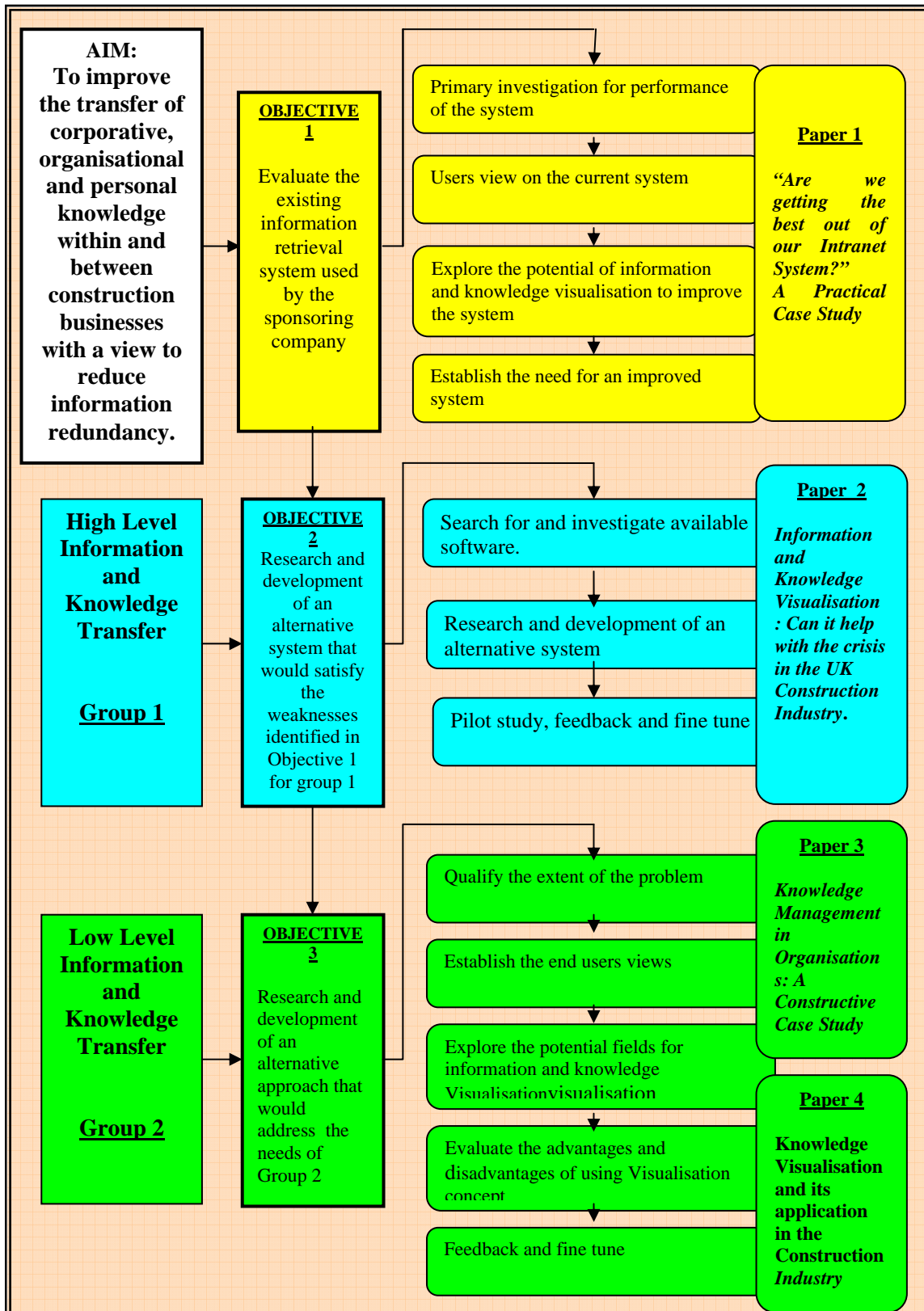d the reasons for its selection are also provided and mapped out against research objectives and associated tasks and research output.

3.2 RESEARCH STRATEGY

A wide range of research methodologies is available to researchers, all of which are categorised in a variety of ways (Siegle 2005).
 According to Dainty (2002) there are three distinct approaches to research methodology:

- Positivist (scientific): the research seeks to discover laws and generalisations which explain reality and allow for prediction; explaining events or phenomena through knowable facts, real causes which have a law-like regularity and measurement *(Woods &Trexler (2001).*

- Interpretative (phenomenological): the focus of research is based on understanding and interpreting occurrences and social structures to provide a meaning to a phenomenon *(Woods & Trexler 2001).*

- Critical: Critical research focuses on the oppositions, conflicts and contradictions in contemporary society, and seeks to be emancipator i.e. it should help to eliminate the causes of alienation and domination.(Myers, 1997)

Research design is the logical sequence that connects the generated empirical data to the initial research objectives of the study and ultimately to its conclusions (Yin, 1994).

'To make academic research relevant, researchers should try out their theories with practitioners in real situations and real organisations' (Avison, et al,1999). Yin (1994) suggested five elements as the main categories for research: experiment, case study, survey, archival analysis and history. These elements have been utilised in this research in that order:

The data collection methods fall into two distinctive categories, qualitative and quantitative research methods, and a combination of the two approaches known as "triangulation".

3.2.1 Qualitative research

Qualitative research is based on the non-numerical examination and interpretation of observations for the purpose of discovering underlying meanings and relationship patterns (Strauss and Corbin 1998). Qualitative research includes detailed descriptions of events, people, interactions and observed behaviours (Patton, 1992) and general opinion. It seeks to describe and explain both the perspectives and the behaviour of the people studied (Brannen, 1992). It attempts to obtain an in-depth understanding of the meanings and 'definitions of the situation' presented by informants, rather than the production of a quantitative "measurement" of their characteristics or behaviour (Wainwright 1997).

There are advantages and disadvantages in using a qualitative research method. The principal advantages are:

- It produces detailed information about a relatively small number of people
- It provides a greater understanding of the topic under study
- It encourages deeper study of the subject matter.

The weaknesses are:
- Data-collection is time-consuming and the analysis requires a certain degree of interpretation
- It may be open to bias and subjectivity.

This method was used extensively in the case studies and one-to-one surveys and validated the initial findings and final outcome of the research. It proved to be a powerful tool, revealing the participants' inner feelings without compromising their position.

3.2.2   Quantitative Research

This approach was originally developed in the natural sciences to study natural phenomena and can be defined as the numerical representation and manipulation of observations for the purpose of describing and explaining the phenomena those observations reflect (Kaplan 2004). It is identified as 'investigation into a social or human problem, based on testing a hypothesis or theory composed of variables which is calculated by numbers and analysed with statistical procedure to establish whether the hypothesis or theory hold true' (Creswell1994). Quantitative research is objective in nature (Naoum, 1998), using a collection of statistics based on data, questionnaires and observations.

This method was used to efficiently gather more extensive data about the wishes of the majority, using telephone surveys and survey questionnaires. Further evidence of its effectiveness can be found in the proceeding chapters.

Figure 6 demonstrates a generic comparison of qualitative and quantitative research epistemology .

Type	Qualitative	Quantitative
Methods	Case studies	Formal Methods
	Interviews	Numerical methods
	Participant Observation	Surveys
	Action Research	Lab Experiments

Figure 6 - Classification of Research Methods

3.2.3 Triangulation

Triangulation can be defined as the application and combination of several research methodologies in the study of the same phenomenon, used to obtain confirmation of findings through convergence of different perspectives (Jakob 2001). There are indications about the different number/types of triangulation, but the general consensus (including Begley (1996) and Guion (2002)) indicates that the five variants in this method are:

1. Data – triangulation of different sources of data across time, space or persons

2. Investigation – triangulation of work amongst several researchers

3. Methodological – triangulation of multiple methods to study a single problem

4. Theory – triangulation of two or more contrasting theoretical positions

5. Analysis – triangulation using more than one analysis technique.

Brannen (1992) cites different types of triangulation:

- Multiple methods: contains triangulation between methods and within methods

- Multiple investigators: research is through partnership or by teams rather than a single individual

- Multiple data sets: the gathering of dissimilar sets of data by the use of the same method but at different times or with different sources

- Multiple theories: can be used in a single research.

The new processes, which this research has strived for, had to satisfy a variety of people across different disciplines and to this end there had to be a common denominator to achieve the acceptance of the majority.

Triangulation exposed the core denominator between the different elements and people affected by this research. By conducting one-to-one interviews with a set agenda amongst people in different disciplines, and a different introduction to different processes to the same people in the sponsoring company (from director to site labourer), a wide variety of opinions was recorded. Examination of these results revealed a common theme which differentiated the needs of the various groups. It was then possible to combine groups with similar interests, to form a larger more manageable group and find common information and knowledge needs. This formed the bases for the new system and processes.

The categories of people varied in race, gender, age and discipline. Although this played a prominent part in establishing the 'wants' of Group 1 by devising a system which cuts through the barriers and embraces employees regardless of their unique qualities, it was also essential for Group 2, precisely for the opposite reason, to take note of the barriers and address them during the process.

3.3   RESEARCH METHODS IN CONSTRUCTION

Construction research makes use of both qualitative and quantitative methods, depending on the type of research. Traditionally scientific-based quantitative methods have been used particularly for analytical research such as structural or materials behaviour and when there is less or no human involvement. Consequently if human participation and thinking participants are involved, greater use of qualitative research methods is required, which works particularly well in the area of construction management.

3.3.1   Action Research

'Action research aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework' (Rapoport, 1970).

Action research normally involves organisational behaviour, and change management has been used in construction management. The original formulation of action research is based on a spiral of cycles of planning, acting, observing and reflecting developed by Lewin (1946).
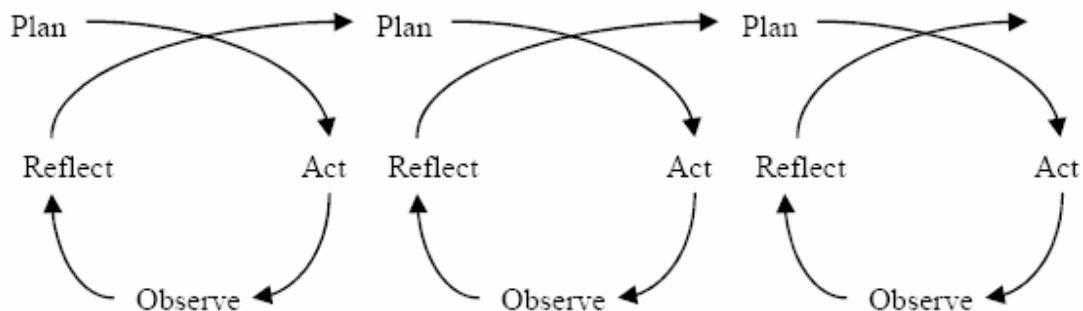

Figure 7 - Action Research 'Cycle of Spiral' as defined by Lewin

'The principles of this research are as follows: planning is seen as starting with a general idea and a certain objective, followed by series of actions, observations and a period of reflection with results and outcomes from the first cycle used to guide actions for the next cycle, and so on'. Stringer (1997) rationalised this by deploying the principals of three-stage research - look, think and act - on the understanding that the original question is not fully defined.

The action research approach played a decisive part in testing the new software proposed for Group 1. The shell software had to be populated in a logical way that can be followed by the majority of users. To this end fifteen one-to-one interviews were held with five key users in different disciplines in three stages. At the end of each stage, the system was reconfigured and fine-tuned to take account of users' opinions, logic and wishes. In essence, this part of the research identified "a user friendly system". The logic and principles of how the information is presented makes it possible for those who need to contribute to it to follow the same concept.

The whole process can be compared to doing a jigsaw puzzle, with the shell software acting as a box with a set of rules. The pieces of the jigsaw were provided by the old intranet system i.e. pockets of information in the system; the mapping out and reconfiguration of where the pieces should be placed came from this part of the research, so that the content can be made visible to those seeking it. Details of how this element was perceived and put into action can be seen in the proceeding chapters.

3.4 RESEARCH METHODS USED AND JUSTIFICATION FOR THEIR USE

The brief from the sponsoring company was clear: "deliver cost effective and targeted solution or it may not be adopted"; therefore, the preliminary studies and justification for methods used formed an important part of this research.

A review of current literature was essential to gain an overview of related research and an understanding concerning the different fields of information and knowledge representation. It was also important to establish areas of uncertainty within the literature and research in the specific field of this research.

Although the focus of recent research had been to accumulate information on company's database there seem to be a distinct lack of studies in how this information should be presented to the employees. Due to the nature of research undertaken in this study, involvement in the daily operation of the business proved to be critical in forming a better understanding of what is needed. Therefore case studies, surveys, interviews and experiments formed essential bases for creating a suitable solution to information and knowledge representation problem.

Figure 8 produced by Yin (1994) shows a generic mapping of several research strategies against various possible situations:

Strategy	Form of research question	Required control over behaviour events	Focus on contemporary events
Action research	Who, what, why, how many, how much?	Yes/No	Yes
Case study	How, why?	No	Yes
Survey	Who, what, where, how many, how much?	No	Yes
Archival analysis	Who, what, where, how many, how much?	No	Yes/No
Modelling	Who, what, how many, how much?	No	Yes/No
History	How, why	No	No
Experiments	How, why	Yes	Yes

Figure 8 - Different Situations for research strategies (Yin 1994)

Archival analysis, which is a form of the observational method and involves the researcher to examine accumulated documents and/or archives in a specific field, consisted of a

review of current literature. This was essential to gain an overview of related research and an understanding concerning the different fields of information and knowledge representation. It was also important to establish areas of uncertainty within the literature and research in the specific field of this research. Other forms of research such as case studies, surveys and interviews were carried out to ensure a meaningful and practical solution to the sponsoring company's problem. Methods such as experiments and modelling could not be used till the later stages of the research because these methods rely on testing the outcome rather than identifying it.

Figure 9 maps out the research phases including the objectives and tasks and the various research methods adopted. The table also reveals the research outputs, including refereed conference papers and journals. The full implication and outcomes of the research can be found in Chapter 7 and Papers 1-5.

Figure 9- List of Objectives, Tasks, Methods and outcomes

Objective	TASK	METHOD	OUTCOME
Objective One- Evaluate the existing information retrieval system used by the sponsoring company.	1.Investigate the root cause of the current poor performance in terms of its practical application.	Survey	**PAPER 1** "Are we getting the best out of our Intranet System? "Practical Case Study" presented in "The Joint International Conference Culture , Innovation and Management (CCIM 2006)
	2.Evaluate the existing system	Case study	
	3. Develop an understanding of the users wants and company's needs	Surveys Interviews Case study and literature reviews	
Objective two- Research and development of an alternative system that would satisfy the weaknesses identified in Objective 1	1. Review of related research in the field and alternative software	Archival Analysis	**PAPER 2** "Information and Knowledge Visualisation : Can it help with the crisis in the UK Construction Industry" Presented in The Joint International Conference in Knowledge Management in Organisations (KMO 2007)
	2. Views of the end users as to how a good system should perform.	Case study Interviews Surveys	
	3.Development and testing of the new system	Surveys Archival Analysis Application development &feed back	
Objective three- . Safety concerns for those working on building sites that struggle in understanding safety instructions and messages	Qualify the extent of the problem	Case study Interviews Surveys	**PAPER 3** Knowledge Management in Organisations: A Constructive Case Study, presented in the "8th International Conference on Knowledge, Culture and Change in Organisations"
	Develop an understanding of the issues with people concerned	Case study Interviews Surveys	
	Explore the potential fields for information and knowledge transfer by graphical and visual means	Case study Archival Analysis	
	Evaluate the advantages and disadvantages of using such a system	Archival Analysis Interviews Surveys	**PAPER4** "Knowledge Visualisation and its application in the Construction Industry". Under review
	Devise a tool and a process and evaluate the results	Case study Interviews Surveys	

Following explanations are given in justification for methods used and to give a more in-depth understanding of why these elements are important to ensure a satisfactory outcome from this research:

Objective 1- Evaluation of the existing system required three forms of investigation to understand the reasons for its shortcomings:

- Surveys - to evaluate reasons for employee's dissatisfaction with the existing system. Methods used were questionnaires and one-to-one informal interviews.

- Case study- to analyse the variables and gain deeper insight in the reasons the system doesn't meet the users expectation

- Archival analysis- using previous work done in this area to form a wider understanding of what is involved and the latest development in this field.

Objective 2 – For the Development of an alternative system the following tasks were identified to ensure the user's needs are considered:

- Archival analysis, to gain a better understanding in how other companies deal with presenting information and knowledge to their employees, and to find the latest developments and current and past research in this field.

- Case studies and interviews at every stage of the system development to ensure the new system meet the expectation of those that are going to use it.

- Pilot studies, questionnaires and one-to-one interviews following system development to ensure the integrity of the new system prior to its full deployment.

Objective 3 – Following tasks were carried out to form a better understanding of safety concerns realise by the employer with respect to certain employees that struggle in understanding safety messages:

- Evaluate the extent of the problem by conducting surveys, one-to-one interviews and archival analysis to understand the issues that affect the industry.

- Carry out archival analysis to gauge the extent of the problem in the wider market and ways it has been addressed.

- Test the new tool by using one-to-one interviews, pilot studies and quantitative questionnaires to ensure a predicable outcome.

3.5   ARCHIVAL ANALYSIS

Archival analysis is the most effective and inexpensive way to gathering the existing literature on a subject matter and to form a wider understanding of what is involved and also the latest development in the domain. Literature review paved the way to a theoretical foundation to enable the research to achieve the objectives. This enabled more effective decision-making and helped to find the best solution to the problem and by using tried and tested methods ease implementation. The majority of the theoretical information was gathered by attending relevant modules in the MSc programme early in the research, participating in knowledge management conferences and production of referred papers and searching through industrial and academic publications, university databases, library research and notes from conferences attended.

3.6   CASE STUDY

Most studies consider common and pervasive elements, and in the case study the intention is to understand the particulars of that case in its complexity (Key, 1997). A case study is a detailed investigation to analyse the variables relevant to the subject under study (Key, 1997). The advantages of a case study can include richer data and deeper insight into the phenomena under study (Hancock, 1998). A case study can combine a variety of data-collection methods and research strategies (Fellow and Liu, 2003). Case studies in this research were carried out to find the effectiveness of the original systems and those which replaced them.

This method has provided essential insight into how systems are used in the workplace. For example in Objective 1, spending time with nine individuals in a variety of disciplines and observing, monitoring and recording their activity on the system, helped identify their needs and configure the design of the new system.

3.7   SURVEY

Survey, the most widely used method in social sciences, provides a representative sample of the area of study and also serves as an efficient and effective means of considering a far greater number of variables than is possible with experimental approaches (Galiers 1992).

Surveys, using written or electronic questionnaires and face-to-face or phone interviews, often deal with how people behave and how their perceptions and behaviour are determined. Personal interviews and questionnaires were used for this research, the results of which can be found on Chapters Four, Five and Seven and a sample of the questionnaire in Appendices E and F.

Questionnaire: is an inexpensive way of collecting information and data. Respondents are normally selected and given a designed set of questions and asked to either tick boxes or select multi-choice options and/or record their views and opinions about given scenarios. The success and accuracy of this method depends on the design of its content and the format (Hoinville and Jowell et al, 1978); the questions should be unambiguous and easily understood by respondents and be easy to administer by the interviewer.

Interview: these were conducted face-to face with individuals and in groups. The interviews were a combination of structured, semi-structured and unstructured.

There are four types of interviews, namely informal conversation, the guided interview, standardised open-ended, and closed quantitative interviews (Patton, 1980).

Interview types (adopted from Coomb, 1999 cited in Sherif, 2002) are classified as follows:

➢ **Structured** - The same order and questions are asked in each interview, the respondent choosing from the alternative answers provided by the interviewer.

➢ **Semi-structured –** The interviewer asks the same major questions of each interviewee, but is free to alter the sequence and ask the reasons for the response given.

➢ **Unstructured –**The interviewer prepares a list of topics for discussion but the sequence is decided according to the interviewee's answers.

Three types of survey were carried out, each targeting a specific area of research:

- Questionnaires – were carried out for all three objectives before and after system developments to ensure their effectiveness.

- One-to-one interviews - were carried out for all three objectives both before and after system development to understand users' needs and the extent to which they have been addressed.
- Telephone interviews - were used predominantly in Objective One to encompass the broader community of people in other organisations facing the same problems and level of satisfaction with their system.

-

3.8 EXPERIMENT

Initial evaluation of the system included an impartial and critical view of how the system performs by mimicking typical enquiries and analysing the results. This element was used extensively in Objective One and the results explained in Paper 1. It was also used in Objective Three to ensure the outcome is practical and useful.

3.9 APPLICATION DEVELOPMENT

Following the assessment of the existing system, the second part of the research involved the development of the shell software to meet the sponsoring company's needs. By employing the three types of interview (i.e. structured, unstructured and semi-structured) a prototype was developed and tested on the users. A period of fine-tuning followed to ensure that the outcome meets the company's needs and the employees' wants; this was also repeated for the third objective of this research.

The full text of the deployment and testing of the system developed for Objective Two can be found in Paper 2 and Chapter 5.

The third objective of this research was to find alternative ways of conveying safety messages to employees with English as their second language, and overcoming their difficulties in understanding verbal commands and written notices in English. For a full description of this objective and the result of the research please refer to Chapter 6.

3.10   SUMMARY OF CHAPTER THREE

In this chapter research methodologies have been reviewed and the advantages and disadvantages of using different elements in the research were discussed. It also highlighted the adopted methods used and justified the reasons for their selection

CHAPTER FOUR: EVALUATION OF CURRENT PROCESSES AND PRACTICES

4.1   INTRODUCTION

This chapter describes the research carried out to meet the Aim by exploring the First Objective ('Evaluation of the Existing System') then outlines the main outcomes of the research and describes the various activities applied to achieve the targets set for individual tasks associated with Objective One.

4.2   PRELIMINARY STUDIES

It was decided that the researcher should explore the system by observing a selection of users in knowledge-intensive roles, and record their activity on the system over a period of time, to establish a trend in user opinion in how the system is performing. These studies revealed that useful information and knowledge provided by the sponsoring company seem to be randomly placed in the system and were usually buried in pages of text.

When searching for relevant information employees may spend long and at times frustrating periods of time sifting through irrelevant information, often abandoning the search. An example of the way the information is presented in the Wates database can be found in Appendix E.

It also became clear that often, due to the volume of work staff has to deal with, and because of the time constraints in providing an answer, they resort to using their tacit knowledge rather than a combination of tacit and explicit knowledge. At best this can lead to making unqualified decisions which may not provide the best solution, and at worst it leads to making completely the wrong decision, potentially costing the company a vast amount of time and money to rectify.

At this stage of the research, a series of familiarisation and introduction steps to different elements of the work took place, summarised as follows:

➢ Establish and ensure the top level management buy-in and support

➢ Develop a working relationship with the employees to gain their trust

➢ Observe current practises in accumulation, storage and presentation of information and knowledge

➢ Inform key members of the IT department about the research activities and invite their active participation

➢ Review the archiving and representation processes

➢ Conduct surveys to develop an understanding of the user's view of information management and knowledge in the company

➢ Evaluate the user's perception of how information and knowledge should be presented.

The following points were identified as problematic:

o The company's system of information retrieval was inadequate

o The users often spent long periods of time searching for information and were not always successful in finding it.

o There were many instances of knowledge gained from practical experiences that were not recorded, and were therefore not available for future use.

o The overwhelming majority of survey participants expressed their lack of confidence in the system provided. (This is referred to in detail in Appendix A, Paper 1.)

4.3   OUTCOME OF THE PRELIMINARY STUDIES

A report was produced highlighting the problems associated with the company's information retrieval system. After consultations with the appropriate people it was decided to direct the research efforts into improving and renewing the system.

4.3.1 EVALUATE THE EFFICIENCY OF THE EXISTING SYSTEM

The following tasks were identified as necessary to understanding this objective:

➢ Case study to understand the process first-hand

➢ Literature review of the current practices in the industry

➢ Surveys to gauge the level of employee participation

➢ Interviews to understand individuals' views about the system

➢ Workshops to discuss how the system can be improved.

Case study - to capture the company's employees' wider understanding and perception of the concept and their engagement with it. This involved a rapid survey using telephone interviews to establish the meanings and values associated with the terms "knowledge management" and "knowledge re-use", and the interviewee's understanding and expectations of this subject domain.

Literature Review - of themes relating to the project and to knowledge representation, human/computer interface, interaction and communication to establish the principles, drivers, barriers and benefits in each case. (Refer to Appendix 1,Paper 1 for further details.) Steps were also taken to engage the sponsoring company's partners to explore how information and knowledge provision are handled in the wider market.

Interviews - gave a greater insight into how the system users think and approach the system, and hoped to uncover areas which may have not have been fully explored before.
 The interviews were loosely structured to allow interviewees flexibility to express their views off the record. The agenda was tailored to match the individual's position and job title. Fifteen samples were taken. Interviewees were randomly selected according to availability and position, but the samples were designed to cover a selection of different occupations, ages and access to the sponsoring company and their own information and knowledge provider network. (See Paper 3 for the further details of the interview participants and the reasons for their selection.)

Using the recommended research methods outlined in Chapter Three, the surveys and interviews enabled a better understanding of the issues involved, paving the way for the foundations to develop a new improved system.

The people selected included Construction Managers, Site Managers, Quantity Surveyors, Site Engineers, Architects and Structural Engineers. This group of people was chosen because of their wider knowledge of the industry. They came under the category of Group 1, classed as being in need of High Level Information and Knowledge Transfer (HLIKT). A total of forty people took part in the written questionnaire, which was completed and returned by thirty-six participants.

(A copy of the questionnaire is included in the Appendix E, and the results can be found in Paper 2 and Appendix B.)
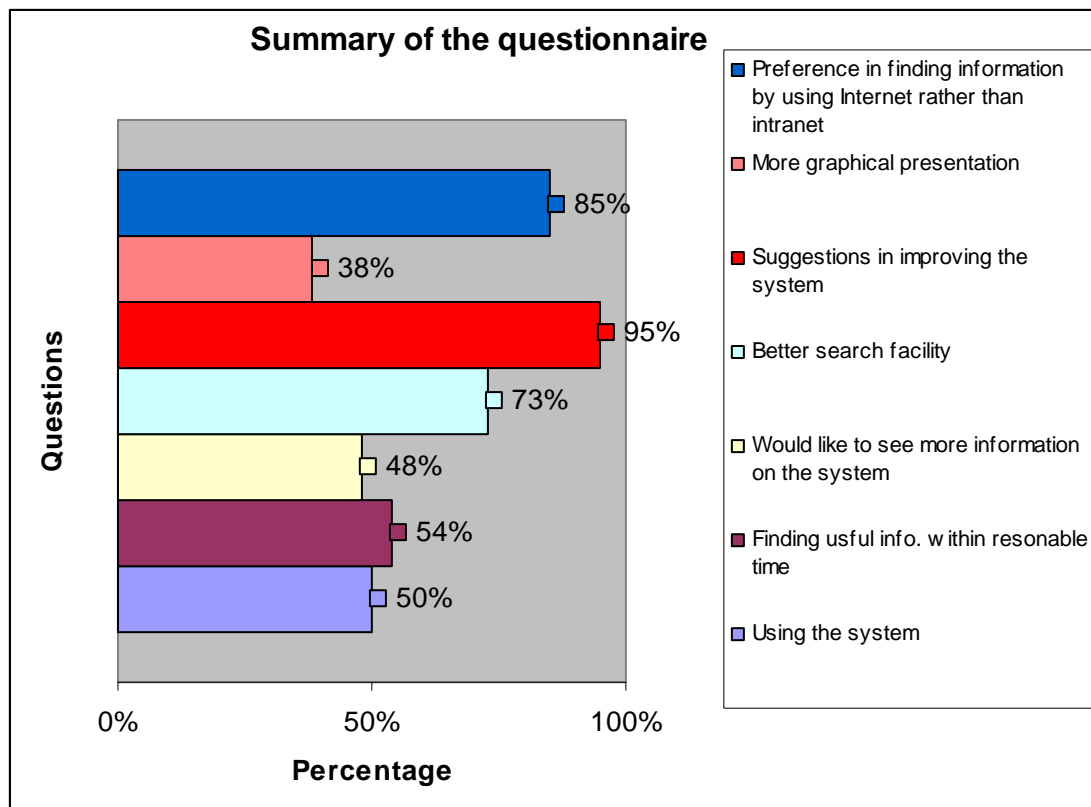
BREAKDOWN OF THE QUESTIONNAIRE AND THE RESULTS

Summary of the questionnaire

Legend:
- Preference in finding information by using Internet rather than intranet
- More graphical presentation
- Suggestions in improving the system
- Better search facility
- Would like to see more information on the system
- Finding usful info. within resonable time
- Using the system

Values: 85%, 38%, 95%, 73%, 48%, 54%, 50%

Axis: Questions (y-axis), Percentage (x-axis): 0%, 50%, 100%

Figure 10 - Summary of the questionnaire

4.3.2   Further analysis of the results

Efforts were made to analyse participants' different viewpoints and to establish common themes in different groups. Consideration was also given to occupation, gender, age, type of computer used and whether they were site staff or office-based staff. The outcome of the analysis is as follows :

- **Occupation -** those with specialised jobs including structural engineers, mechanical and electrical engineers and support staff were generally more successful in finding information, partly because their information needs are specialised and limited. Architects, project managers and design managers, on the other hand, need a wider field of information and experiences with materials, workmanship and construction methods.

- **Gender -** women were more persistent and less likely to give up looking for information, and once they had located it they would generally seek confirmation of its validity before using it. By contrast, men generally felt they could locate information quickly, but if it was not kept where they anticipated, they became more anxious and illogical in their attempts to find it. Often they gave up altogether and resorted to other means to look for information, such as calling a colleague.

- **Age -** no significant pattern emerged with respect to participants' age, although the older they were the more they relied on tacit knowledge and less on explicit knowledge, if it proved hard to be obtain.

- **Types of information provider -** generally desktops were used in offices, and laptops were more predominant on site, because of their portability. There were also limited numbers of PDAs used in the workplace although, for reasons that became clearer later, the use of these devices was dwindling.

- **Site or office-based –** office-based employees were generally more successful in finding usable information than site staff, mainly due to their repetitive work, although an exemption to this was bid teams, who relied in part on past experiences to make qualified decisions and minimise risks.

4.4   CONCLUSION OF OBJECTIVE ONE

The study's findings showing the main reasons for the failure of the company's information system are summed up as follows:

- ❖ Multiple information sources are scattered across the company's database
- ❖ The existing system is not user-friendly
- ❖ There are many different user interfaces to different information sources
- ❖ Users find information more successfully on the internet rather than the intranet
- ❖ Only a selective few can upload information on to the system
- ❖ There is no logic to where the information is kept within the system, so finding it can be time-consuming and cumbersome
- ❖ There are no standard methods for capture and re-use of the information and knowledge gained.

4.5   SUMMARY OF CHAPTER FOUR

To sum up, if the existing system if it is to succeed changes are required not only in providing the company with information and knowledge which are currently too laborious, time-consuming and in some cases inaccessible, but also to ensure that adding new information, and therefore knowledge, is not restricted to the few people who currently control it.

This chapter has also identified a clear business case for providing a new system to improve information and knowledge presentation, retrieval and upload that can be utilised by all the employees.

CHAPTER FIVE: RESEARCH IN FINDING AN ALTERNATIVE SYSTEM

5.1   INTRODUCTION

This chapter deals with the implications of Objective One i.e. the research and development of an alternative method for HLIKP (High Level Information and Knowledge Presentation) in the sponsoring company for use in Group 1.

A good user interface can make the difference between a user's acceptance or rejection of a system. If end-users feel the process is not easy to learn, hard to use, or too time-consuming to deploy, an otherwise excellent system could fail. Good user interface, therefore, is crucial in any system design, and making a product easy to understand will result in greater user acceptance and uptake.

The financial implications have been both a driver and a constraint in this research, but the fact remains that *'If senior managers place too much emphasis on managing by the financial facts, the organisation's long term viability becomes threatened.'* (Kaplan and Norton 1996)

The other factors playing a key part in this research are as follows:
- The end-users' perception of how the system should perform.
- Employees' mindset and resistance to change
- Reason or reasons for change
- Catering for all regardless of background
- A balance between new technology and traditional values.

5.2   AIM AND OBJECTIVES OF THIS CHAPTER

The research aimed to develop a system which is simple to use, requires little initial training and is flexible enough to re-use and capture new and updated information and knowledge with minimal effort.

The objectives are as follows:

- To deliver more efficiently a broader range of information and knowledge

- To help new users become proficient more quickly and with less training

- To reduce redundant efforts in searching for information, to give the user more time to perform their other duties

- To ensure that logic and common sense prevail.

5.3 EXPECTED OUTCOME

The expected outcome was the deployment of a knowledge-based intranet system which can readily present knowledge gained in previous projects in conjunction with related information the user requires to achieve their day-to-day information needs, including:

- ➢ Materials selection

- ➢ Availability of resources

- ➢ Laws and regulations

- ➢ Quick access to operating manuals (vital in PFI projects)

- ➢ Past responses to problems in given situations and the resulting outcome

- ➢ Compatibility with existing software environments such as Project Net, Build On Line and Humming Bird collaboration systems.

5.4 RESEARCH, ANALYSIS AND DESIGN OF THE NEW SYSTEM

A summary of the performance specification for the new system agreed with the sponsoring company is displayed in Fig. 11. Following are a combination of requirements, as outlined in methodology chapter, derived from literature review and surveys carried out with sponsoring company's employees and employer highlighting areas they feel is important to be included in the new system:

- Visual presentation which is graphical in appearance has a wider uptake

- Minimisation of the use of jargon and more extensive use of outstanding words

- Keep training to the minimum

- Compatibility with existing IT hardware

- Minimisation of the need for specialist IT staff to deal with queries and problems arising from the software.

The Methodology chapter highlighted tasks that needed to be carried out to ensure the new system fulfils the requirements. From Archival analysis it became clear that there were two choices available, either to develop new software or to deploy existing shell software.

New Software-The choice of programming language for creating new software was identified by using the archival analysis as indicated in the methodology chapter. Following initial research two query based programming languages were considered, Visual Basic and Prolog as preferred programming languages for development of a new system. The costs estimate and time span for development were also communicated to the sponsoring company for their consideration.

Shell Software-The shell software option had to satisfy the performance specification as outlined in Fig 11. Subsequent surveys and case studies referred to in the Methodology chapter were carried out and the results revealed the strengths and weaknesses of different types of software available by comparing their performance compared to what is outlined in Fig.11. For each element required points were awarded out of a hundred, and the final output tabulated in Table 1. (please refer to paper 2 for full details)

The following discussions with the sponsoring company regarding the findings resulted in their preference to use the shell software because it was available, satisfied majority of the requirements and it was also less time consuming to adapt into to the employers' requirements and could therefore be utilised earlier. The software required little memory to store and relatively low Random Access Memory to run. The cost of running and maintaining was also considered to be less than the existing system.

The software was installed on the sponsoring company's intranet and to access it the user need to log onto the intranet system using user name and password. The location of the software is displayed on the homepage and to access it the user clicks on the logo to enter the and then follow through the different choices offered. The programme is a simple tool

that works on the principals of hyper linking logical choices that leads the user to the place the information is kept. The fact that the software will only need to be installed in one and is compatible with all computers that access is a big advantage as well as saving costs and maintenance.

Whilst the shell software provides a convenient tool, the main challenge of this research was making the information in the system visible, so the users can locate it quickly and with minimal effort or training. The old system failed because the users could not logically locate the information they sought without navigating layers of headings and pages of text before they could locate it. Consequently they often ended the process before finding the information they sought. To ensure that this does not occur with the new system, the opinion of the majority had to be considered, as to how the information should be presented. As outlined in the methodology chapter this was achieved with the help of surveys, questionnaires and one-to-one interviews followed by formal discussions. (Refer to Paper 2 for full details).

Figure 11 indicates the topics that the end user prefer to be considered when presenting information on the company's intranet. A breakdown of the performance specification and how it was achieved is further explained in Paper 1.

By ensuring that pockets of information and data in the system are carefully mapped out on the new system, and taking into account the opinion of the majority as to how system should be presented and configured, the system was structured, modified and put through pilot studies to prove its effectiveness.

Figure 11- Summary of Performance Specification

Table 1 - Shell Software Comparison

SOFTWARE	PLATFORMS	FEATURES	Percentage of Software matching job specification
ConceptDraw MINDMAP	Microsoft Windows, Mac OS X	Mind mapping and Brainstorming	25
MINDGENIUS	Microsoft Windows	For Business, Home and Education, Integrates with Microsoft Office and allows users to capture information easily.	43
MindManager	Microsoft Windows	Mind mapping, idea visualization, brainstorming Process Flow, Org Charts, Fishbone diagramming Concept maps and Flowcharts Project Management with built in Gantt Charts Built in Presentation Post it style memo notes Integrate with Microsoft Office 2007	67
MindView	Microsoft Windows, Mac OS X	Mind mapping, brain storming, project planning, timelines, gantt charts, XML-support,	34
Xmind Pro	Microsoft Windows, Mac OS X, Linux	Mind maps, spreadsheets, fishbone diagrams, tree charts, org-charts. Compatible with Mindmanager/Freemind. Presentation Audio Notes Gantt View/Task Info Embed Web Search Online Sharing Map Shot Map Merge	69
Visual Mind	Microsoft Windows	Supports collaboration (client/server) mode	38
SmartDraw	Microsoft Windows	Microsoft Word & PDF export handles basic automation	24

Buzan's iMindMap	Microsoft Windows, Mac OS X, Linux	Provides organic Mind Mapping methods to create Maps for organising, brain storming, creative thinking, project planning and management, can Integrates with Microsoft Office, Open Office and iWorks.	**63**
Mindomo	Microsoft Windows, Mac OS X	Online/Offline Flash-based mind mapping tool	**18**
Solution Language Tool	Microsoft Windows	activity maps and organic mind maps	**48**
Personal Brain	Microsoft Windows, Mac OS X, Unix	Graphically intensive and customisable GUI, extremely cross-platform, easily expandable and logical Notes, calendar, features include Microsoft Outlook	**87**
NovaMind	Microsoft Windows, Mac OS X, Linux	Mind Mapping, Presentation, Screenwriting	**18**

Provision was also made to enable the user to add information to the system by simply dragging a link from the area, where they think, new information should be added to the system and typing a brief summary of their contribution, followed by a hyperlink to the location where the new information is kept. This initially will only be visible to the small number of people supervising the system, and subject to their approval the new information will be made public on the system, i.e. available to all those able to use the system.

A summary of how the system operates is shown in Fig 12, following:
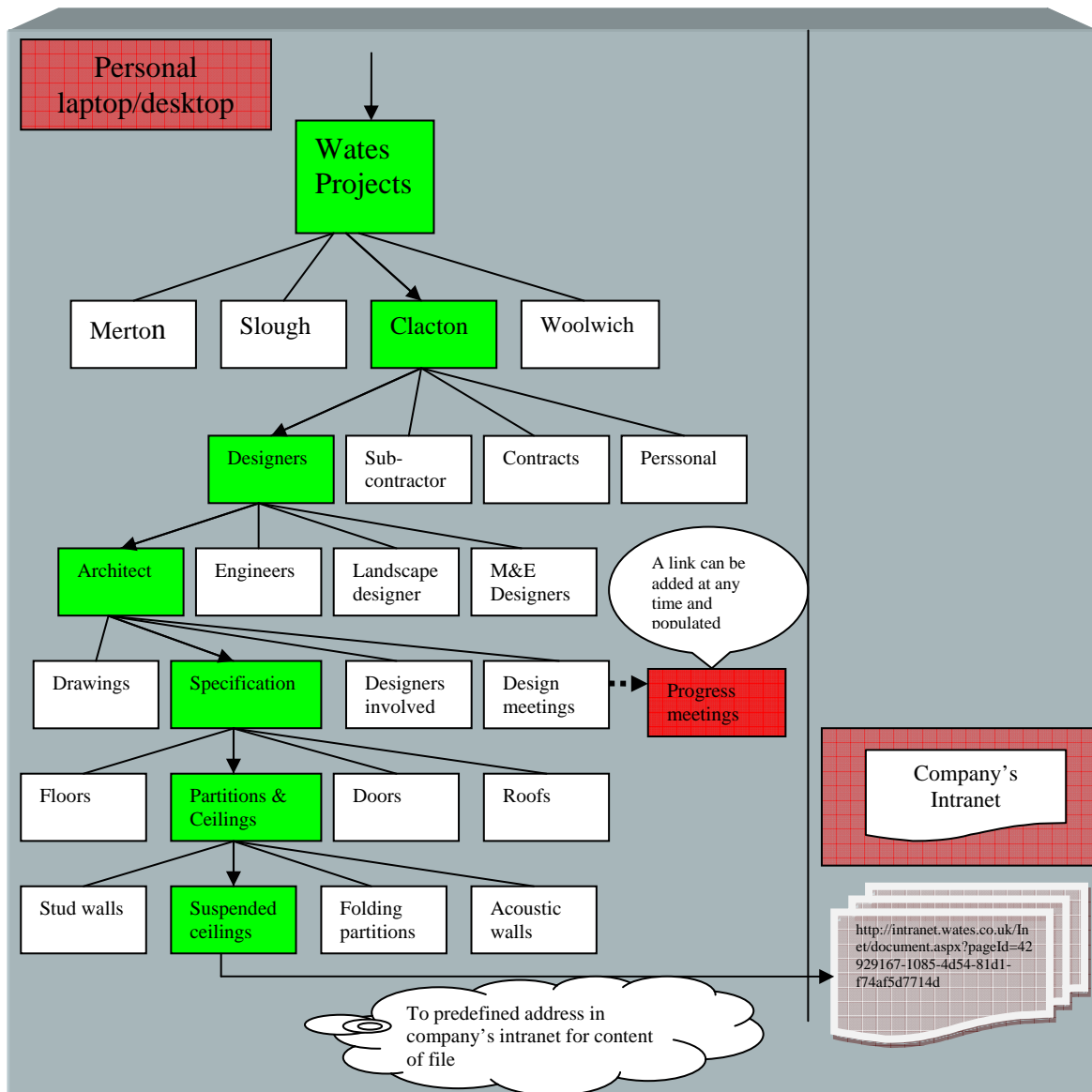
Figure 12 - Example of System Performance

The system was engaged and populated to accept the requirements of the sponsoring company within the shell software and made available to serve the sponsoring company's specific needs. The information and knowledge gained from three PFI Projects were uploaded into the system and the final product was made available in a pilot study to a selection of employees who had received no prior training in using the new system.

In the pilot study the employees were asked to try the system to find certain information. During this process, their actions were observed and recorded and the system fine-tuned to follow the predominant reasoning processes and how they expected to see the results. Further tests were carried out under different scenarios to ensure the validity of the results.

Participants were then given a set of questionnaires to complete about how the new system compared with the existing system, and results were recorded. (A copy of the questionnaire is attached in Appendix E)

The new system offers two different facilities for finding the answer to queries:

1. **Logically** - encouraging the user to think where information might be kept on the system, by clicking on a series of hyperlinks, to find the answer to a query. This also allows the user to explore other fields of information kept on the files and folders related to the subject matter. A simple effective option to upload information on to the system is available to maximise the user's contribution.

2. **Search Engine** - this facility allows the user to directly access an answer, if it is kept on the system, by typing in the area of interest. The system is alphabetically sequenced, so once the first letter has been entered all the information kept in the system starting with that letter will be displayed, and as the following letters are entered it will narrow the search to the particular subject the reader is interested in.

5.5   CONCLUSION OF THE SECOND OBJECTIVE

The results following the introduction of the new system were encouraging; a survey carried out as a part of a pilot study amongst thirty-three employees revealed that 87% preferred the new system compared to the existing system and wanted the company to adopt it, see Figure 13.

Since its introduction in the Design and Construction Teams, uptake has been encouraging and the new system has the potential to be rolled out throughout the business.
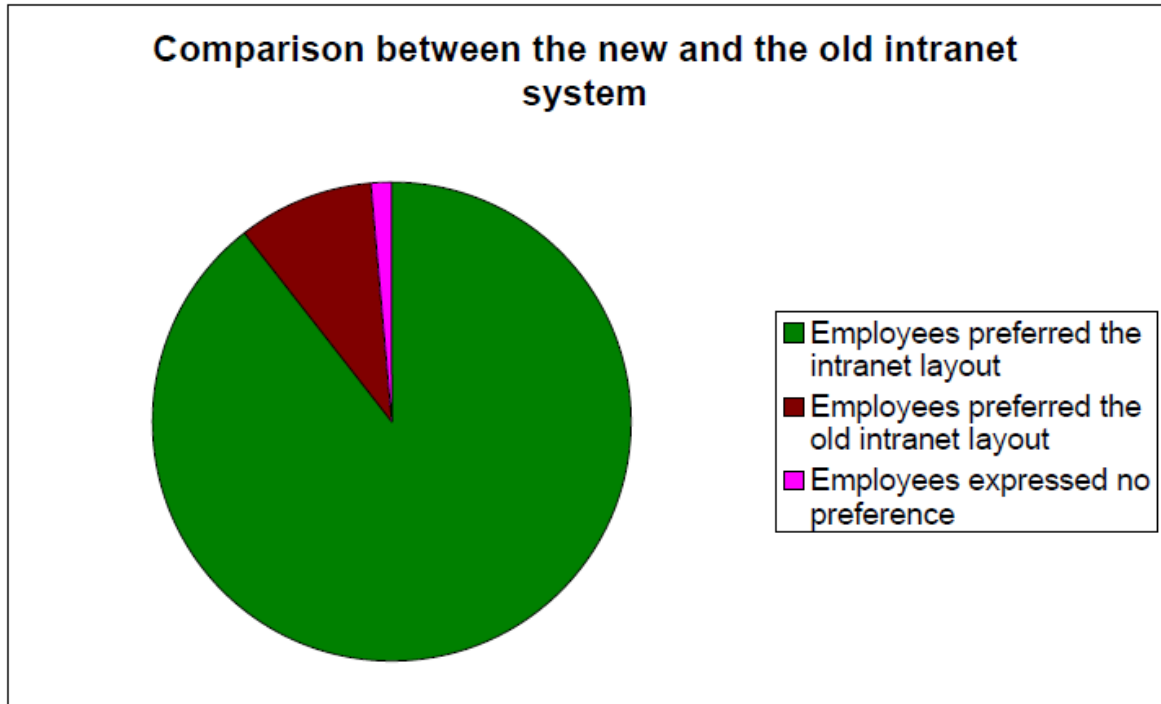
Figure 13- Result of the survey following trial test for the new system

The research findings have the potential to be considered, not only in other sectors of the Construction Industry but also in the wider market where other companies have experienced similar problems to those of sponsoring company.

A paper was produced and published from the results of this part of the research (Paper 2 in Appendix B).

CHAPTER SIX: INFORMATION AND KNOWLEDGE PRESENTATION AND RE-USE IN LIVE BUILDING PROJECTS

6.1   BACKGROUND

'Most business organisations often cite the staff as their greatest asset but have no appropriate mechanism for managing the knowledge or intellectual capital that is embodied in these staff.' (Carrillo et al. 2000)

The fact that information is available does not automatically mean it can be found, shared, or understood, so effective transfer of information and knowledge is becoming a key-challenge in today's organizations.

In the Building Industry people who create buildings usually deal with objects and shapes, so their minds are more accustomed to understanding figures and diagrams, rather than words and pages of text. Furthermore, because the building trade demands physical work from its employees, it often attracts individuals who are either unwilling to read pages of text or have limited understanding of written words. To ensure information is passed on quickly and effortlessly, it is therefore logical to present it in a visual format.

The use of visual metaphors is effective for knowledge communication. Eppler (2003) describes six advantages: (i) to motivate people, (ii) to present new perspectives, (iii) to increase retention of information, (iv) to support the learning process, (v) to focus attention and support the concentration of the viewer, and (vi) to structure and co-ordinate communication.

6.2   VISUALIZATION: A BRIEF INTRODUCTION

The transfer of knowledge, a core process in knowledge management, is difficult to manage (Probst et al, 1997). Visual metaphors can improve this process (Nonaka,1991; Eppler, 2003). The research focuses on *knowledge visualization*, which examines the use of visual representations to improve the transfer of knowledge between at least two persons (Burkhard and Meier, 2004). Knowledge visualization integrates results from information

visualization (Bertin, 1974; Card et al, 1999; Chen, 1999; Ware, 2000), cognitive art (Horn, 1998) communication science (Fiske, 1982), information architecture (Wurman, 1996) and knowledge management (Alavi and Leidner, 2001).

'Look around you - symbols are everywhere. From signs in airports to icons on computer screens - we increasingly communicate not only in words, but with images.' (Wycoff,2005)

Kosslyn (1980) and Shepard and Cooper,(1982) suggest that visual recall is better than verbal recall. Although, it is not yet clear how images are stored and recalled, it is clear that humans have a natural ability to use images. 'All writing fosters categorical thinking and analysis, because analysis is built into the very act of writing. Writing is a technology for dividing the world into categories.' (Botler, 1991:209)

Records from Egyptian times indicate that the use of figures is an effective way to transfer knowledge. The real challenge is to utilise the principals of Knowledge Visualisation to a point where information and knowledge can be transferred solely by using symbols, graphics and figures, side-stepping the use of language to convey essential information. More research in this area is needed before the potential of this objective can be realised. (See Chapter Seven)

'In knowledge development, researchers have found through empirical studies that people can more quickly integrate and act on information presented visually.' (Botler, 1991), a notion which dates back to Vygotsky in the 1920s:

> 'The independent elements in a visual field are simultaneously perceived; in this sense, visual perception is integral. Speech, on the other hand, requires sequential processing. Each element is separately labelled and then connected in a sentence structure, making speech essentially analytical.' (Vygotsky, 1930)

Visual representations are superior to verbal-sequential representations in various cognitive tasks (Larkin and Simon, 1987; Glenberg and Langston, 1992; Bauer and Johnson-Laird, 1993; Novick, 2001). Weidenmann (1989) explores aspects of illustrations in the learning process and Demain and Fruchter (2009) examine effective visualisation by Visual Storytelling for Design Re-use.

Novak and Gowin (1984) carried out research into human learning and knowledge construction, which led to their development of a graphical tool presenting knowledge in a format easily understood by others known as Concept Maps.
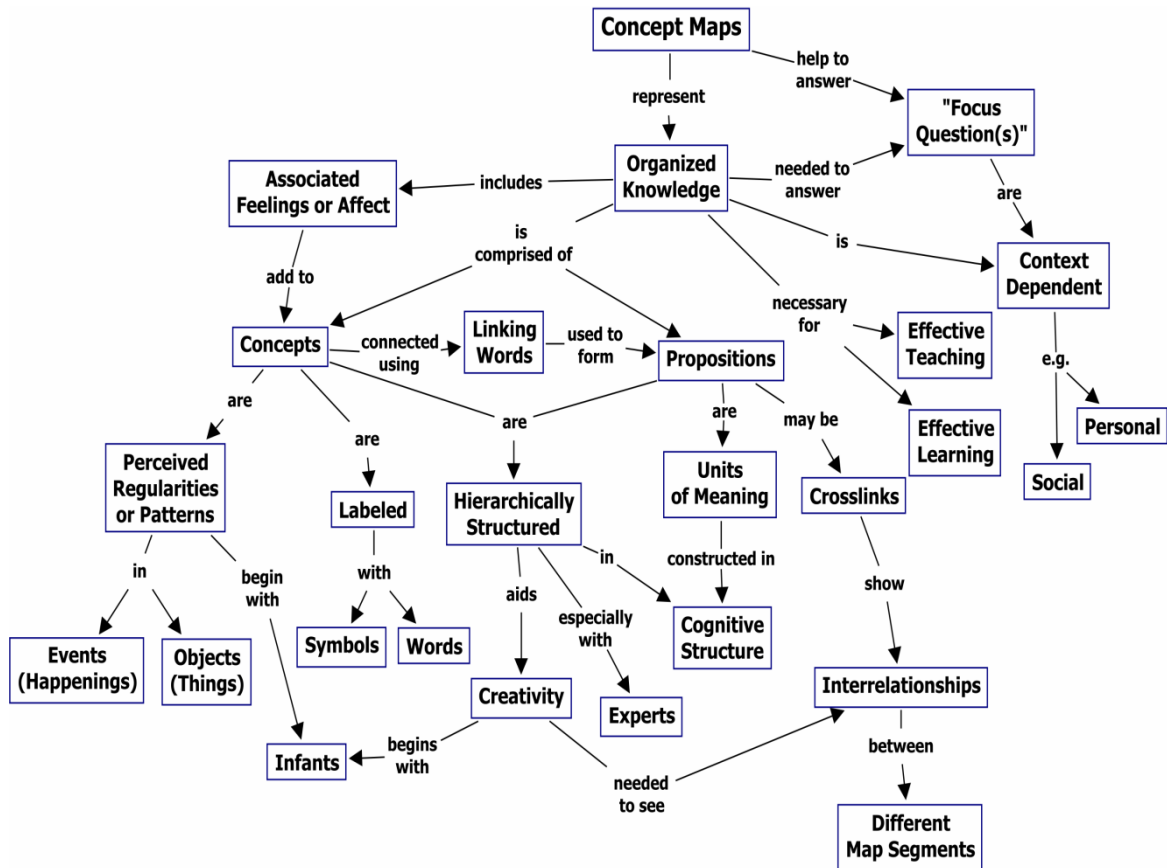

Figure 14 – A concept map about concept maps (Novak, 2003)

Studies in visual cognition lead to the conclusion that visualization dramatically increases our ability to think and communicate. (Burkhard, (2005)

Visualization is any process which, by creating images, diagrams, or animations, communicates a message or messages. Visualization through visual imagery has been an effective way to communicate ideas since the dawn of humankind; familiar examples from history including cave paintings, Egyptian hieroglyphs and Greek geometry.

Card et al (1999) define information visualization, as '*the use of computer-supported, interactive, visual representations of abstract data to amplify cognition.*' It is useful in displaying large amounts of abstract data by using simple often graphical means to enable the end-user to digest the results in a glance.

At this point, it became clear that the second part of the research had a different and opposing agenda to that of the first part. Whereas the first part had a pulling effect, dealing with people searching for information and knowledge who had difficulty finding it, in the second part of the research the information is predefined and explicit, and the problem is to ensure it is delivered to and understood by those it is aimed at, the pushing effect.

The use of visualization for information presentation is not a new phenomenon: it has been used in maps, scientific drawings, and data plots for a thousand years. The human brain has the ability to identify patterns in graphics, colours and visual images. (Tuthill, 1998)

The business community's recent interest in Knowledge Management (Becerra-Fernandez et al, 2003; Takeuchi and Monika, 2004; Tirana, 2000) has brought attention to the effective portrayal and sharing of knowledge, and awareness to the issue of knowledge visualization.

According to Pepper and Burkhart (2005), six formats can be distinguished in Knowledge Visualization: Heuristic, Sketches, Conceptual Diagrams, Visual Metaphors, Knowledge Animations, Knowledge Maps and Domain Structures. This was highlighted by the surveys carried during the course of the first objective process. Table 3 summarises the problem. (The full text related to this problem can be found in Paper 2 in Appendix B).

Another factor with a significant impact on the choice of information presentation is the ability to pass on safety messages and method statements to employees who may not have much understanding of the common language. The findings of a survey carried out on a live project are summarised in Table 3. (For further detail refer to Paper 3)
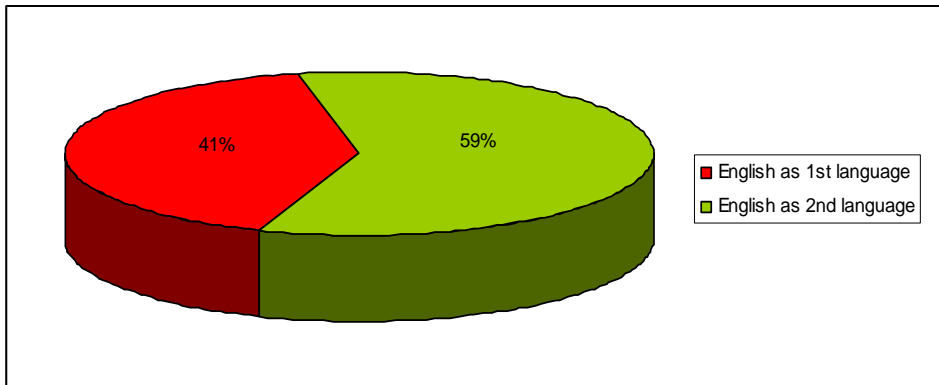
Figure 15- Employees language background- survey taken on a live project
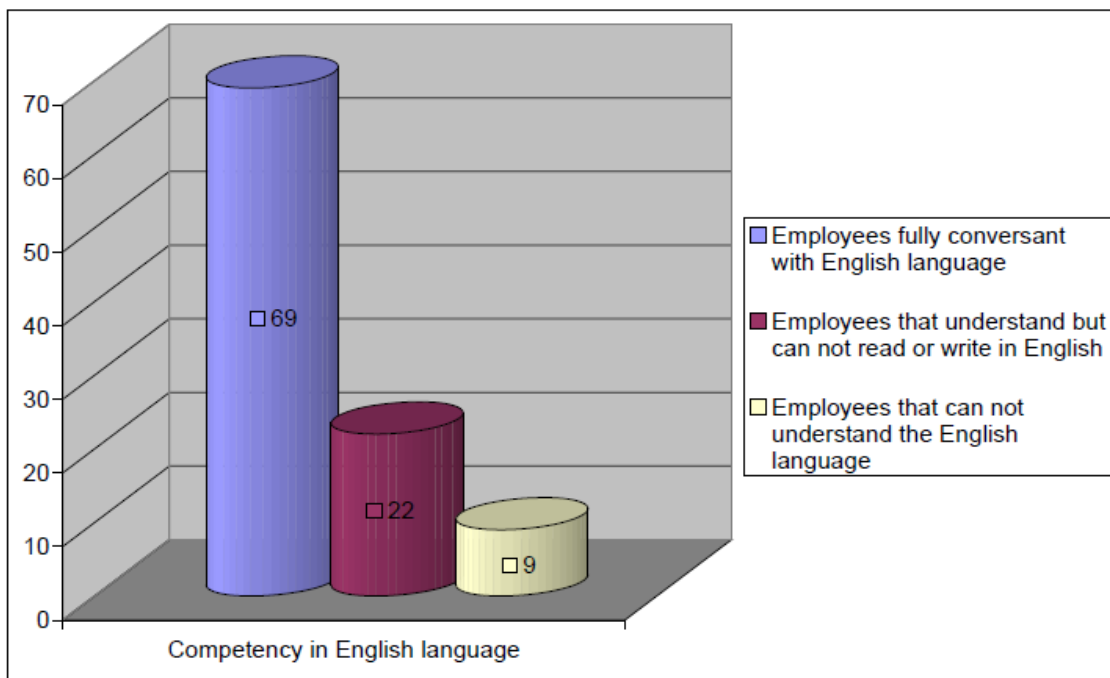
Figure 16- Percentage of employees with language difficulties

6.3   SAFETY BY VISUAL THINKING

A process was developed from the principles of visual thinking and visual knowledge transfer for the sponsoring company's safety department, using graphics to provide safety induction and risk assessment, for Group 2, i.e. those employees in need of LLIKP(Low Level Information and Knowledge Presentation).

 The process - which presents the users with graphical information relaying safety messages, to ensure the use of appropriate tools and information to carry out their job safely and efficiently - is effective regardless of language ability and educational background.

From the methodology it became clear that the following tasks had to be carried out to ensure a viable outcome:

1. Qualify the extent of the problem
2. Develop an understanding of the issues with people concerned
3. Devise a tool and a process and evaluate the results
4. Explore the potential fields for information and knowledge transfer by graphical and visual means
5. Evaluate the advantages and disadvantages of using such a system

Papers 3 and 4 explain how the above tasks were carried out methodically and with help of surveys, questionnaires and one-to-one interviews, as outlined in the methodology chapter, to ensure a viable outcome. Following is a summary of the process undertaken and the final outcome.

6.3.1   Low Level Information and Knowledge Presentation (LLIKP) for Group 2

Access to the sponsoring company's construction sites is a single point of entry where all work personnel must register and undergo a safety induction prior to entering the site, before subsequently being issued with a swipe card. Personnel must also attend safety workshops and safety meetings. The primary objective of the new process is to target

people who may have difficulty in reading and writing English, either because of their educational background or command of English language.

The process starts by establishing new employees' level of understanding; if they prefer to use the graphical presentation, depending on numbers each user is given access to a computer to complete the required safety program. The program begins by displaying the site location, and then displays site rules in graphical form i.e. locations for smoking, eating, washing, bins etc. The computer then displays all available trades and the user chooses the trade which best describes his/her role. Depending on which trade the user chooses, the computer displays a series of hazards and potential dangers relating to that trade, and the user then needs to determine if it applies to him/her. Depending on the answer, the program decides if further questions need to be asked before proceeding to the next level. The system also has a generic set of question dealing with areas users thinks may be hazardous in the kind of work they undertake, and their opinion of how it can be improved. All replies to questions are recorded for analysis by the system. The system then prints out a list of safety items each employee should carry and safety processes that should be observed and carried out whilst working on the site. It also prints out the map of the building and locates the employee's designated work area.

Following is a screen shot of the software used on the system. This particular page identifies if there is a danger of electrocution and the kind of personal protection equipment that should be provided. The user will tick the boxes that apply and the system will check to ensure that the options identified conforms to what is given in the database. Depending on the answers given the system will inform the user if he/she has the correct protection listed, and if not, at the end of the test the computer will print out a list of protective items to be used and measures that the user should take to ensure he/she can carry out their duties safely. A copy of the result will be given to the supervisor responsible for that part of the works by email.
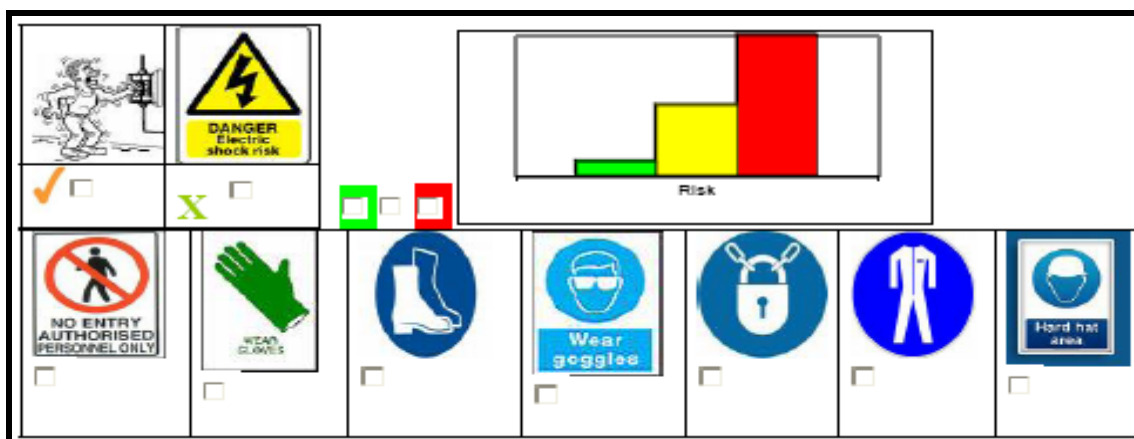
Figure 18- Screenshot of the safety questionnaire

The new process can be in paper format for sites not yet connected to electric and electronic communication.

The data gathered from individual sites will be held in the data base for future analyses. The information gathered will highlight operations with associated risk elements. It can also be used to understand which work elements have caused accidents and what part of the design could be improved to avoid the associated risks.

This method not only ensures that everyone, regardless of their level of language and education, understands the safety messages but also covers the employer in ensuring that the safety messages reach employees without having to translate them into twenty-one languages, as requested by UCATT. It has the added benefit of knowing the risks to workers involved with each operation.

This simple, effective and logical system is being used on selective London projects and will eventually be rolled out to all regions.

6.4   Organisational breakdown

Other visual elements were introduced to the sponsoring company to ease information flow. For example the following chart - made, using the "tube mapping" concept, to map out the management structure - shows the breakdown of the sponsoring company's organisational structure, and brings together almost all the operations and procedures the

sponsoring company has placed on a page which can be understood at a glance. This map is now rolled out to all the sites and displayed on their notice boards.
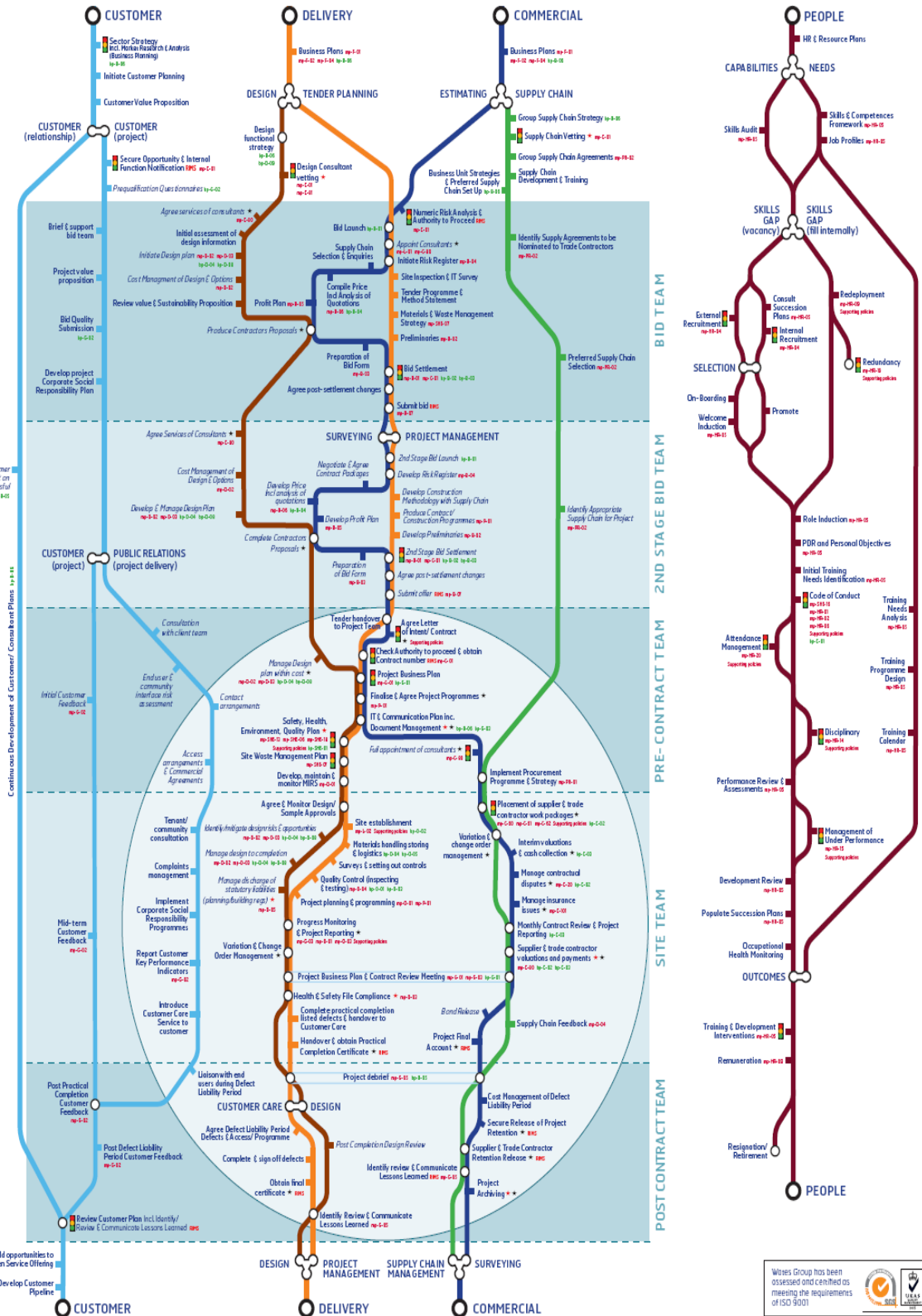
Figure 19 - Organisational breakdown using "Tube Mapping" concept

An effort has been made as part of this research to formulate concepts for a user-friendly building site of the future. One of these, initiated by this research and undergoing a trial

period, is the use of colour coding to ensure employees and visitors can find their way around the building site. This is done by using different colours to identify different routes through the building. It consists of mapping out the location of work areas on a day-to-day basis to avoid workers getting lost and possibly wandering into potentially dangerous operational environments. The labour force receive their job brief and safety updates either in paper format or ideally via PDAs at the reception or security access point to the construction site, and are then directed to their place of work by following the allocation of colours displayed at strategic points throughout the building, all from a single point of entry to the site. The colours can be changed using computers and multicolour lighting at key points in the building at the start of each working day/week. The full working of this method has not yet been published.

6.5   CONCLUSION OF OBJECTIVE THREE

Times are changing, laws and regulations are becoming stricter, more complicated and less precise, even as building works are becoming more sophisticated and specialised, with increasingly demanding clients and shorter construction periods to complete projects. The need for new methods of information and knowledge transfer is therefore becoming essential to the success and safety of employer and employees alike.

New ways of communication can enhance performance and profitability, and in certain circumstances could help save lives. It is unreasonable to expect that inductions, risk assessments or even safety messages should be translated into twenty-one languages to be universally understood. It is therefore appropriate that academia and industry should join forces to embrace new ideas and dictate change to ensure that safety and performance are not compromised.

CHAPTER SEVEN: FINDINGS AND IMPLICATIONS

7.1 INTRODUCTION

This chapter presents the key research activities and findings, expanding on the earlier chapters. The industrial sponsor's principal reason for supporting this research was to enable the researcher to discover a way to utilise more efficiently data, information and knowledge acquired by the company in over a century of practice. It was also hoped to find a way to provide staff with a logical useable format for accessing the latest techniques, regulations and practices stored in the company's database, and to ensure optimum support is provided to achieve the best solution to employees' queries.

There follows a summary of the research activities:

➢ **Evaluation** was carried out of the existing information and knowledge base system, its strengths and weaknesses, the users' views and perceptions about how a good system should perform. (Chapter 4)

➢ **Interaction** identified the users' needs and wants, by monitoring their activities on the system to find common themes and patterns in information retrieval processes. (Chapter 4)

➢ **Exploration** was undertaken to find a new system offering simpler, more effective knowledge presentation, transfer and re-use. (Chapter 5)

➢ **Data transfer** took place from the old to the new system, ensuring its storage in a structured logical way for future use. (Chapter 5)

➢ **Implementation** of the new system was initially done with pilot studies followed by a retune then full deployment. (Chapter 5)

➢ **Feedback and Fine-tuning** was undertaken to ensure the smooth operation of the system.

> ➢ **Development of a new tool** took place to ease the transfer of information and knowledge to those users in the company who are either not keen to read pages of text or have difficulties reading/understanding English. As the direct result, new processes have been created for conveying safety messages to employees without using the written word. (Chapter 6)

The system and processes created in this research have the common theme of utilising the principles of visualisation to encourage users to locate and extract the information they seek. They also rely on the user's ability to use logic and commonsense. They consist of both outstanding words and sentences, in conjunction with the use of graphics and images. The emphasis has been not to rely on the user's educational background and/or command of English, which has particular relevance because the UK construction workforce has evolved to comprise mixed groups of people from varied backgrounds, and because the sponsoring company is preparing to expand their activity into the Middle East market, where reliance on language should be minimised, in the international community in that part of the world.

The first process, aimed at Group 1 (HLIKP), is concerned with the simplification of information and knowledge retrieval from the company's intranet system by using key words and phrases. This process encourages the user to sift through different links and locate where information is kept, by displaying a series of logical options with outstanding words and phrases to choose from, so that by electing the desired route the final outcome is a hyperlink to the location in the database where the information is kept.

The second process, aimed at Group 2 (LLIKP), uses images and graphics to relay safety messages, by displaying icons, visual images of materials, equipment and key words to encourage the user to think about the processes they are expected to undertake, and the tools they need to carry them out safely and efficiently. It also gathers valuable information on the workers' views of safety and performance, and stores useful information on "lessons learned" for future work.

The processes outlined in this research simplify access to information pockets in the system by relying on the users rather than on technology to sift through information

pockets to locate it, and minimises the jargon associated with long sentences by using graphics and outstanding words.

7.2   CONCLUSION OF THE FIRST OBJECTIVE "HLIKP"

The fact that the sponsoring company initiated this research indicates recognition of the inadequacy of the existing system of information and knowledge management. The reasons for this became more apparent as the survey and interview findings were analysed. Those responsible for the system's upkeep had a systemic overview of how information is presented and used, but had been concerned only with information upload and not whether the user was able to locate it.

 This research also concluded that as far as possible, for Group 1, restrictions to adding information to the system should be avoided since people's expectations are varied. The intention was also to devise a system to capture knowledge as it develops, making it available in a way that can be easily located and used with minimal effort.

The decision was taken that in the case of "HLIKP" the information can be added by anyone at any time, but that security should be set initially on all new uploads to "private", only accessible to those the uploading user considers would immediately benefit from it. It was then decided that at set intervals those responsible for the upkeep of the system would periodically review all new information, to decide whether it should become public i.e. "every user of the system has access to it".

7.3   PROTOTYPE SOFTWARE CONCLUSION

The overarching aim of this research was to provide the tools necessary to improve the accessibility of information and knowledge to all company employees, regardless of background and command of English. Addressing these issues ultimately saves the company time and money, making resources more efficient by ensuring that their employees can access information without struggling with the technology providing it.

This part of the research concluded that the following can help in devising a better system:

- The use of visual graphics rather than pages of text
- The use of the principles of concept mapping to ease knowledge transfer
- Object-orientated presentation
- The use of outstanding words and key phrases
- Procedures which are easy to understand and follow
- Simple procedures for adding and revising information on the system.

The research examined the software by comparing them together and against performance specification to ensure that the chosen software addresses the majority of the issues.

The selection of the new software only formed the initial part of this work. The main challenge for this part of the research was to ensure that logical links are provided for users to sift through information pockets to obtain the answer to their queries with minimal effort. This was achieved through interviews, workshops, one-to-one meetings and questionnaires. The views of the workforce played an important part in achieving this objective, and the system is structured to suit the majority's views.

The outcome has been encouraging, so much so that the sponsoring company is in the process of performing further tests before the new software replaces the existing system regionally. (The full background and results can be found in Chapter Five, and Paper 2 in Appendix B.)

7.5   CONCLUSION OF THE THIRD OBJECTIVE

Capturing and sharing knowledge to enable the right information to reach the right people when they need it and in its simplest format has many compelling benefits. In the construction industry information and knowledge is normally provided primarily for the indigenous workers. It is typically composed by managers and gurus in the field, who must provide information to employees which include legalistic jargon to cover the company legally, so often the information is presented as pages of text too cumbersome for most recipients to read and understand.

Visual techniques offer a possible solution by encouraging both indigenous and foreign workers to at the very least absorb the safety messages intended for them, thereby ensuring a safer environment for all employees. (See Chapter Six and Papers 3 and 4 in Appendixes C and D.)

7.6   IMPACT ON THE SPONSORING COMPANY

Using the principles of visualisation concepts in the research has contributed in two distinct areas in the sponsoring company:

- The simplification of access to information and knowledge kept in the company's data base by using key words and graphical means, with an emphasis on minimal training and maximum understanding of the sponsoring company's information system.

- The creation of simple graphical tools to communicate and convey information to employees with little English and/or employees who either may not wish, or may not be capable of, reading pages of text.

The new system, used correctly, is capable of replacing the need for using the extranet and other external collaboration systems. The principal use of such systems, apart from acting as an external repository for the distribution of information, is that they are query-based and can therefore direct users to where the information is kept by offering simple top-down choices, and/or by offering a search engine which takes the user directly to the information they seek.

 The advantages are:

1. A repository facility is offered which can be accessed at any time, anywhere
2. A simple top-down query-based system which can direct the user to where the information is kept in the system
3. It provides tools and interfaces to access different software in a structured environment
4. It offers a search engine to access the repository by using outstanding words or numbers e.g. drawing a title or number.

The disadvantages are:

1. The cost of hire;

2. Security issues for using a "third party" system;

3. Training staff to use the system, and because different systems offer different functions, every time a different system is used staff need to be trained

4. Some sub-contractors, particularly in the building industry, lack the capability or resources to use an extranet system, so traditional ways of transferring information must still be available.

However, the system developed for the sponsoring company is capable of offering the benefits of collaboration systems without the additional expense. The benefits of this system, compared to collaborative systems, are as follows:

1. The cost of storing information is negligible since it already exists in electronic format in the users' and their partners' systems

2. Security issues should have already been addressed for their intranet system, and the cost of making it available to others outside the company is minimal

3. Little training is needed since the system relies on simplicity, use of logic and graphical presentation, which are more conducive to the human mind

4. Saving time by no longer uploading information since it already exists in the system

5. The information kept in the system will always be available there for future queries and references.

Put simply, any information kept on the computer has an address and as long as that address is known the information can be accessed (subject to the appropriate security setting). The critical factor is to create a route the user can logically follow. For example, if a new or revised drawing is produced by an architect, it will be uploaded to the desired location on his company's server, and as long as the address to the architect folder is mapped out on the new system, it can be accessed as soon as the drawing is uploaded, subject to the security settings of the architect practice's server.

7.7   CRITICAL EVALUATION OF THE RESEARCH

There are many examples of good ideas and inventions which have failed to materialise. Generally, the reason for failure is associated with people or technology and/or timing. Technology and timing are the two factors which are to some extent known quantities which can be controlled. On the other hand, predicting how people will react to new ideas can be a risky business.

During this research the development of a good working relationship with the sponsors has been crucial in ensuring that each and every step meets their expectations and garners their support.

The overarching aim of the EngD Programme is to make a visible difference in both the wider industry and the sponsoring company, while also contributing innovatively to the knowledge domain. It can be argued that the construction industry is relatively conservative, and that the background of its employees makes it resistant to change and disruption.

Often when introducing the research to potential contributors, a popular question was, 'What is Knowledge Management?' Even practitioners in the field of Knowledge Management have difficulty answering this simple, reasonable question.

Encouragingly, however, given the nature of the research, the integration of visual images and graphics in the solution to the often baffling task of reading many pages of text, proved popular with the participants and the feedback was in most instances immediate and positive.

It should also be noted that this research has been conducted with the sponsoring company and its partners, whose responses may not be representative of all construction companies, which may limit the applicability of the findings. Other factors which may influence its uptake by others could be IT infrastructure, buy-in by top management and the deployment of existing processes. Nevertheless the fact that its success in the sponsoring company has been immediate and positive, and that the principles of the solution in this research are

based on human cognition, may indicate that the concepts are sound and should be considered by others both in this field and in other industries.

7.8   IMPACT ON THE CONSTRUCTION INDUSTRY

It should be noted that this project has focused on delivering a solution for the specific needs of the sponsoring company, but its findings can and should be used to assist others facing similar problems. There are two main areas this research has an impact on, and implications for the construction industry and other industries:

1   **Simplification** – the construction industry, perhaps more than any other, requires simplification of information retrieval because of the vast amount of information and knowledge requirements of a typical construction project. The industry has to deal with new technological advances on many fronts, from new building materials to new working methods, constantly changing rules and regulations and political issues such as open European Union borders and free movement of labour, minimum wage and retirement age legislation, dealing with periods of high and low demand, and boom and bust culture . The ease with which it can adapt to these changes may be crucial to success or failure. The challenge for the industry is to ensure that the people involved in the process are informed and evolving. The aim is to ensure they are willing to embrace new information which is easy to access and logical to follow, and also encourage the user to contribute and expand the knowledge base by using this simplified process.

2   **Integration** - the current structure of construction industry organisations has inherent barriers to sharing knowledge and information because of worries about competition and rivalry, which has resulted in an aversion to the technology, knowledge sharing and progress. The continuation of fictionalisation and "over the wall mentality" mean these inefficiencies are likely to persist.

7.9   FUTURE WORK

Two main areas could benefit enormously from further research in the topics explored in this thesis:

7.9.1   Monitoring and evaluation of activities in the new system

Initially it was envisaged that monitoring and evaluation of activities in the system would form part of the research. Analysis of the activities of those using the new system would enable better understanding of how, why, when and where employees obtain the information they seek, so that the company can make the popular queries on specific items on the system better laid out and more readily available. It would also provide an insight into how people behave in the working environment and their ability to resolve issues about which information would meet their needs.

This part of the research met with considerable distrust and resentment. It became apparent that employees regard their time on the computer as a private commodity regardless of where they use it, even though it is in the company's time and with the company's computer.

In time, there was a clear indication that this part of the research would not be as productive as was initially envisaged. Both employees and employer were uncomfortable with having a computer program which collates data from their movements on-line. Although they were reassured that the system would only collate information from the computer's daily activity and not the people operating it, there were nevertheless concerns that it would be possible to extract personal information from the system which would benefit the company. This part of the research has therefore been shelved for the foreseeable future.

This was a radical change to the initial concept, and it took time, and somewhat slowed the process, to find alternative domains that would both be useful to the sponsoring company and have academic and wider market value, while also complimenting the first stage of this research. Following the findings outlined in Chapter Four other key areas for research were identified which not only complimented the first part of this research but also had significant importance for the sponsoring company. (See Chapter Six.)

The intention behind the secondary system was that once the system described in Chapter Four becomes operational and extensively used by the employees for their IT needs, it would then be possible to monitor users' activities by recording how often they use certain

addresses, and by knowing what those addresses are, the computer with the help of new software will identify, record and display the sites previously accessed. By analysing the most visited sites, the company can gain an understanding of their employees' needs and weaknesses, thereby providing the resources their employees need rather than those their managers think they need.

Most explicit data, information and knowledge are kept in any computerised database and the web has an address, so as long as these addresses are recorded and mapped out, monitoring the addresses visited by users can analyse the data and draw conclusions from it.

An initial survey revealed an increasing amount of resistance to the principles of recording participants' activities. Even the selected group which agreed to take part in the pilot study were reserved about how they used the system, even though it was made clear to them that the system was not designed to distinguish between users, only recording the number of hits to any particular address.

Eventually it transpired that this part of the research, as originally envisaged, was unpopular with users, and the employer - concerned about possible legal issues with privacy laws etc., - advised that it should be shelved for the time being.

7.9   PUBLICATIONS

Three conference papers and two journal papers were produced during this research. Two papers reflect the findings in Objectives One and Two respectively, and the other papers reflect the findings in Objective Three. The papers broadly covered the efficiency of the use of visual presentation methods and managing knowledge.

7.10   FINAL CONCLUSION

Technological advances are moving forward at such a pace that we often lose sight of what brought us here in the first place. It is often assumed that unless a process is complicated and sometimes difficult to comprehend, it offers nothing of great value. As humans we

have always strived to put our efforts to better use, and simplify our tasks, but it seems on occasions the temptation to provide more can result in fewer uptakes.

A company's ability to share with its employees information and knowledge accumulated over many years' experience is of great advantage to its progress. "Reinventing the wheel" is unnecessary and costly, so lessons learned in earlier projects can significantly enhance the profitability of new projects.

This research was initiated by the sponsoring company because they realised they were not getting the best out of their information provider system. During the course of the research the problems were identified which face a typical medium to large construction company in their presentation of information, and technology used in knowledge management and retrieval was examined, by conducting case studies and surveys to establish the facts, before introducing and deploying solutions to address and overcome these problems. The research has also made recommendations for further research in the subject matter. This research, and the supporting documents in the appendices, provides essential evidence of these achievements. The aims and objectives have been met and the sponsoring company has introduced the new system and processes in the workplace. The overwhelming majority of employees who have used the new system and processes are delighted with what they can now achieve.

This research has also highlighted other areas to explore and suggested ways to achieve it. There follows a summary of the research activity and its outputs:

1 Evaluation of the current practices in information and knowledge management in the sponsoring company

2 Identification of the employees' wants and company's needs

3 Examination of the current technology within the specified framework and identification of a new system which is capable of directing the users to their information needs

4 Devising of a process to address the shortfall in communication of safety messages for the workforce

5 Establishing of frameworks for managing, monitoring and updating information in the company's intranet system.

There are two main research outputs from this study:

1 Research and development of a new system which presents information and knowledge in a logical and usable manner

2 Devising a process using graphical and visual imagery to relay safety messages to employees who were not catered for in the old system, and gathering information on how to make building sites safer by designing out accident-prone activities.

The main research output was the development a shell software and its adaptation to the company's specific needs. The success of the process is dependent on four critical factors: management support, user acceptance, IT support and scope for integration within the company and its partners.

The evidence following the pilot study revealed a willingness and desire for change, and that if the change is to improve old practices and the need is clearly communicated to the users, its chances of succeeding are exponentially increased.

The outcome of the research has convinced participants that extracting information and knowledge, through logic and simplicity of presentation, can be markedly easier. This has overcome the resistance to change and at the same time has encouraged willingness to contribute.

The sponsoring company has been extremely supportive and is delighted with the outcome, expressing their gratitude to the university and their willingness to support more researches to explore other problems they would like to resolve. (See letter on P.193).

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Appendix A

Paper 1

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"ARE WE GETTING THE BEST OUT OF OUR INTRANET SYSTEM ?"
A PRACTICAL CASE STUDY

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ABSTRACT

The construction industry as other industries is exposed to considerable advancement in information technology. Construction companies are no longer judged exclusively by the level of their past performance but also how they can sell their expertise and services by employing the latest technology. Investment in new hardware and software technologies is necessary to gain a competitive edge but this investment needs to be justified particularly by demonstrating that companies are actually benefiting from the investment It is also vitally important that the knowledge gained on construction projects is captured and shared for continuous improvement to avoid 're-inventing the wheel' and to prevent repetition of previous mistakes. This is particularly useful for construction companies that undertake PFI (Private Finance Initiative) projects where they are responsible for maintenance of the building for a long period of time. By using a practical case study, this paper examines how one of the largest privately owned European companies provides information & knowledge to their employees, what their employees feel about the system and if the company is getting maximum return for their investment.

KEY WORDS: Case study, Information Technology, Information Management
Intranet Systems

INTRODUCTION

The information and knowledge provided by the sponsoring company and other external sources through their Intranet system are often lost in pages of text, and is difficult to access in a user friendly and rational manner. The user normally requires training and long periods of time to search through the database to find any relevant information that could be of use. Often due to the volume of work that the staff has to deal with and because of the time it takes to retrieve the information they need from the system they simply give up. At best this may lead to making unqualified decisions that may not provide the best solution and at worst may lead to making entirely the wrong decision potentially costing the company a great deal of time and money to rectify.

Within the research work presented in this paper, the author has conducted a number of interviews focussing on the use of IT within the sponsoring company. The literature survey (see section 5- Literature Review) And the authors' extensive experience in the construction industry suggest that it is unusual to come across any contractor that can present knowledge gained from previous contracts and useful information in a comprehensible, structured and user friendly manner not only as a record that can be accessed in future but also as a bench mark to be used in forthcoming projects.

Despite 21st century technology, a great deal of time is wasted trying to find information, because of the various systems and techniques. The user has to be highly trained and/or spend a lot of time to stand any chance of finding the expected results. Jim Carty (2005) observes "A major overlooked cause of many IT project issues is that the technology tool set is not the correct one for that particular project. However, many IT professionals valiantly try to make it work since management likes the economics of using what you already have. Yet, ultimate success often depends on knowing when it's time to stop and re-evaluate the technology direction before its too late."

This paper continues on section 2 by stating its aims and objectives, it will then briefly explains the methodology in section 3 followed by presenting a case for the need for improvement in section 4 and literature review in section 5. It then proceed to present the Practical case study that will review the outcome of a survey carried out within the sponsoring company , the result presented in pie chart format in the appendix and short

summary of the conclusion of the survey in section 6. Finally it will conclude by a summary of the findings in section 6 ,future work in section 7 and recommendation to the industry in section 8.

RESEARCH AIMS AND OBJECTIVES

At the time of carrying out this research Wates Construction (sponsoring company) were looking to explore the effectiveness of their information systems with the following fields of study:

- How often the information provided in their intranet is being used

- How effective it is in providing information needed by the users

- What are the strengths and weakness of the existing system

- What is the success rate in finding the information that the users need

- Which company employees are more likely to use the system

- How likely is it that the users find what they looking for on the system

- Is there a need to improve their system

- Can they develop or deploy a better system that would serve their needs better.

Taking into account all of the above, the justification for this research is the need to:

- Provide an up-to-date survey of effectiveness in dissemination of information within the company and their partners

- Give a qualified view of the effectiveness of the existing systems

- Advise in improvement of the existing system including costs and predicted benefits

METHODOLOGY

In the first few months of the study, the research engineer undertook a period of investigation, participation and learning in how the existing system of information retrieval, management and presentation is carried out within the company and its partners. This was achieved by:

- Adjusting into the new role as a researcher

- Learning about the company's IT system and how it is maintained and updated

- Gaining an insight into how various information is uploaded into the system

- Understanding how company employees and their partners access the system and find the information they are looking for

- Building relationships with key personnel, particularly those who expressed their interest in the research subject.

- Informing key users of the IT systems of the researcher's activities and asking for their active participation in the project

- Developing an understanding of who decides what information is archived and made available to the users and why.

THE NEED FOR IMPROVEMENT

The government, as the largest client of the construction industry, has led the drive to change. Its Construction Task Force challenged the industry to commit itself to change. Their report commonly referred to as the 'Egan Report', set clear targets for improvements. Egan (1998) states: 'The industry must replace competitive tendering with long term relationships based on clear measurement performance in quality and efficiency...Construction companies must prepare comparative performance data and share it with clients and each other without compromising legitimate needs for confidentiality'.

There are also calls from the academic profession for change, Anumba et al. (2000) found that: 'Competitive pressures from within the industry as well as external political, economic and other considerations are now forcing the industry to re-examine and improve its modus operandi'.

LITERATURE REVIEW

Carty, J.,(2005) emphasises that: 'if you find your staff is short on the skills needed to meet the schedule in a timely and cost-effective way, it is possible that the wrong technology may have chosen vis-à-vis the resources'. He also observes 'One benchmark of the right technology is that you don't feel like the technology is a daily struggle and you have time to focus on critical success factors like maintaining your business partners active support and participation'. He goes on to say that it is enough of a struggle just staying on top of ever changing user requirements, scope, and maintaining organisational buy-in from the

sponsors and that the last thing you have time for is a struggle with the very tools you're using to implement the system.'

Karl-Erik, S., (1996) identified two 'tracks' of knowledge management:

Management of Information –'Knowledge = Objects that can be identified and handled in information systems.'

Management of People – 'complex set of dynamic skills, know-how, etc., that is constantly changing.' Hemamalini, S., (2002) in her paper proposes that the organisations who are driven by knowledge are the ones that will succeed. She emphasises the fact that the Combination of global reach and speed compels organisations to ask themselves, "What Do we know, who knows it, what do we not know that we should know?" Dougherty, V., (1999) confirms that knowledge transfer is about connection not collection, and that connection ultimately depends on choice made by individuals.

CASE STUDY

In this case study the emphases are on strengths and weaknesses of the existing information retrieval system. The major source for retrieving information is the company's Intranet. The information and knowledge provided by the company and other external sources are often buried in pages of text, and seldom can be accessed in a rational and user friendly manner, the user normally requires training and long periods of time to search through the database to find any relevant information that could be of use.

Following an in-depth study of the current Intranet system as the point of access for provision of knowledge and information in the sponsoring company the following findings were observed:

- There seems to be no logic in where in the intranet the user should be looking for the information they require.

- The format is not user friendly and information is more likely to be achieved by luck rather than judgement.

- Although there is a vast amount of information and knowledge stored in company's servers often the result that the search engine provides is not what the user may expect.

- The sub-sections in different folders provided within the Intranet system often don't seem to present the user with clear and concise heading. Consequently the user need to almost open every folder to find the subject matter that they maybe interested in.
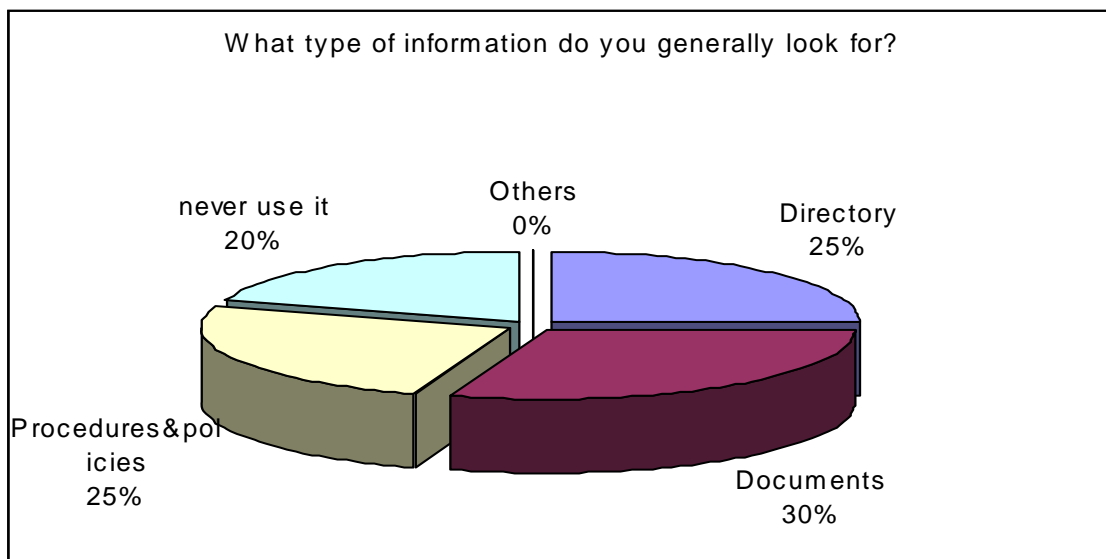
A survey was carried out to test the suitability of the existing system and how and why certain information is accessed within Wates Company and its partner's Intranet systems. The survey included questionnaires on the company's Intranet, the internet and the collaboration systems. A total of 36 people from different disciplines took part. The results of the survey are presented in pie chart format .The outcome is as follows:
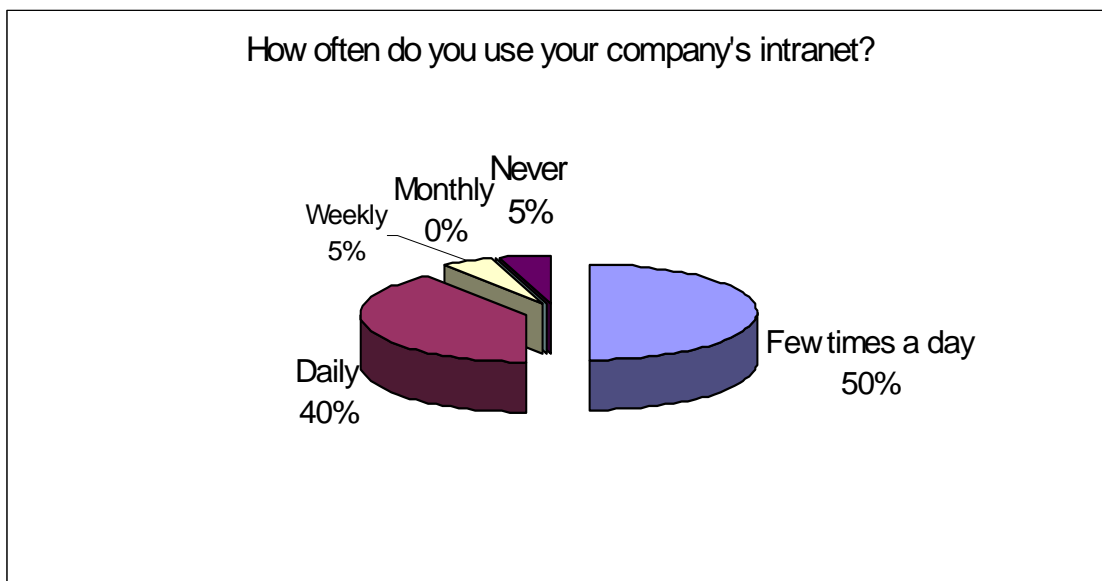
Fig.1- Over 95% of employees seem to be using the company's Intranet system on a daily bases mainly to retrieve their emails, although about 5% of management have never used the system. A further study through one-to-one interviews was carried out with the individuals not using the system, and the results analysed and conclusion drawn in the summary section of this paper.

Generally how quickly can you find information you are looking for?

often give up
8%

less than
couple of min.
28%

long time
38%

More than
couple of min.
26%
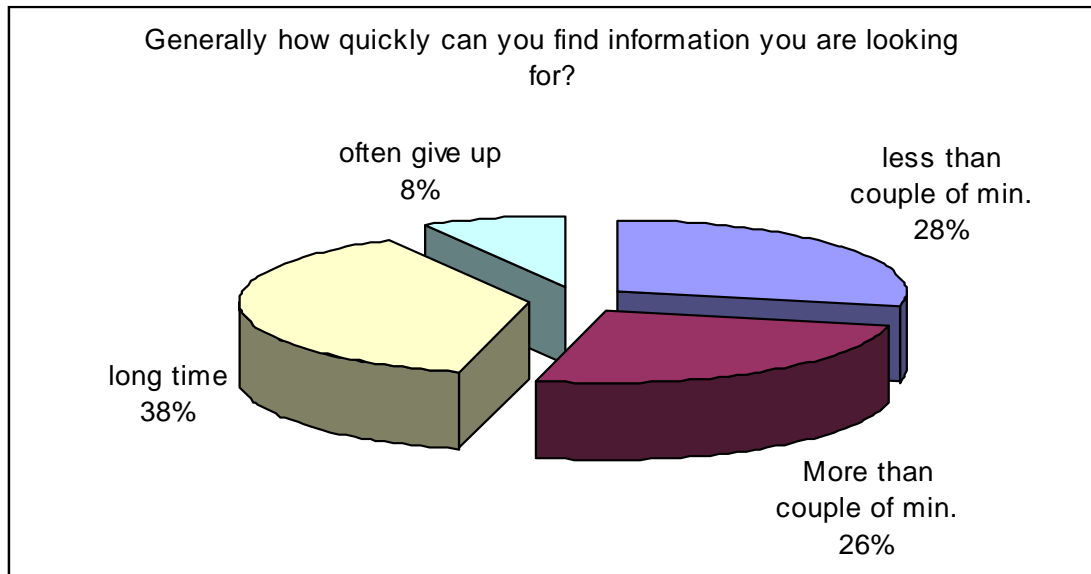
Fig.2 -The pie chart indicates the excessive amount of time taken to look for information, this seems to discourage the users in making use of the system to the extent that 8% give up trying.

What type of information do you generally look for?

never use it
20%

Others
0%

Directory
25%

Procedures&pol
icies
25%

Documents
30%

Fig.3 -It is interesting to find that 20% of users who are part of the management team do not use their company's Intranet to retrieve information and seem to rely on other sources in finding the information they seek. This was analysed further through one-to-one interviews to establish their reasons and conclusion listed in the summary.

Is there any information you like to see included in your intranet?

don't use it
10%

Too many to list
18%

No its OK
24%

Yes I like to see
more…..
48%
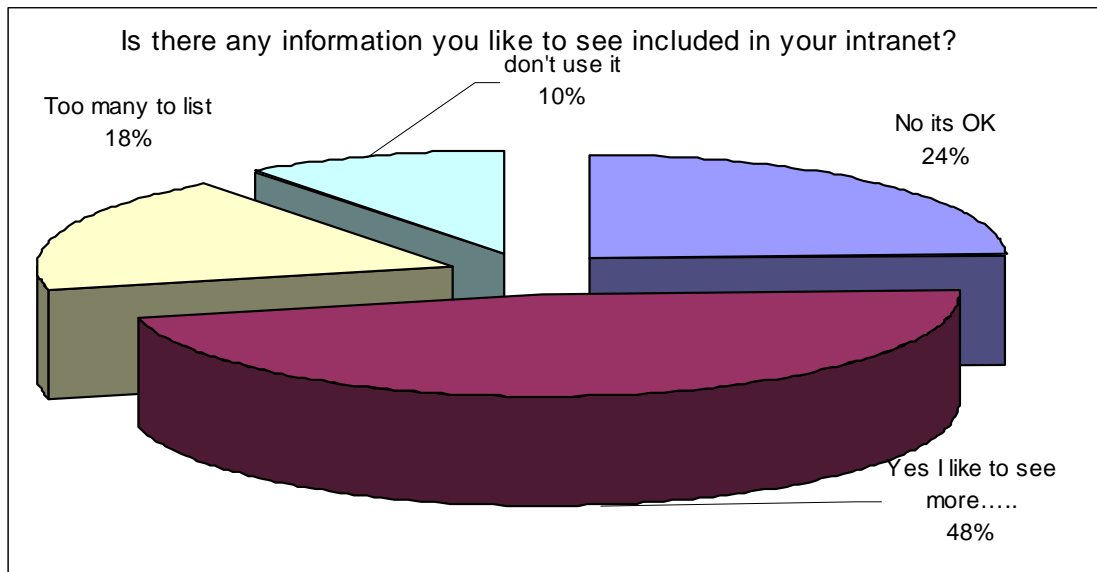
Fig.4 -In fig.4 66% of the users that use the company's intranet expressed the need to have more information on their intranet system and only 24% think that it is fine as it stands.

What way do you think the system could be made more user friendly?

0%

quicker response
7%

better graphics
20%

spoken words
0%

better search engine
73%
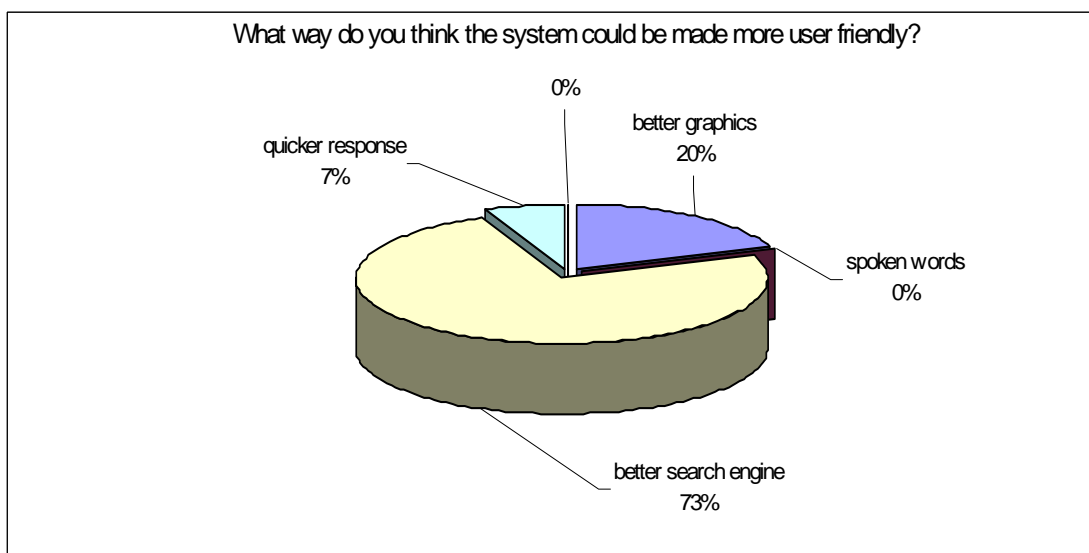
Fig.5 -Gives an idea of what end users think about how the knowledge is presented, The overwhelming majority seems to struggle in finding information on the Intranet;

- 73% would like a better search engine. Further research indicated that the search engine provided was based on alphabetic word driven search engine and not context driven hence unless the wording in the questions are exactly as presented in the specific topic is as presented in the database the result of the search returned the wrong results .

- Better graphics seems to be the next area that could be improved.

- With improved connectivity the concerns in connection problems seem to have diminished and the 7% with this problem is seen to be an acceptable number.

- Spoken words seem to have no attraction amongst the users. This may well have to do with office environment, a further study in this section could prove beneficial.
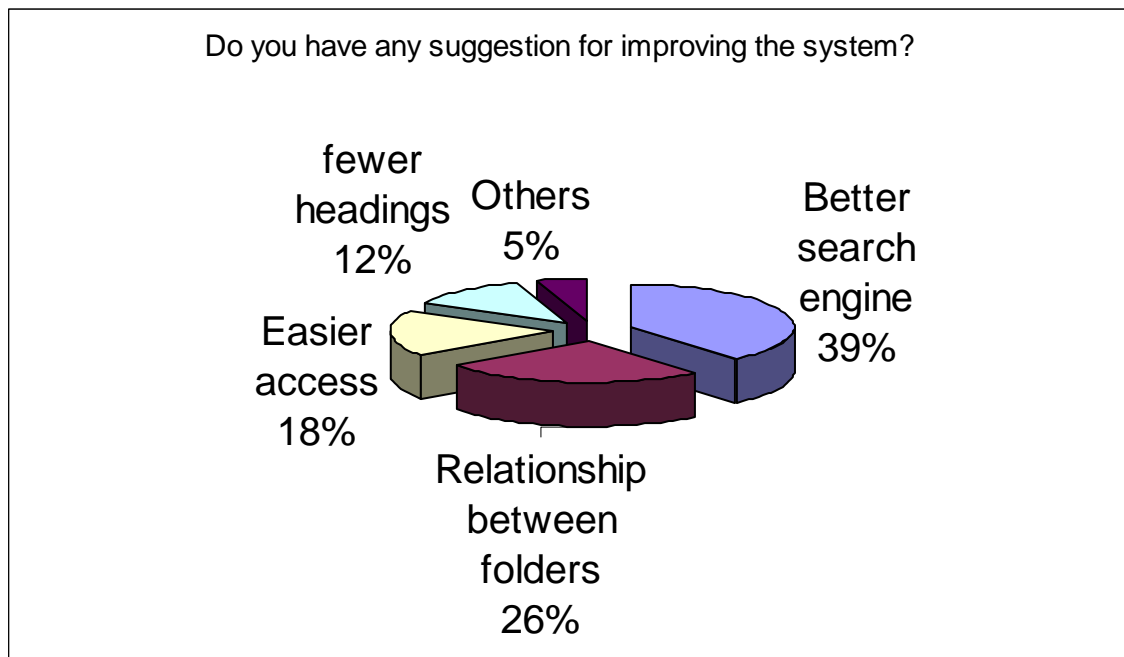
Fig.6 -This question had a blank answer section to encourage some feedback from the participants, their views on what could be lacking in the system. The following observation can be deduced from their responses:

- Better search engine (39%) Clearly information retrieval a major problem.
- Relationship between folders (26%) –On further analysis it became apparent that there were many subfolders within folders, these were subdivided into further subfolders. There seem to be no logic to the way they have been arranged. This has caused confusion as can be seen from the pie chart.
- Easier access (18%)-This again points to the confusion caused by the way the folders were put together.
- Fewer headings (12%)-Ditto

Judging by the response to the above question it is clear that the problem lies in finding the information rather than the lack of it.
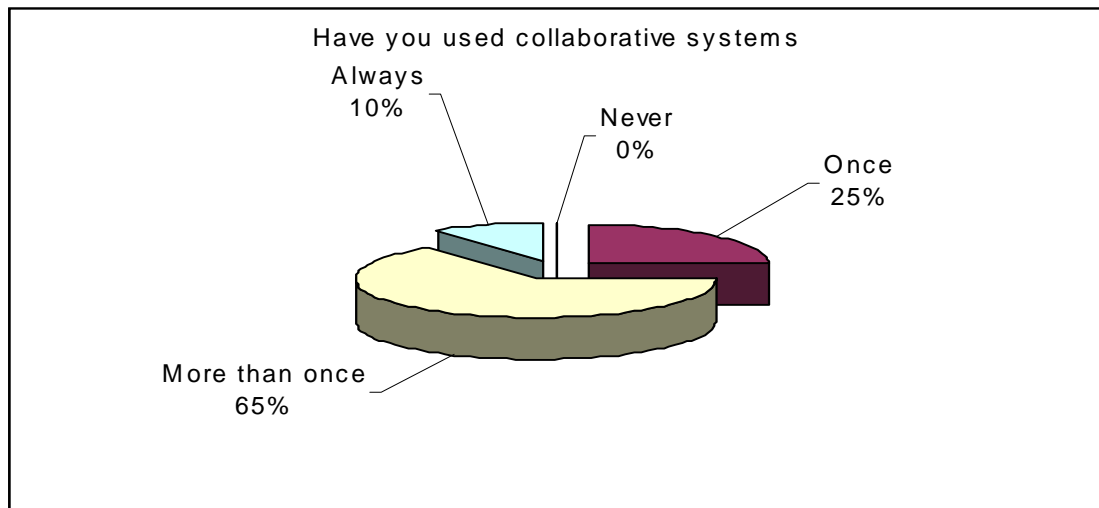
Fig.7 - The reason for posing this question was to see if there are preferences in using a particular system and if those reasons are purely to do with the information provided or the way the system is presented.

Although it should be noted that collaborative systems are not yet widely used and the users may not have been fully conversed with different elements of these systems.
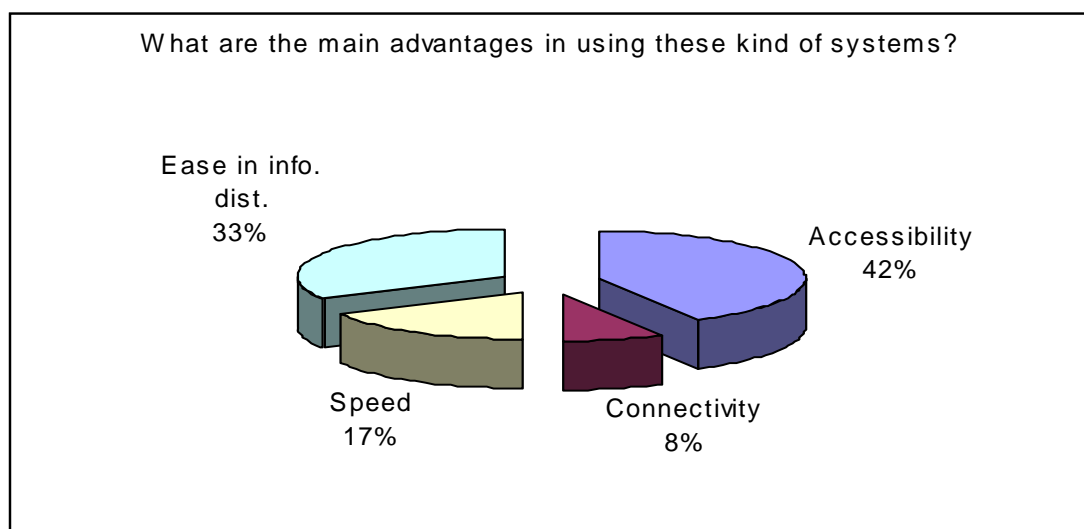
Fig 8 -Accessibility seem to play a large part in this question which is only to be expected, again speed although an issue does not seem to be of primary concern to the users and it is clear that the ease in information distribution plays a big part in using collaborative systems.
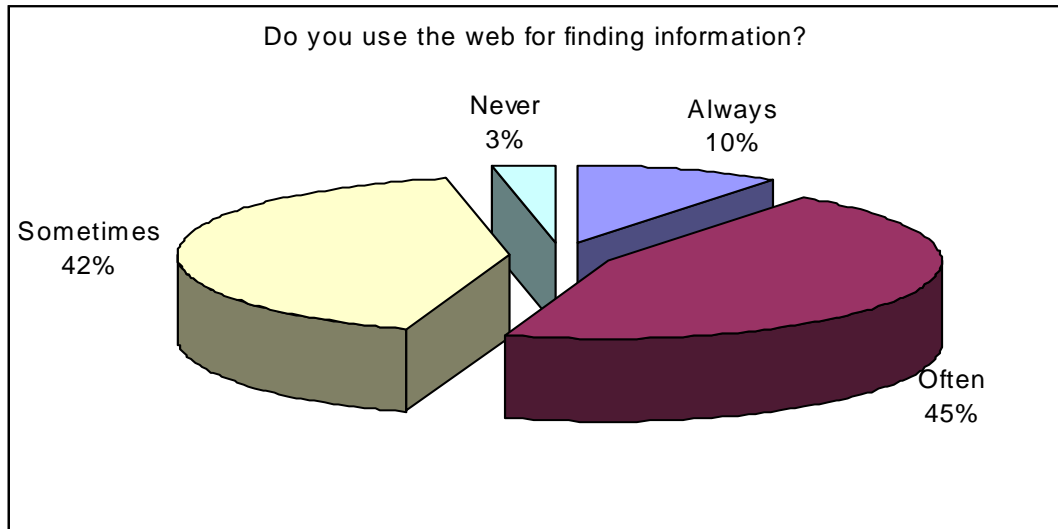
Fig.9 - This question was posed to find the users perception in inadequacy of the company's intranet; it can be argued that if the information provided was adequate there would be less need to use the web. Again the overwhelming majority seem to be using the internet to find information , products and services.
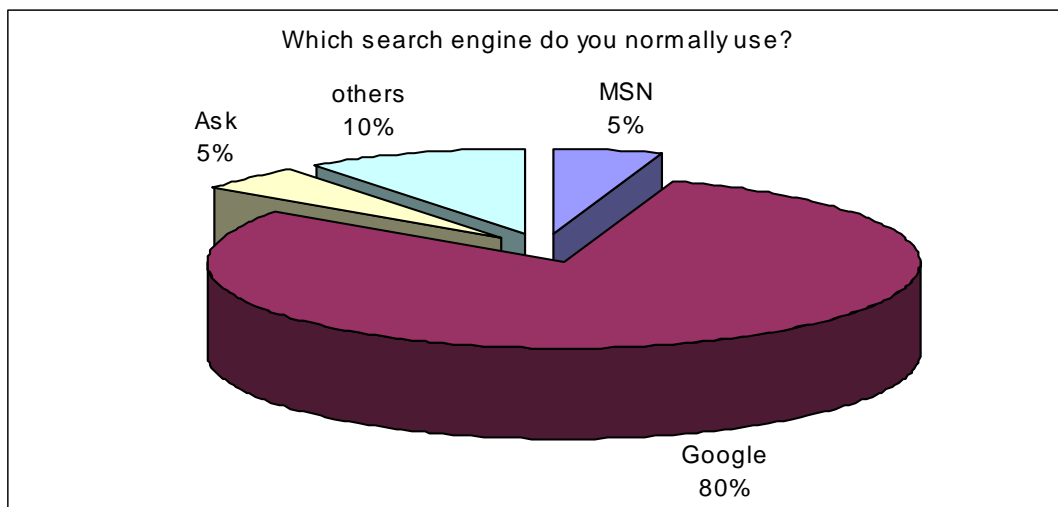
Fig.10 -This question highlights the reasons for user preference in the type of search engine they prefer and the results can be analysed to identify the factors influencing their choice.

A separate study was carried out to find if the same question given to the three search engines would give similar results. The findings reinforced the idea that layout of the search engine has a lot to do with gaining confidence of people using it. The following observations were made from the result of the study:

- Google-By far has the majority, the users seem to prefer Google search engine due to its clutter free presentation and layout

- MSN- Although gives almost the same results to the question the search engine layout is cluttered and not user friendly.

- Ask- Ditto
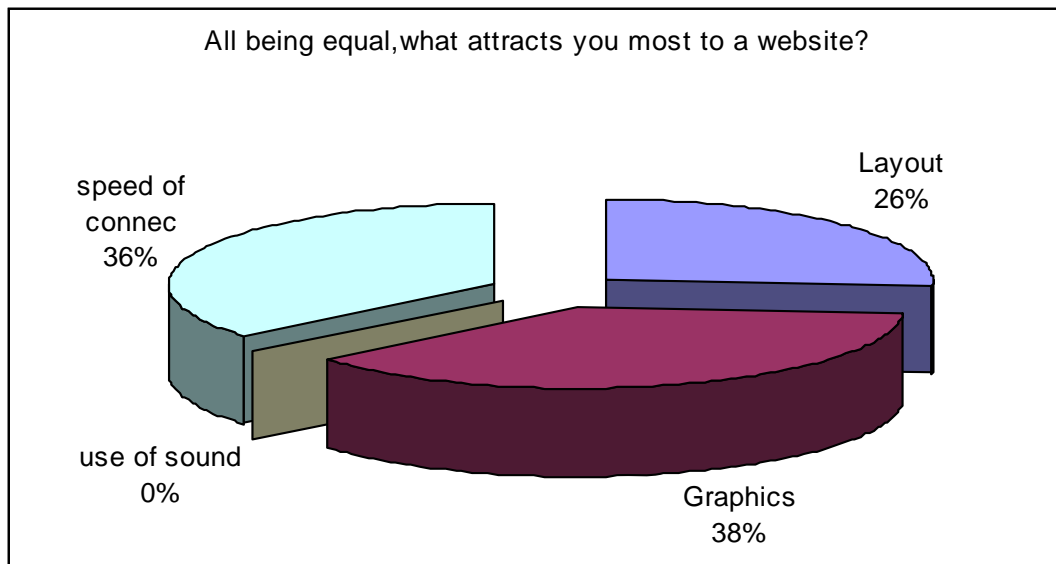
Fig.11 - Indicate the reasons behind using a particular search engine, the three areas of concern are sound, graphics and layout. Sound do not seem to have big impact; the major factors to consider are graphics & layout.

Fig. 12 –This question indicates the success that user
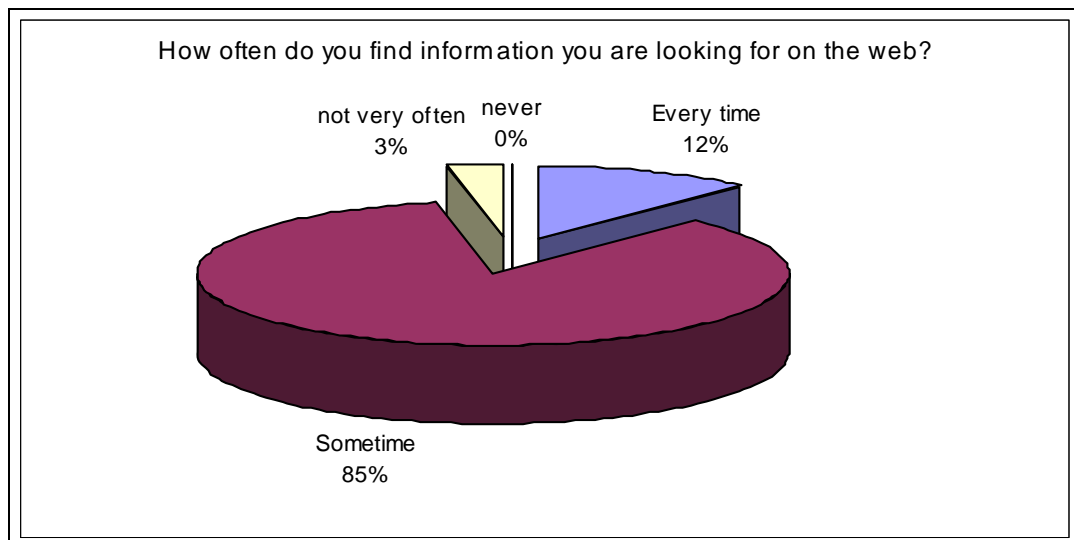
have in finding the information they need from the Internet query systems such as Google . From the response the success rate seems to be quite high, so connecting the company's Intranet search engine to the search engines such as Google could be part of the solution.

CONCLUSIONS OF THE QUESTIONNAIRE

Results of the questionnaire can be highlighted by the following:

- Multiple information sources scattered across the companies database

- Existing system is not user friendly

- Many different user interfaces to different information sources

- Users seem to have more success in finding information on Internet than the Intranet

- Employers store a lot of documents on the system, but you can never seem to find the right files when they need them

- There is no standard method to capture and reuse knowledge

SUMMARY OF FINDINGS

The survey concludes that changes are required to the existing system if it is to succeed in not only providing the employees with information and knowledge that although present is too laborious, time consuming and in some cases inaccessible to find, but also the process of adding to the information and consequently knowledge should be made available to everyone rather than the very few that currently control it. It has also explored the reasons for the system failure through conducting interviews and collating employees views via questionnaires. The finding of this paper has presented the sponsoring company with a business case to replace the existing system as soon as possible

FUTURE WORK

There is a clear need to develop a new system of information retrieval and knowledge management that would take account of the latest advances in information technology and delivers the goals for the company to be able to compete with its rivals. To satisfy these goals one should start by looking into how human mind/brain can absorb information with

minimal effort rather like writing programmes for a computer in computer language i.e. zeros and ones. It can then explore how the information can be added to the knowledge base system without the need for rewriting the software programme and by making the individual's contribution to the system as easy and logical as possible. This can possibly be achieved through the principals of mind mapping and software's such as Object Orientated Design.

RECOMMENDATION TO THE INDUSTRY

There are two main areas where this research has impact/implication on the wider construction industry. It should be noted that this research has focused on delivering the solution for the specific needs within the sponsoring company, but its findings can and should be used to assist others that may be faced with the same problems. The two areas are:

- **Simplification**- the willingness in participation through simplification and logic in other word to contribute to the knowledge because it is possible and easy. The challenge for the industry is to ensure that the people involved in a process are informed and can draw from latest technology to willingly cruise to change, not drive change through necessity, need and competition.

- **Integration**-The current structure of organisations within the construction industry has formed barriers to sharing knowledge and information because of worries about competition and rivalry, this has resulted in alienation of the technology and progress. The continuation of fictionalisation and 'over the wall mentality' means that inefficiencies will remain.

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<u>Appendix B</u>

Paper 2

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INFORMATION & KNOWLEDGE VISUALISATION: CAN IT HELP THE CRISIS IN THE UK CONSTRUCTION INDUSTRY?

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The UK construction industry, more so than any other, is subjected to a new and ever increasing influx of migrant labour workers as additional countries join the European Union. This will intensify as the construction for the Olympic Games Facilities (2012) gets nearer to the critical construction period. Naturally, any language barriers can en-danger the safety and performance of the foreign employees as well as their fellow indigenous workers. Coupled with the natural tendency of construction workers not wanting to read pages of text, this would reinforce the need for a supplementary and/or an alternative system to present information and knowledge. Information and Knowledge Visualisation can be a solution to ease the communication problem. At the very least it can help with the essential information that should be communicated prior to starting on a project. This would minimise the need for a full understanding of the English language as well as being able to transfer information and

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knowledge in an effective and simplified way. This paper proposes the use of Knowledge Visualisation in the context of the construction industry and argues the case for the need to develop an 'information flow' through this kind of process. It briefly dwells on problems that exist with knowledge transfer, explores the views of some experts in this field and presents a case study to substantiate the validity of the facts. This document then proceeds to analyse a survey, resulting in the case study and concludes by confirming the advantages and disadvantages in using Knowledge Visualisation for optimising both safety and productivity on construction sites.

Introduction

The UK construction industry is currently experiencing an unprecedented volume of migrant labour from Eastern European countries and other parts of the world, the majority of which are working on construction sites. Within this new labour force, performance and Health and Safety are in some cases impaired due to the inability to communicate with a common language. Most migrant workers occupy higher risk occupations and usually work in the most hazardous sectors. They often don't understand or can't read and/or write in English and rely on their fellow workers to help them get through the day with day briefs and method statements essential for their performance and safety.

The demand for delivery on tight programmes is increasingly putting more pressure in speedy operations. Consequently employers tend to neglect or overlook their short comings and in turn may expose their employees to unnecessary risks in a hazardous environment.

"Skill shortages have eased due to the influx of migrant labour from Eastern and Central Europe with the number of Chartered Surveyors reporting shortages of trade persons falling to 29% from 36%, offsetting most of last quarter's increase" says RICS UK construction market survey Q3 2006 05 October 2006. What this report fails to point out , and as is clear from the Home Office online report 03/06 (Sally Dench) explains "for many employers, language barriers were the only disadvantage they could think of in employing migrant workers (understanding health and safety procedures was sometimes a specific concern)."

Labour organisations estimate that there are roughly 96 million migrant workers and their dependents in the world today. It is very likely that these workers are handicapped by inadequate training and language skills.

Kevin Fear, Head of Health, Safety and Environment for Construction Skills points out that "all employers have a legal and moral duty to protect the health, safety and welfare of workers on their sites through the provision of information, training, induction and supervision - all key requirements of the Health and Safety at Work Act. This clearly will be a problem if there is a language barrier. Employing migrant workers can make these obligations more challenging, particularly when workers are not competent in their command of English language. Providing services, support and guidance to help employers to ensure that they manage health and safety issues and that any migrants working in UK construction are competent and safe, is a new duty placed upon construction companies by the new CDM Regulations."

The Sector Skills Council for Construction has been asked by employers to tackle the issue of integrating migrant workers to fit with its wider remit of ensuring everyone in the UK construction workforce is safe, healthy, qualified and competent. Wrench (1999) in his examination of 4000 accidents in five factories in the West Midlands found that the high level of industrial injuries to migrant and ethnic minority workers was 'entirely attributable to the fact that migrants and ethnic minority workers were over presented in the more dangerous jobs'.

Research Aims and Objectives

Wates Construction (sponsoring company) aim to improve presentation of essential information and knowledge by simplification and to ensure it is user friendly, whatever the user's background and capabilities. The following points were considered:

- What is the frequency in the use of information and knowledge, as provided by the company's intranet?

- What would be the likelihood of finding information if the user has a limited ability in their command of the English language.

- The effectiveness in providing information, as required by the users

- The success rate in finding the information the users are seeking.

- Which company employees, directly or indirectly, are more likely to use the system.

- Alternative solutions to any problem*(s)* raised

The Need for Improvement

By walking onto any building site, particularly in London, and observing the labour force, it is evident that a problem exists. The relationship between migrant workers and safety and performance can be further explored by reviewing past research carried out by experts in this field: Corvalan (1994) following a study of 1,211 cases of work related fatalities among people from 51 nationalities working in various sectors in Australia, concluded that the fatality rate was higher amongst non-English speaking workers than that of the indigenous Australian. This case study concluded that language and duration of residence are important determinants of safety at work in Australia.

The government, as the largest client of the construction industry, has led the drive to change. Its Construction Task Force challenged the industry to commit itself to change. Their report commonly referred to as the 'Egan Report', set clear targets for improvements.

There are also calls from the academic profession for change, Anumba et al. (2000) found that: 'Competitive pressures from within the industry as well as external political, economic and other considerations are now forcing the industry to re-examine and improve its modus operandi'.

Extent of the problem on a live project

On an existing PFI project, building three schools in Slough UK, a survey was carried out to establish the extent of this problem. The number of people working on the project as an average over the construction period ranges 250-400/day. The following chart was developed showing percentage of foreign workers against total employed and the percentage of people that cannot read and write and/or understand the English language. This survey shows that about 12% do not understand any written signs displayed or cannot read method statements and health and safety written signs as can be seen from Figure A. This clearly poses a problem in terms of performance and health & safety prospective.
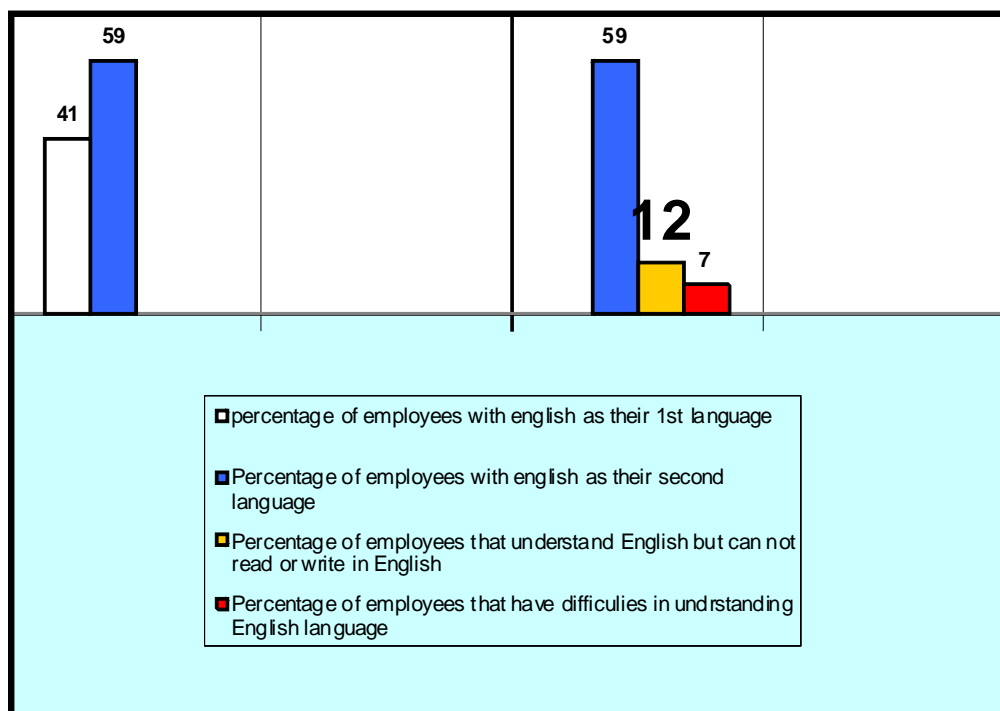
Fig. A- Percentage of foreign workers and those that cannot read or write in English on a typical building site in London.

One of the possible solutions to this problem can be information and knowledge visualization. Following are some of the simple examples of passing on information through visualisation:

Fig. B-   Passing on Information through visualization

How can Information and Knowledge Visualisation help

Knowledge visualisation is the use of visual representations to transfer knowledge between at least two persons (Burkhard and Meier, 2004). Knowledge Visualisation can be used to transfer knowledge by the use of visual images, sketches, objects and key words or numbers. As an example "9/11" may conjure up images of the Twin Towers but when presented in a different format "911", for the car enthusiast, may remind them of a powerful sports car. Visualisation has the ability to trigger thoughts in values, experiences, perceptions, expectations etc.

Visualisation can be divided into six categories:

- Data Visualisation
- Information Visualisation
- Concept Visualisation
- Strategy Visualisation
- Metaphor Visualisation
- Compound Visualisation

A successful example of solving the problem of language by visualisation methods is in the motoring signage; it can be understood wherever they are displayed in the world. Other successful examples include the underground, road and train/flight route maps.

Carty (2005) emphasises that 'if you find your staff short on the skills needed to meet the schedule in a timely and cost-effective way, it is possible that the wrong technology may have chosen vis-à-vis the resources'. He also observes 'one benchmark of the right technology is that you don't feel like the technology is a daily struggle and you have time to focus on

critical success factors like maintaining your business partners active support and participation'.

In her paper, Hemamalini (2002) proposes that the organisations who are driven by knowledge are the ones that will succeed. She emphasises the fact that the combination of global reach and speed compels organisations to ask themselves, "What do we know? Who knows it? What do we not know that we should know?"

Dougherty (1999) confirms that knowledge transfer is about connection not collection, and that connection ultimately depends on choice made by individuals. Connection initially starts with communication before transfer of information and knowledge can begin.

"Look around you - symbols are everywhere. From signs in airports to icons on computer screens - we increasingly communicate not only in words, but with images," explains Joyce Wycoff (1995), co-author of the book Transformation Thinking. "Mindmapping helps us to stretch our thinking beyond our usual paradigms. (It) can help you to see the big picture, capture complex ideas quickly and easily and identify relationships between ideas and processes," she adds.

The example below may further highlight the problem:

Lost in translation!

Maybe this sign would have been a better option?

Case Study

Already certain information can be transferred with the use of information visualisation and without the need for understanding a particular language as demonstrated in section 5. However conveying knowledge through the use of visualisation techniques is a more challenging objective to achieve. History from the Egyptian times shows that this is possible, with some training. The real challenge is to utilise the principals of Knowledge Visualisation

to a point where one can transfer knowledge solely by looking at symbols, graphics and figures so that the use of language as a way to convey essential information can be side stepped. An increasing amount of research in this area is needed before the potential of this objective can be realised.

The following is an example of what can be achieved through visualisation and graphics, reducing the need for reading through pages of text, by using the principals of Windows type software and logical mind mapping. A shell software from a company called "TheBrain"**[1] was used to carry out a pilot study on a selection of employees with emphasis given to "no prior training" in using the software. They were told to try and find specific information by using the system. During this process their actions were observed and recorded and the system was fine tuned in accordance with how the majority of users expected to see the results by following certain scenarios. They were then given a set of questionnaires to complete to establish how the new system compared with the existing system.

The new system has two different facilities for finding the answers to queries:
Logically - This encourages the user to think where the information may be kept on the system and by following a series of clicking on the hyperlinks can subsequently find the answer to the question. It would also allow the user to explore any other fields of information which are kept on the folders and files. This option is also used for uploading new information onto the system.

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[1] ** TheBrain., Visual Information Management, http://www.thebrain.com/

Search Engine - This facility allows the user to go directly to the answer if it is on the system. The system works with alphabetical sequencing so that as soon as the first letter has been entered all the information kept within the system starting with that letter will be displayed and as the subsequent letters are entered, it will narrow the search to the particular subject that the reader is interested in.

Due to graphical nature of this software some screen shots have had to be included for ease of understanding and to show the ability for reasoning by using the system. Please note that

within each file there is a facility of hyperlinked options that if activated (clicked on) will take the user to a pre-programmed address. This address may be linked to the company server or the internet or even within the user's computer hard drive.

The following is an example of a typical question put to the participants in the survey and the arrows indicate the path which the majority followed to find the answer to that question:
Question: What was the mix design for concrete used in the foundation by the ground worker sub-contractor working on Bishops Park School, PFI Project, for Wates Construction Project
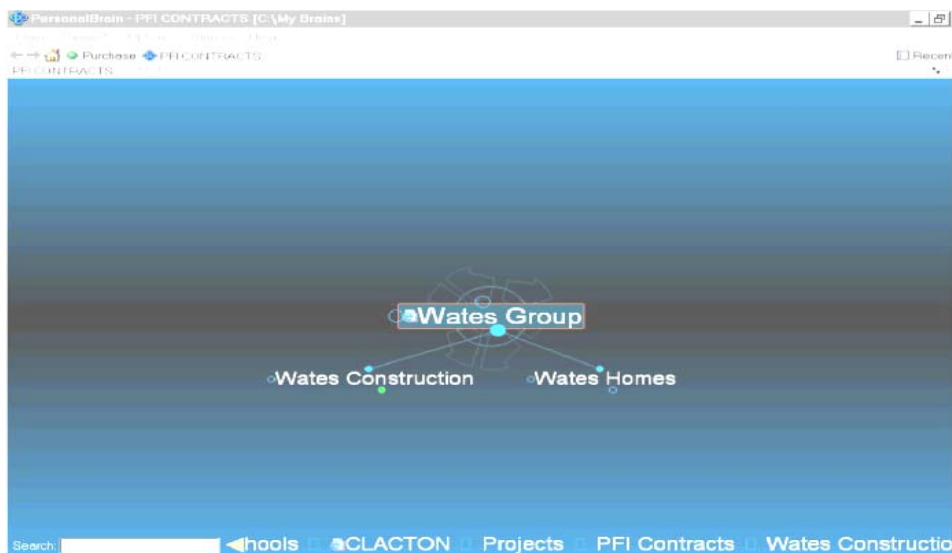
Fig.1 The user is presented with the above screen at the start of the search. Since the question refers to Wates Construction within Wates Group, that specific option is activated by clicking on it.
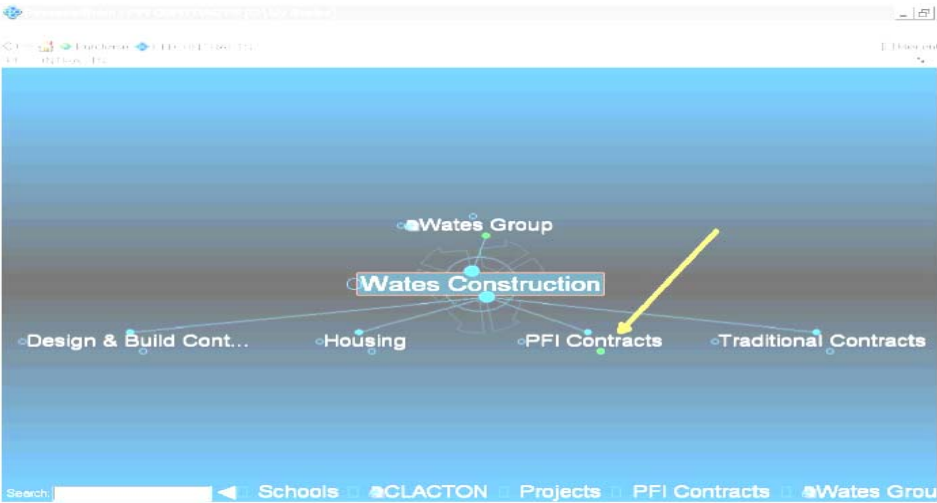
Fig. 2 The next screen will pop up and will present the user with more choice. As 'PFI Contracts' features in the question, it will be the next logical option to click on.
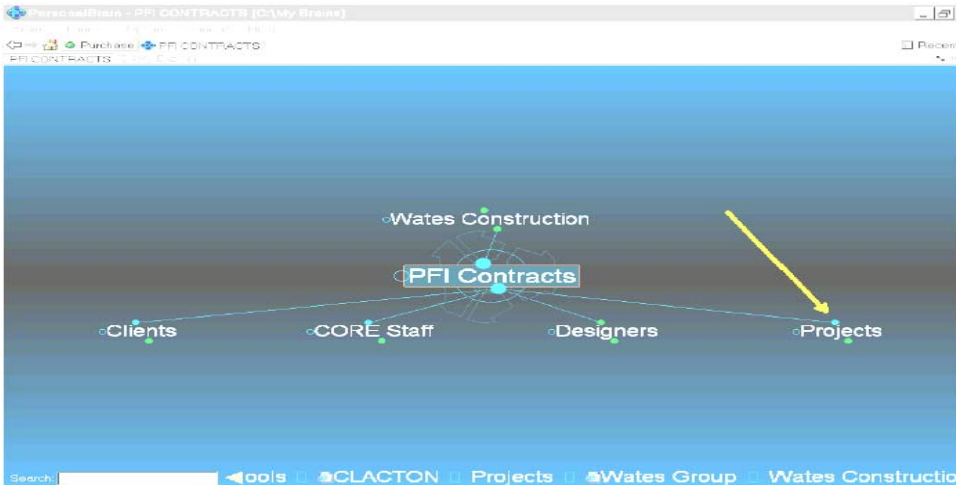

Fig. 3- In the third screen 'Projects' would be the next logical area to click. Please note that the other options also contain information on the subjects presented.
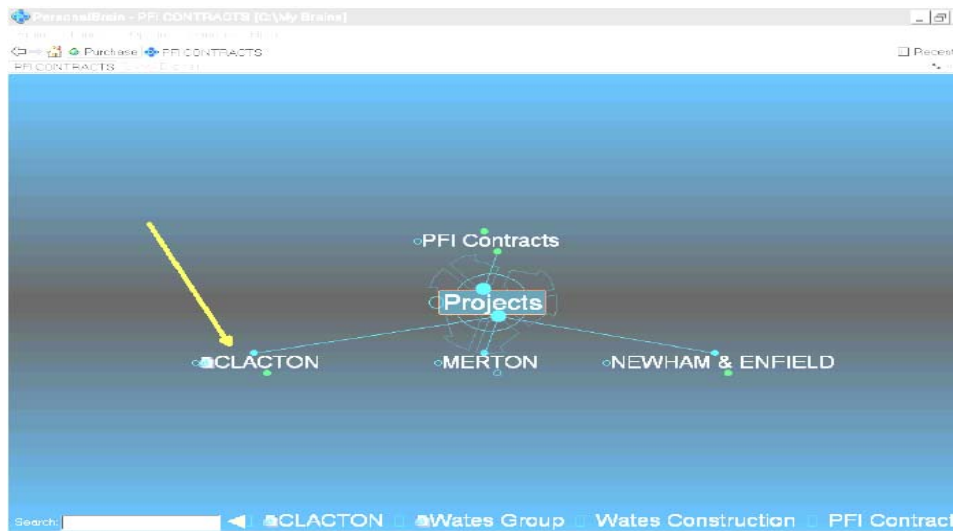
Fig. 4 Since Clacton features in the question as the location of the work it would be the next logical option to click.

Fig. 5- Bishops Park School is the project in question so it is the next obvious option
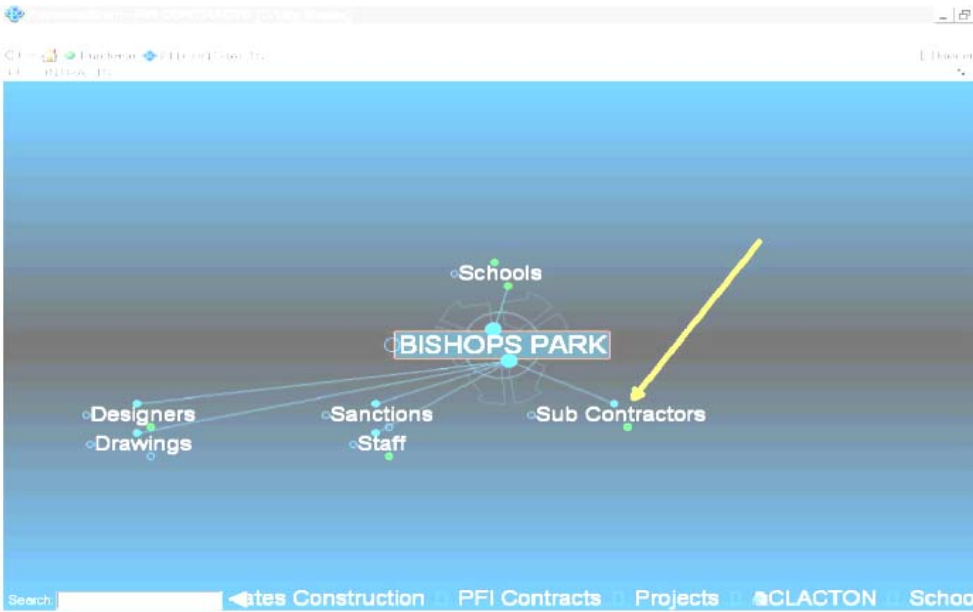
Fig. 6- Sub-Contractors will be the next file to explore
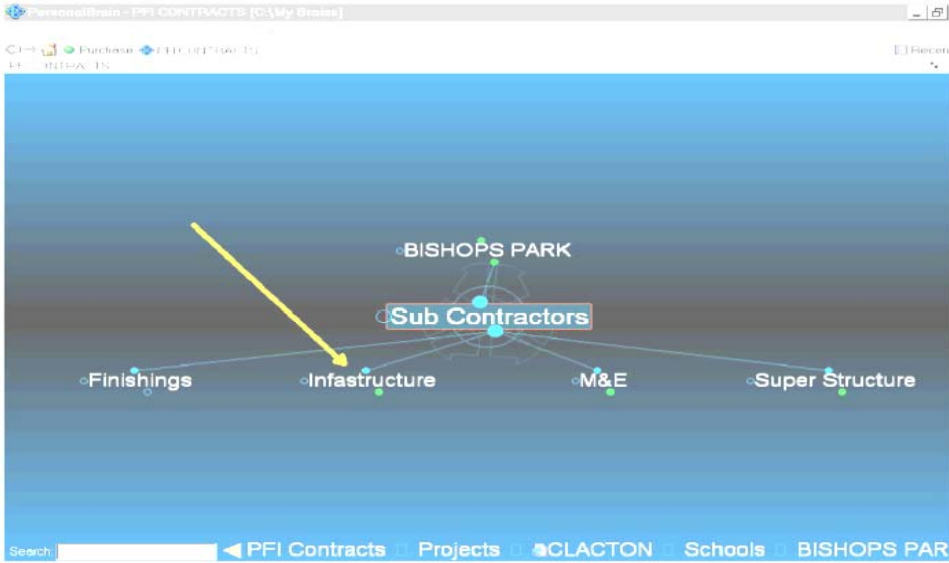
Fig. 7- Since the sub-contractors are Ground Workers the next option logically would be Infrastructure
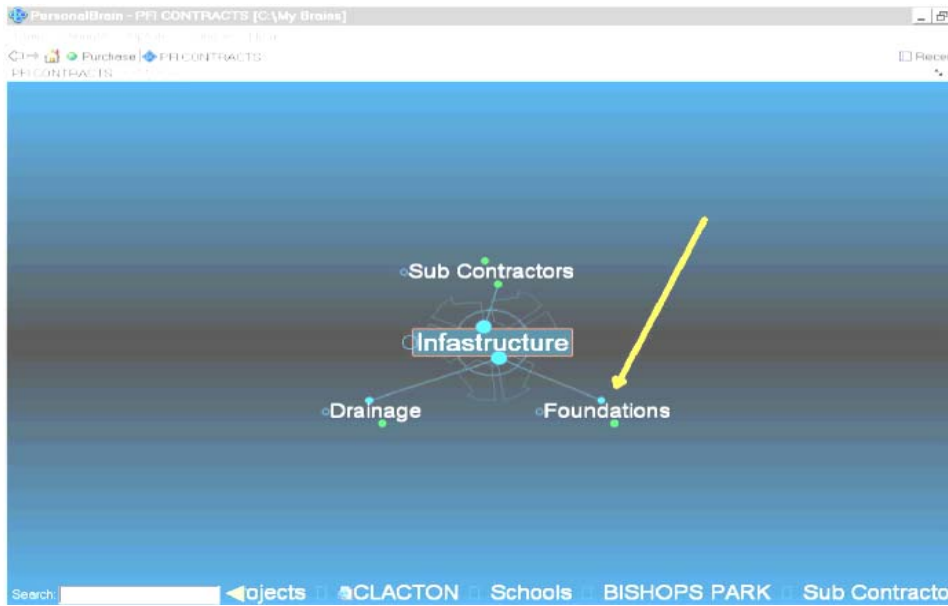
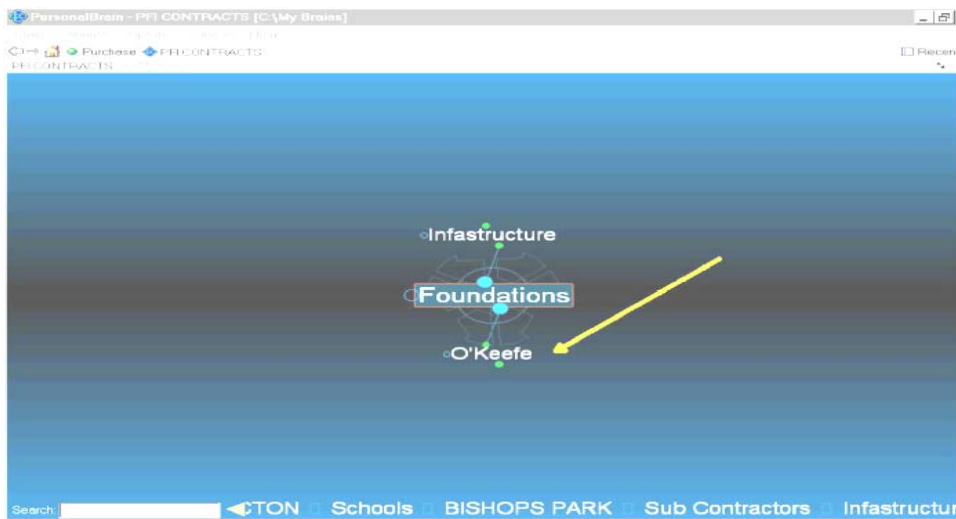Fig.8- In the next screen foundations option is in the next heading to display

Fig.9- And therefore the name of the subcontractor laying the foundation is in the question and displayed
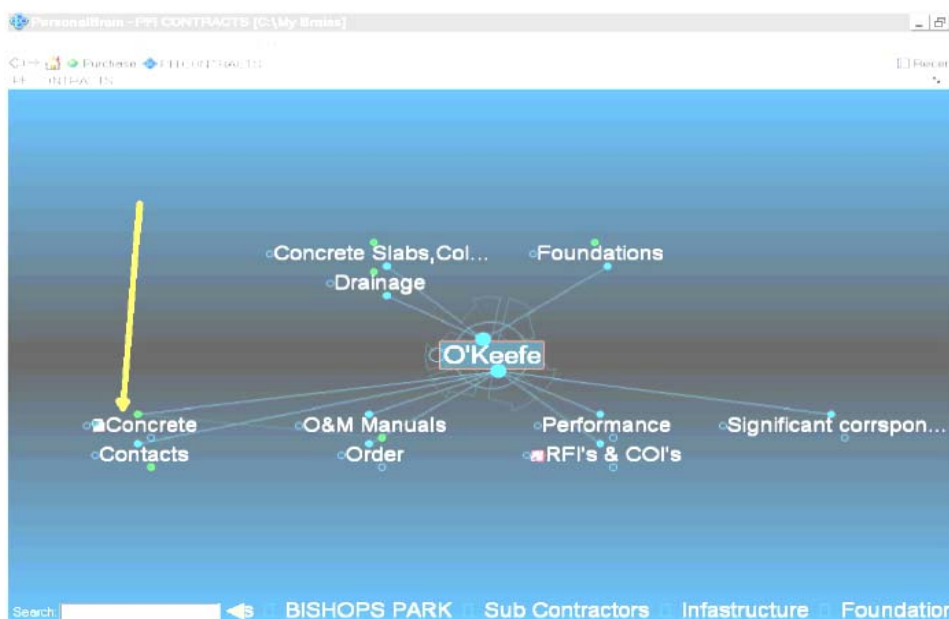
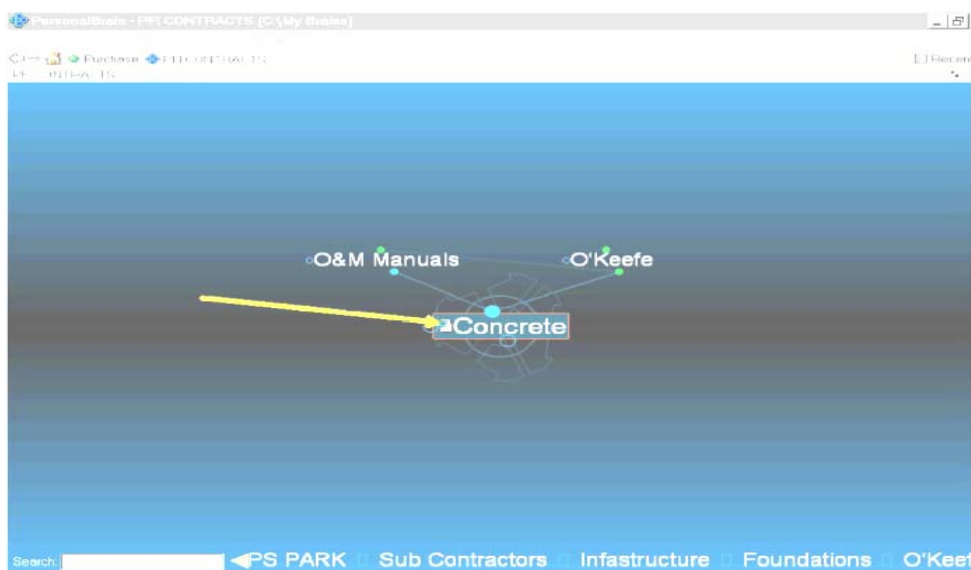Fig. 10 -The next step is to click on the concrete

Fig. 11- By clicking the Concrete folder the hyperlink will direct the user to a word document where the information is stored. This file could be on the company server or on a web site or even on a collaborative web site such as Build Online.

The new system has made a big improvement in knowledge sharing within the company and it will replace the existing Information Retrieval System in due course.

Conclusion and Future Work

The UK construction industry will increasingly rely on migrant workers and although there is some evidence that the majority speak some English there remains quite a large number that cannot understand, read or write in English. There are obvious advantages in reducing the need for understanding information and knowledge by the use of text. Utilising Information and Knowledge Visualisation tools, as the primary source of information presentation and retrieval, could be the answer. The success of this form of knowledge transfer, all be it in its simplest form, is apparent from the motoring industry in that regardless of where you are in the world the majority of signs are the same and have the same meaning.

This form of information dissemination should be extended and expanded to cover other industries not only to avoid accidents and fatalities but also to get better performance from those that struggle with language. As can be seen from the pilot study carried out, the presentation of knowledge graphically is easier to understand and will make information

retrieval simpler. It reduces the need to read pages of text which is normally off putting and unnecessary.

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<u>Appendix C</u> –

Paper 3

Also a shorter version was presented in the

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Knowledge Management in Organisations;
A constructive Case Study

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Introduction

This paper seeks to evaluate problems faced by a typical medium-large construction company in knowledge management and proposes solutions by deploying methodology, structure and vigour prescribed by academia. The key to the success is balancing the needs of the industry with knowhow of the academia using the tools prescribed by academia in a live situation and evaluating problems encountered in the industry. Arriving at solutions by using the latest technological advances usually visible in academic circles long before it takes root in the industry. This form of collaboration could lead to bridges that can close the gap between the two entities which in turn could benefit academia in their quest to further knowledge and the industry by increasing productivity and profits. In short the driver is the industry, the key is knowledge, the engine can be committed leadership and the route to success devised by academia. This research aims to contribute to better understanding of application of academic theories in a commercial environment under the topic of Knowledge Management.

The UK construction industry is the currently experiencing an unprecedented volume of migrant labour from Eastern European countries as well as other parts of the world. This new labour force's performance and Health and Safety can be impaired due to inability to communicate in a common language. Majority of migrant workers occupy higher risk jobs and usually work in the most hazardous sectors. They often can't read and/or write in English and in some cases can't speak or understand the English language. They therefore rely on their fellow workers to keep them informed on safety briefs and method statements, essential to their safety and performance.

On the other hand the demand for delivery on tight programmes is increasingly putting more pressure on contractors for speedy operations. Consequently employers tend to neglect or overlook the new workforce's short comings and in turn may expose them to unnecessary risks in hazardous environment. The extend of the problem can be deduced from the latest headlines appearing in the news such as *UK workers outnumbered by foreigners on London sites*, *MPs heard that 40% of construction workers in London were migrants in 2006 - up from just 21.5% in 2001* [2] .A UCATT spokesman confirmed. Concern that migrant workers could be missing out on crucial health and safety training because their employers are not

providing safety material in any language other than English has prompted the Health and Safety Executive (HSE) and the Trades Union Congress (TUC) to produce new safety information to be translated into 21 different languages.

The UK government, as the largest client of the construction industry, has led the drive to change. Its Construction Task Force challenged the industry to commit itself to change. Their report commonly referred to as the 'Egan Report', set clear targets for improvements. "The industry must replace competitive tendering with long term relationships based on clear measurement performance in quality and efficiency...Construction companies must prepare comparative performance data and share it with clients and each other without compromising legitimate needs for confidentiality" (Egan 1998).Most of the demands on this report has not yet been realised.

It is apparent that almost all businesses in the world face the same fundamental problem: i.e. maintaining their competitive edge by gathering and reusing knowledge gained. Hemamalini (2002) proposes, organisations that are driven by knowledge are the ones that will succeed. She adds the Combination of global reach and speed compels organisations to ask themselves, "What Do we know, who knows it, what do we not know that we should know?"

In many companies, much of the operating knowledge is not documented; this tacit knowledge can easily be lost through promotion, movement of people or retirement. Employees who become experts in certain fields through years of training and experience gained whilst working for the company are in demand and are often lured by competitors offering better remuneration. In many construction companies, much of the organisational "know-how" exists in notebooks of the employees, and managers. Without the ability to retrieve, organise, manage and store knowledge much hard-won-knowledge will simply be lost.

The above background and the preceding sections emphasises the need for improvement in how information and knowledge is presented and managed It therefore underscores wider need for enhanced and effective action to achieve the industry's needs.

Aim of the Research

The aim of this research is 'To explore the possibilities of finding a practical, easy, logical and user friendly tool to aid with Information and knowledge Management and to propose a system that can encourage wider use of information and knowledge provided by the sponsoring company with emphases given to minimal training, ease of usage and the possibility of minimising the need for a common language in retrieving the information.

Objectives of the Research

- To be able to achieve the goal of this research the following five key objectives were set:
- The current practises in presentation of information and knowledge within the company and its partners.
- The user's view in relation to the management of information and knowledge within the company and its partners
- Evaluation in users perception of how the information and knowledge should be presented and whether or not the existing system satisfies their needs
- Research into the current state-of-the-art through literature review and current practises employed by sponsoring company's competitors and the wider market.
- Research for an alternative system that will satisfy the company's need and the user's wants by ensuring that it is user friendly, logical and would provide maximum effectiveness with minimal training.

Novelty of the Research

The novelty of the research is to initially evaluate the mindset of the employees of a typical construction company and its partners, which to a degree represent the industry in general, by understanding their strengths and weaknesses in using IT systems and how they find information. Secondly to investigate the latest advances in presentation of information and knowledge so that the user can extract the information they require with minimal need for training. To this end the software utilised should encourage the user to follow logic in his queries and graphics for usability thus minimising or even completely removing the need for training or the full understanding a common language.

Carty (2005) observes, "It's difficult to find the needed technical expertise. This is a common symptom that sometimes has as much to do with your approach as your selection of technology. If you find that your staffs are short on the skills needed to meet the schedule in a timely and cost-effective way, you may have chosen the wrong technology vis-à-vis your resources." He also observes ". One benchmark of the right technology is that you don't feel like the technology is a daily struggle and you have time to focus on critical success factors like maintaining your business partners active support and participation. He adds It's enough of a struggle just staying on top of ever changing user requirements, scope creep, and maintaining organisational buy-in from the project sponsors – the last thing you have time for is a struggle with the very tools you're using to implement the system."

Evaluation of sponsoring company's existing system

The information and knowledge provided by the sponsoring company and other external sources are often lost in pages of text, and is difficult to access in a user friendly and rational manner, the user normally requires training and long periods of time to search through the database to find any relevant information that could be of use. Often due to the volume of work that the staffs has to deal with, and because of the time it takes to retrieve the information they need from the system, they simply give up. At best this may lead to making unqualified decisions that may not provide the best solution and at worst may lead to making entirely the wrong decision potentially costing the company a great deal of time and money to rectify.

Some time was spent in attending meetings and having one-to-one interviews with participants, observing their activities and particularly the way they conduct their information retrieval from the company's IT system a set of data was than gathered that led to the following understanding of the existing practices:

The company's system of information retrieval was inadequate for their employees needs.

The users at best spend long periods of time looking for the information and at worst gave up and either made unqualified decisions based on their tacit knowledge or others unqualified advice.

There were many instances of knowledge gained from practical experiences that were not recorded and therefore not available for future use.

Overwhelming majority that took part in the survey expressed their total lack of confidence in the system provided

Case study-This was imperative to capture the industry's wider understanding, perception and engagement of the concept. In view of this, the second part of this study involved a rapid survey through telephone interviews to establish the meanings and values associated with the term knowledge management and the management and employees views on how the access to this resource can be simplified, and to further explore the ways in which it was being applied in the construction industry

Survey and Interviews-The interviews were a great insight into how the users think of the system and to cover the areas that may have not been fully explored on the survey. The approach to the interviews was loosely structured to allow interviewees the flexibility to express their views without going on record. The agenda differed to cover the individual's position and their job title. Total of 14 samples were taken. The choice for interviewees were based on random selection depending on availability and position but the samples were designed to cover a selection of different occupations, ages , access to Sponsoring company network and their own information and knowledge provider network. The summary of participants is as follows:

Table: 1 Interview details

Company	Occupation	Age	Gender	Type of computer
Wates (Contractor)	Project manager	38	M	Laptop
Wates (Contractor)	Design Manager	54	M	Laptop
Wates (Contractor)	Quantity Surveyor	28	F	Laptop
ACP (Architects)	Architect	38	M	Desktop
ACP (Architects)	Architect's Technician	61	F	Desktop
Wates (Contractor)	Quantity Surveyor	24	M	Laptop

Whitbybird(Engineers)	Structural Engineer	29	M	Desktop and PDA
Whitbybird(Engineers)	Drainage Engineer	32	M	Desktop and PDA
Wates (Contractor)	Site Manager	29	M	Desktop
Wates (Contractor)	M&E Manager	33	M	Laptop
Plincke (landscape Architect)	Landscape Architect	31	M	Desktop and PDA
Plinke(landscape Architect)	Landscape Architect	42	M	Desktop and PDA
O'keefe (Groundwork)	Ground workers agent	37	M	Desktop
Wates (Contractor)	Secretary	27	F	Desktop

The reasons for choosing the above selective number of people was because of their requirements and prioritisation of their needs .Following one-to-one interviews, surveys and case study the following points were highlighted as problematic areas in information and knowledge retrieval that needed to be addressed:

- There seem to be no logic in where the user should be looking for the information they require
- The format is not user friendly and information is more likely to be achieved by luck rather than judgement.
- Although there is a vast amount of information and knowledge stored in company's servers often the result provided by the search engine is not what the user expected
- The sub-sections in different folders provided often don't seem to present the user with clear and concise heading. Consequently the user's need to almost open every folder and file to find the subject that he/she may be interested in.

A total of 36 out of 40 people returned the questionnaire. The questions were posed to establish the reliance of staff on their company's intranet (information provider) and how they felt about using the system. Their responses were transformed into pie charts. Each question was based on the findings of the interviews and concerns raised to give an overall picture of the IT system and its usefulness as experienced by the end users. The results were further

analysed and then a report of the outcome was evaluated to help with the design of the new system.

**Figure A**. Result of a survey
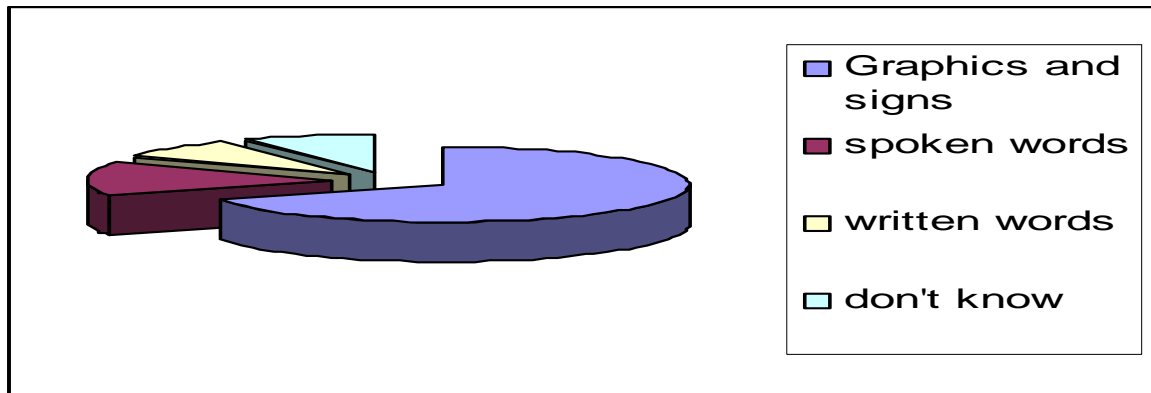
the above pie chart indicates the preference of the workforce in how they would like information to be presented to them. Therefore graphics and visualization could be a possible solution to encourage indigenous as well as foreign workers in absorbing at the very least the safety aspects of the jobs they are task with.

Extent of a common language problem on a live project

On an existing building project, constructing three schools in Slough UK to the value of £47m, a survey was carried out to establish the extent of this problem. The number of people working on the project as an average over the construction period ranges between 250-400/day.

Figure B-Case study
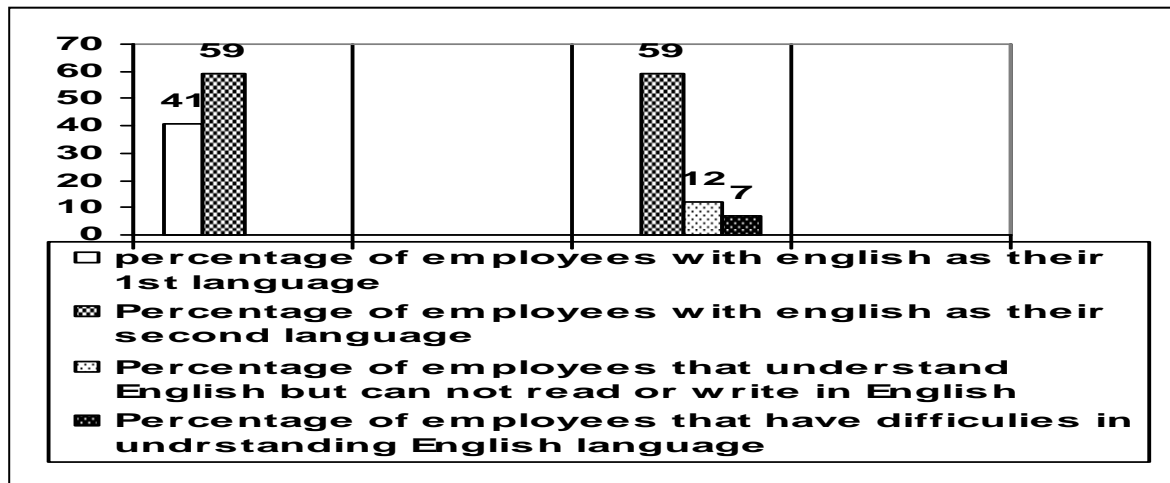
The above chart was developed showing percentage of foreign workers against total employed and the percentage of people that cannot read and write and/or understand the English language. This survey shows that about 12% do not understand any written signs displayed and/or read method statements and health and safety written signs, and 7% cannot understand any English, as can be seen from Figure B. This clearly poses a problem in terms of performance and from the health & safety prospective.

Problems with existing systems

It is clear that the sponsoring company has very little visibility into how their staffs resolve issues. Their system relies on a simple top down workflow where issues are entered, assigned to a single owner, and either resolved or escalated to the next level. There is no provision for capturing descriptions of each issue, how long it takes and how it is solved. Most of this potentially valuable information is simply lost before it can ever be captured. Also the provision of information and knowledge by the sponsoring company according to the survey is often not used mainly due to the design of the system. Although from the survey it can be deduced that if someone persist often the information exists within the system.

The following are the key points to develop a system that is simple to use, require little initial training and is flexible enough to capture new and updated information/knowledge with minimal effort:

- Deliver a broader range of knowledge faster and at a much lower cost than the existing system

- Help new users to become effective faster, and with less training, by using logic, simplification and graphics in presentation

- Decrease the workload for users by reducing redundant efforts in finding information therefore giving them time for their main day to day issues

- Giving business managers greater visibility into the process of how issues are resolved and knowledge is used.

Importance of Human computer interface in knowledge management

The concept of human computer interface is also an important topic since most information and knowledge are transferred through this media. The use of direct manipulation, immediate feedback, and proper use of animation, sound and also protection from accidental mistakes are the necessary elements in this domain.

To design a good interface there are certain topics that needs to be taken into consideration, typically:

- Immediate Capture and reuse by less experience users

- Use of the same concepts, in the same terms, with lesser misunderstandings

- Users should be given room to use their individuality to encourages creativity

- Ensure simplicity and ease in adding and extracting knowledge to the system.

To achieve the above there are benefits in using Object Orientated Design (OOD)

Why use Object Orientated Design (OOD)

"Abstraction is the elimination of the irrelevant and the amplification of the essential",
Robert Martin

The object-oriented (OO) paradigm is said to be one of the best and most flexible environments for developing user friendly systems. This is achieved by transferring responsibility from functional modules to a local level. *"The object-oriented approach combines three properties: encapsulation, inheritance, and organisation" (* Nguyen 1986)

The properties for OOD are; ease of reuse, maintenance, extensibility and scalability, all of which are vitally important for knowledge management.

Re-thinking information managemen*t*

The final area of research is how best to present knowledge to the user so that it can be understood with minimal training and background of the subject matter. Tony Buzan developed an effective method of note taking that uses the generation of ideas by associations called Mind Maps™. The principals of this form of knowledge presentation is to start from centre with the main idea/query and works outward in all directions, producing a growing and organised structure. This includes key words and images. According to Tony Buzan the main features of this methods are:

- Key Words
- Association
- Organisation
- Clustering
- Visual Memory - Print the key words, use colour, symbols, icons, 3D-effects,arrows and outlining groups of words
- Outstandingness
- Conscious involvement

He emphasises that with this method there is only need to start with a basic problem as the centre, and proceed by generating associations and ideas from it in order to arrive at a number of different possible approaches, he concludes by utilising this manner and possibly using colour and pictures, a better overview is gained and new connections can be made visible.

Research in finding alternative system

Development of knowledge base intranet system using object-orientated technologies that can present knowledge gained in previous projects on tap and address issues such as:

- Materials selection.
- Availability of resources.
- Quicker access to operating Manuals

- Past responses to problems in given situations and the resulting outcome.

- Environmentally sensitive techniques or material alternatives.

- Compatibility with existing software environments such as Project Net, Build On Line and Humming Bird collaboration systems..

To be able to understand the essentials for a practical knowledge management system the following areas of study were explored:

- How to transfer knowledge with minimal effort

- What type of interface could be employed so that the content can be updated easily and as it is being used?

- Where can the information /knowledge be stored

- When can it be deployed

Choosing the Best Software

Following a study into how human mind works and how information can best be presented to users with minimum effort, and an extensive search both in existing readymade systems and what can be developed, the decision was made to use a shell software that has been developed by an American software company called "Brain Technology", the software is called "Personal brain", this is designed specifically for advanced, time-critical knowledge delivery, which is essential in problem resolution. It organizes information in an associative network that mimics human thought processes and utilizes visualization, collaboration, natural language search, and data integration and maximises performance. It seems to thick all the boxes identified in the system specification.

The system was developed and made available to serve the specific needs of the sponsoring company. The information and knowledge gained from live Projects were uploaded into the system and the final product was made available in a pilot study to a selection of employees with emphases given to 'no prior training in using the new system'. They were told to try and find certain information using the new system. During this process their actions were observed and recorded and the system fine tuned to follow the majority way of reasoning and how they expected to see the results. Further tests were carried out under different scenarios to ensure the validity of the results.

They were than given a set of questionnaires to fill in as to how the new system compared with the existing system and results were recorded

To sum up the working of the new system has two different facilities for finding answers to queries:

Logically- This encourages the user to think where the information may be kept on the system and by series of clicking on the hyper links graphically presented to eventually find the answer to the queries they need. It would also allow the user to explore any other fields of information that is kept on the files and folders.

Search Engine- This facility allows the user to go directly to the answer if it is kept on the system by typing in, or clicking on graphics present, the area of interest.. The system works on alphabetical sequencing so that as soon as the first letter has been entered all the information kept within the system starting with that letter will be displayed and as the following letters are entered it will narrow the search to the particular subject that the reader is interested in.

12.   Summary of the Research Findings

Important to this research has been the collaboration of the users. Changing the mindset of employees can only be achieved by promotion of new skills and training. Old habits die hard and to think that by introducing a new system the problems can be eliminated can lead to disappointment and distrust. A sustainable change therefore requires first and foremost the buy in of the leadership followed by the willingness of the users and the commitment of the drivers for change and only after these are met, perhaps controversially, it depends on the product and its usefulness.

New ways of thinking have always been the backbone of progress and inevitably as with any new ideas that has been welcomed by some equally been resisted by others. There are many examples of good inventions and ideas that have failed to materialise perhaps due to some or all of the obstacles mentioned above.

It should be noted that this project has focused on delivering the solution for specific needs within the sponsoring company, but its findings can and should be used to assist others that may be faced with a similar problem.

13.   Future work

Once the user has gained confidence in using the new system for all their IT activities,(due to its simplicity) it will then be possible for the company , through another simple monitoring

system that purely counts the number of times an address has been visited by each computer, to monitor their employees daily activities and to make considered judgements as to what topics is of particular interest and to expand the available information/knowledge in those areas. Also the company will be able to realise their strengths and weaknesses of their employees through the system and address them accordingly.

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<u>Appendix D</u>

Paper 4

Under review

"The Journal of Information and Knowledge Management"

By World Scientific Publishers

Information & knowledge visualization and its application in the Construction Industry

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ABSTRACT

Global market and economy dictates closer collaboration between nations. With the provision in free movement of labour in the European Market as well as the need for migrant labour from the rest of the world, better means of communication other than language has become essential to provide safety and enhance performance. This paper highlights the problems encountered due to lack of a common language within a typical medium- large construction company in particular and in the UK and the rest of the world in general and suggests that visualization methods could be the key to ease the transfer of information and knowledge. The paper begins by exploring the problems the construction industry is currently facing in field of communication within its workforce, followed by a background to the current needs of the industry in this field. It then proceeds to define the concept of information and knowledge visualization with particular emphases given to the Construction Industry. This paper explores

the potential fields for Visualisation application within the Construction Industry and by presenting the result of a survey, carried out on a live project, highlights the problems that exists. It then proposes alternative methods to resolve issues by utilising Visualisation concept. The paper concludes by offering visualisation concept's viability, as a tool, to transfer information and knowledge within the construction industry and the wider market facing the same dilemmas.

Keywords: Knowledge Visualization, Knowledge Visualization in Construction, Migrant Workers, Visualization Methods, case study.

1   INTRODUCTION

"*Habit differs from disposition in being more lasting and firmly established. The various kinds of knowledge and of virtue are habits, for knowledge, even when acquired only in a moderate degree, is, it is agreed, abiding in its character and difficult to displace...*"
Aristotle (Born 384 BC)

New ways of thinking have always been the backbone of progress and inevitably as with any new ideas that might be welcomed by some could be rejected by others. There are countless examples of good inventions and ideas that have failed to materialised due to lack of presentation and/or confidence to drive it through the barriers.

The use of visual presentation as a media to acquire, supply and exchange ideas, information and knowledge in a user friendly manner could be the key to train and educate, regardless of language and to some extend educational background. This not only can prove to be a practical supplement and in some cases an alternative to language but it could also be vital in certain circumstances.

 '*making knowledge visible so that it can be better accessed, discussed, valued or generally managed is a long standing objective in knowledge management.* Sparrow (1998)

Human brain activity mainly deals with analysing and processing visual images. There are several studies and research in this area and majority seem to arrive to the same conclusion

i.e. visual representation is superior to verbal sequential representation in different tasks for example pattern identification, present overview and details, improve understanding and problem solving, and communicate different types of knowledge.[Bauer and Johnson-Laird, 1993; Novik and Hmelo, 1994; Novick , 2001; Larkin and Simon, 1987]

Burkhard (2005) confers he emphasises that *our* brain does not differ greatly from that of our ancestors, the troglodytes. He adds that at the time, perception helped for basic functions, for example for hunting (motion detection), seeking food (colour detection), or applying tools (object-shape perception).Lengler (2007) describes a working definition for visualization as '*Visualization method is a systematic, rule-based, external, permanent, and graphic representation that depicts information in a way that is conducive to acquiring insights, developing an elaborate understanding, or communicating experiences.*'(Kosslyn, 1980; Shepard and Cooper,1982) shares this vision and adds that visual recall seems to be better than verbal recall.

 It has been said that a picture speaks a 1000 words; in addition it can also be argued that "a picture speaks a 1000 words in any language".

The major barrier to gathering useful information is not finding what is available but finding what is available to satisfy our needs. The problem is not how the information is presented but how we perceive it to be presented and consequently, if it is not, we bypass or ignore useful information and on occasions when we do find it, it is used and forgotten.

Architects have successfully used visualisations methods for centuries to create and transfer knowledge among individuals from different cultural, social, economic and educational background.

2   AIM

The aim of this paper is 'To explore the possibilities of finding new ways for easier transfer, storage and presentation of information and knowledge by using a tool that is in keeping with human cognition.

3   OBJECTIVES

To be able to achieve the goal for this paper the following key objectives were set to be explored:

1. Analysis of the problem

2. The user's view

3. Effective methods in information and knowledge transfer

4. A brief introduction in visualisation concepts;

5. How can visualisation help?

6. A case study in a successful deployment of the theory in a live project

7. Outcome of the research and conclusion

4   THE NEED FOR CHANGE

The UK construction industry is currently experiencing an unprecedented volume of migrant labour from Eastern European countries as well as other parts of the world, a good proportion of which are working in the construction industry. This new labour force's performance and Health and Safety can be impaired due to inability to communicate in a common language. Majority of migrant workers occupy higher risk jobs and usually work in the most hazardous sectors. They often can't read and/or write in English and in some cases can't speak or understand the English language. They therefore rely on their fellow workers to keep them informed on safety briefs and method statements, essential to their safety and performance.

On the other hand the demand for delivery on tight programmes is increasingly putting more pressure on contractors for speedy operations. Consequently employers tend to neglect or overlook the new workforce's short comings and in turn may expose them to unnecessary risks in a hazardous environment.

Corvalan (1994) following a study of 1,211 cases of work related fatalities among people from 51 nationalities working in various sectors in Australia, concluded that the fatality rate was higher amongst non-English speaking workers than that of the indigenous Australians.

This case study argued that language and duration of residence are important determinants of safety at work in Australia.

The extend of the problem in the UK can also be deduced from the some of the headlines appearing on the news such as "*UK workers outnumbered by foreigners on London sites*, *MPs heard that 40% of construction workers in London were migrants in 2006 - up from just 21.5% in 2001*., "It's possible that it has now topped 50% in London, although it's impossible to get totally accurate information on migrant labour in London." A UCATT spokesman confirmed.[1]

Concerns that migrant workers could be missing out on crucial health and safety training because of their employers unwillingness to provide safety material in any language other than English has prompted the Health and Safety Executive (HSE) and the Trades Union Congress (TUC) to produce new safety information to be translated into 21 different languages.

There have been a number of fatalities involving migrant workers employed in the UK. Workplace deaths are on the increase and there's a danger that we could soon start to see more fatalities and serious injuries at work as language barriers mean safety messages are not getting to the people involved. Salt&Millar (2005)

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There are also calls from the academic profession for change, Anumba et al. (2000)[12] found that: 'Competitive pressures from within the industry as well as external political, economic and other considerations are now forcing the industry to re-examine and improve its modus operandi'.

Employers have a duty under the Health and Safety at Work Act to provide all their employees with the appropriate safety training to enable them to do their jobs without risk of illness or injury. But in some cases without the means to transfer information and knowledge this task will prove to be very difficult if not impossible. On the other hand if the employers refuse to take on labour purely because of the persons understanding of English, they could be accused of being prejudice and there may be legal implication for their company.

5   ANALSIS OF THE PROBLEM

On an existing building project, constructing three schools in Slough UK, a survey was carried out to establish the extent of this problem. The number of people working on the project as an average over the construction period ranged between 250-400/day.

The following pie chart has been produced to show extent of the problem on a typical live project near London. As can be seen the numbers seem to agree with what the papers were projecting. It was then agreed to carry out a further survey to establish the extent of the language problem within the group of employees. It should be noted that overwhelming majority of the people interviewed were working for subcontractors and received wages rather than salaries as is normally the case in construction industry.

Percentage of indigenes and foreign workers

41% Indigenes

Foreign

59%
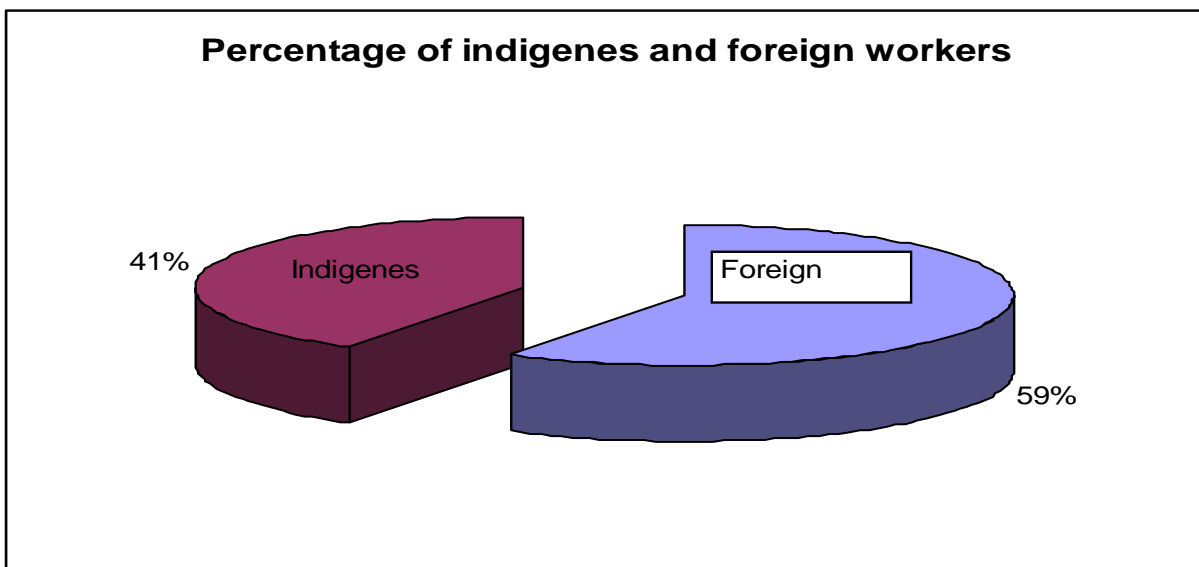
Figure A- Percentage of Indigenise and foreign workers on a typical London construction site
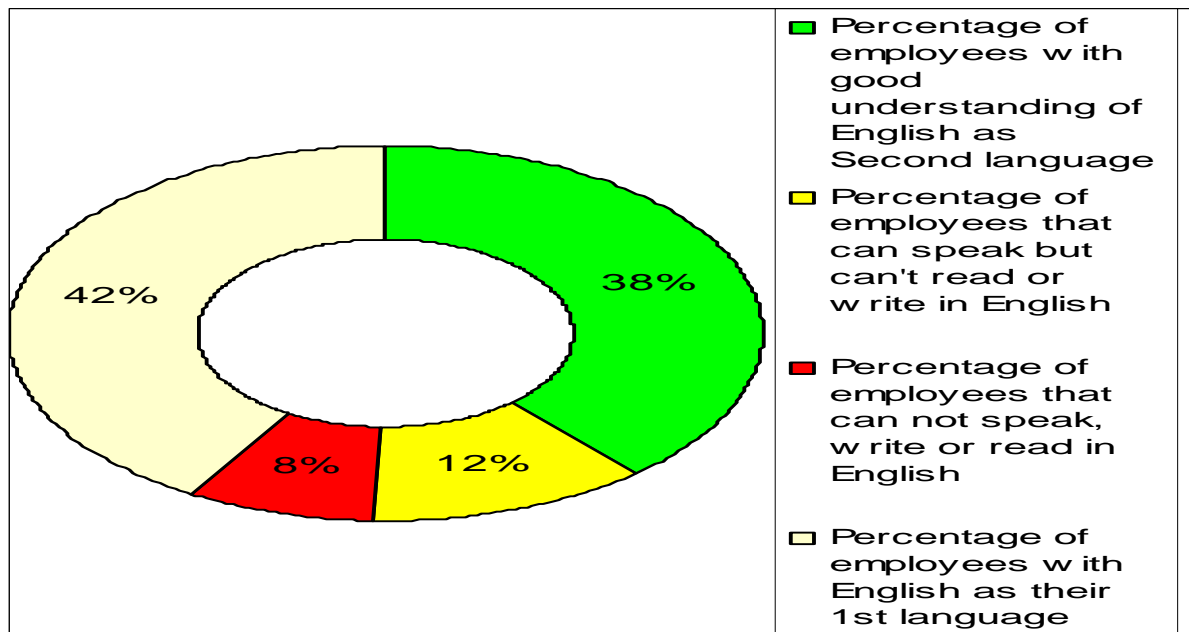
Figure B -Percentage of employees with language difficulties

The above chart was developed showing percentage of foreign workers against total employed and the percentage of people that cannot read and write and/or understand the English language. This survey shows that about 12% do not understand any written signs displayed and/or cannot read method statements and health and safety written signs, and 8% cannot understand any English verbal or written. This clearly poses a problem in terms of performance and from the health & safety prospective.

Carty (2005) [13] observes, "It's difficult to find the needed technical expertise; he adds "This is a common symptom that sometimes has as much to do with your approach as your selection of technology. He concludes "if you find that your staff is short on the skills needed to meet the schedule in a timely and cost-effective way, you may have chosen the wrong technology vis-à-vis your resources."

6   INFORMATION AND KNOWLEDGE PRESENTATION

- The mind remembers key words and images, not sentences

- "Memory is naturally associative, not linear. Any idea probably has thousands of links in human mind"

- We remember what stands out (9/11). Visual quality allows you to make key points to stand out easily.

- Need to use the same structure as memory itself

Capturing and sharing knowledge so that the right information gets to the right people at the time and in its simplest format has many compelling benefits. Unfortunately, in the construction industry not only the information and knowledge is normally provided for the indigenous workers but also it has been composed by managers and gurus in the field that not only need to provide the information to the employees but also have to include some jargon to cover the company legally hence often the information is either misunderstood or too cumbersome to read. With the best of intentions more resources are given to fine-tune the technical components than on improving the fundamental information and knowledge transfer processes issues. Consequently it ends up generating resistance and frustration among users who don't want to be bothered with anything that distracts them from solving the issue in hand. .
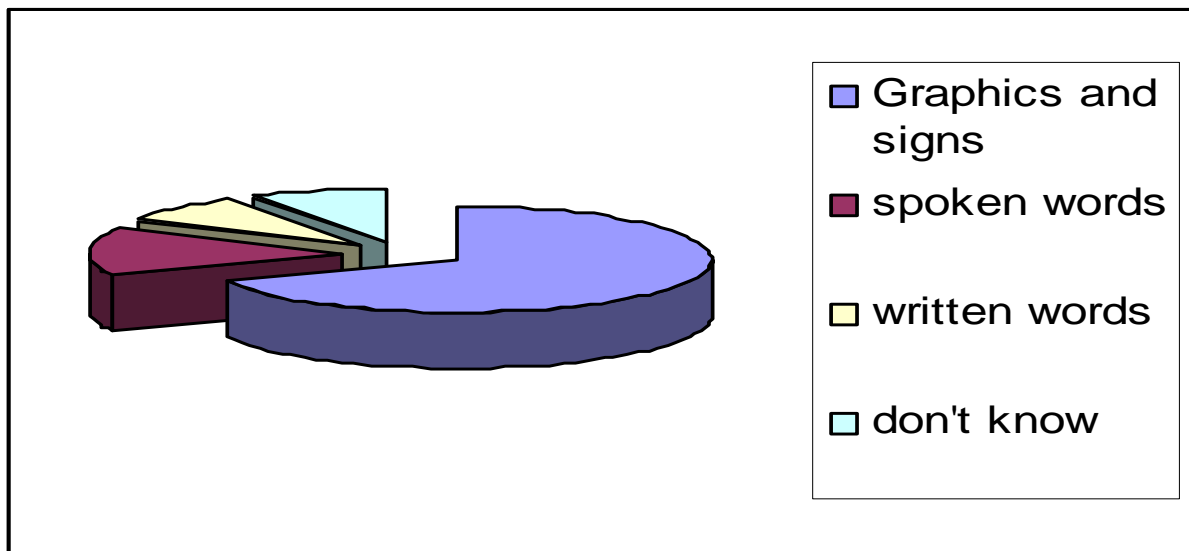
Figure C- Comparison between methods of learning

Following a survey on a typical construction site the result shown on the above pie chart indicates the preference of the workforce in how they would like information to be presented to them.

7 LITERTURE REVIEW IN METHODS OF INFORMATION AND KNOWLEDGE TRANSFER

Miller [1956] reports that a human's input channel capacity is greater when visual abilities are used.

Koffka [1935] observes that our brain has a strong ability to identify patterns, which is examined in Gestalt Psychology

Tony Buzan developed an effective method of note taking that uses the generation of ideas by associations called Mind Maps™. The principals of this form of knowledge presentation is to start from centre with the main idea/query and works outward in all directions, producing a growing and organised structure. This includes key words and images. According to Tony Buzan the main features of this methods are:

- Key Words
- Association
- Organisation
- Clustering
- Visual Memory - Print the key words, use colour, symbols, icons, 3D-effects,arrows and outlining groups of words
- Outstandingness
- Conscious involvement

He emphasises that with this method there is only need to start with a basic problem as the centre and proceed by generating associations and ideas from it in order to arrive at a number of different possible approaches, he concludes by utilising this manner and possibly using colour and pictures, a better overview is gained and new connections can be made visible.

Nowadays we seem to use these techniques in our day-to-day activity without realising it, the examples of this is sending text by phone and rationalisation or surmising long words into small but understandable equivalents which on their own maybe meaningless but given the context can relay a message.

A successful example of solving the problem of language by visualisation methods is in the motoring signage; it can be understood wherever they are displayed in any part of the world regardless of language. Other successful examples include the underground, road , train and flight route maps.

"Look around you - symbols are everywhere. From signs in airports to icons on computer screens - we increasingly communicate not only in words, but with images", Wycoff (2005)

Records from the Egyptian times indicate the use of figures as an effective way in transferring knowledge. The real challenge is to utilise the principals of Knowledge Visualisation to a point where one can transfer information and knowledge solely by looking at symbols, graphics and figures therefore the use of language as a way to convey essential information can be side stepped. An increasing amount of research in this area is needed before the potential of this objective can be realised.

The other successful example of visualization is the use of Windows operating system, it uses visualisation as an effective tool to display information.

As a part of this research effort has been made to emulate future concepts of a user friendly building site. One of the tools utilised is the use of colour coding in access points to buildings and internal spaces of large building sites to map out and locate areas of work, the labour force can receive their job brief and safety updates either in paper format or ideally via PDAs and be directed to their place of work by allocation of colours on display at strategic places throughout the building from a single point of entry to the site. The colours can be changed using computers and multi colour lighting at key points in the building at the start of each working day/week. .

Utilising Information and Knowledge Visualisation tools, as the primary source of information presentation and retrieval, could be the answer.

"In knowledge development, researchers have found through empirical studies that people can more quickly integrate and act on information presented visually. "Botler (1991)
The thought dates to Vygotsky in the 1920s:

"The independent elements in a visual field are simultaneously perceived; in this sense, visual perception is integral. Speech, on the other hand, requires sequential processing. Each element is separately labelled and then connected in a sentence structure, making speech essentially analytical." Vygotsky (1930)

8   VISUALIZATION;A BRIEF INTRODUCTION

The transfer of knowledge is a core process in knowledge management and difficult to manage [Probst et al., 1997]. Visual metaphors can improve this process [Nonaka,1991; Eppler, 2003. Our research group focuses on *knowledge visualization*, which examines the use of visual representations to improve the transfer of knowledge between at least two persons. Knowledge visualization integrates results from information visualization [Bertin, 1974; Card et al., 1999; Chen, 1999; Ware, 2000], cognitive art [Horn, (1998)communication science [Fiske, 1982], information architecture Wurman (1996) and knowledge management ,Alavi and Leidner, (2001).

Studies in visual cognition lead to a conclusion that visualization dramatically Increases our ability to think and communicate. Eppler and Burkhard (2005)

All writing fosters categorical thinking and analysis, because analysis is built into the very act of writing. Writing is a technology for dividing the world into categories.

Visualization is any technique for creating images, diagrames, or animations to communicate a message. Visualization through visual imagery has been an effective way to communicate both abstract and concrete ideas since the dawn of man. Examples from history include cave paintings, Egyptian hieroglyphs, Greek geometry, and Leonardo da Vinci's revolutionary methods of technical drawing for engineering and scientific purposes.[26]

Burkhard and Meier (2004) defined knowledge visualization as the use of visual representations to transfer knowledge between at least two persons. [27]

Card et al. (1999) define information visualization, as *"the use of computer-supported, interactive, visual representations of abstract data to amplify cognition*". It is useful in

displaying large amount of abstract data by using simple often graphical means so the end user can digest the results in a glance.[28]

Examples of visual presentations are sketches, diagrams, images, objects, imaginary visualizations and stories. On the other hand knowledge visualization can further transfer experiences, insights, perspectives, attitudes, values, expectations, opinions, and predictions. Knowledge Visualisation integrates methods from a variety of fields, such as Visual Communication, Communication Sciences, Visual Perception and Knowledge Management. [29]

Knowledge transfer is about connection not collection, and that connection ultimately depends on choice made by individuals [16], and amongst individuals with limited understanding of written words it is logical to be of visual nature. The fact that information is available does not automatically mean that it is also used, shared, or understood therefore the effective transfer of knowledge is becoming a key-challenge in today's organizations.

The use of visualization to present information is not a new phenomenon. It has been used in maps, scientific drawings, and data plots for over a thousand years.Human brain has the ability to identify patterns in graphics, colours and visual images.

The recent interest in Knowledge Management on the part of the business community (Becerra-Fernandez *et al.*, 2003; Takeuchi & Nonaka, 2004; Tiwana, 2000) has brought attention to the effective portrayal and sharing of knowledge, and awareness to the issue of knowledge visualization.

Card et al. [1999]   define it, as ″ the use of computer-supported, interactive, visual representations of *abstract data* to amplify cognition".

According to Eppler and Burkhard (2005) six formats can be distinguished in Knowledge Visualization: Heuristic, Sketches, Conceptual Diagrams, Visual Metaphors, Knowledge Animations, Knowledge Maps, Domain Structures.[21]

Eppler [2003] describes six advantages of Visual Metaphors: (1) to motivate people, (2) to present new perspectives, (3) to increase remembrance, (4) to support the process of learning, (5) to focus attention and support concentration of the viewer, (6) to structure and coordinate communication.[33]

9 HOW CAN VISUALIZATION HELP?

Visualization is a tool to make Information and Knowledge transparent and easy to cognate. To be able to use visualisation as a tool for better transfer of information and knowledge the distinction should be made between information and knowledge visualisation.

Information Visualisation can be used to digest large amount of data by utilising the human ability in recognising patterns and rationalising techniques and knowledge visualization will make transfer of knowledge , in certain cases, easier and simpler to perform.

Visual Imagery [Kosslyn, 1980; Shepard and Cooper, 1982] suggests that visual recall is better than verbal recall. (Yet, it is not clear how images are stored and recalled, but it is clear that humans have a natural ability to use images).

Visual representations are superior to verbal-sequential representations in various cognitive tasks [Larkin and Simon, 1987; Glenberg and Langston, 1992; Bauer and Johnson-Laird, 1993; Novick, 2001].

Instructional Psychology and Media Didactics investigate the learning outcome in knowledge acquisition from text and pictures [Mandl and Levin, 1989][36], and Weidenmann [1989] explores aspects of illustrations in the learning process.

Therefore visualization could be possible solutions to encourage indigenous as well as foreign workers in absorbing at the very least the safety aspects of the jobs in hand.

Figure C shows some examples of passing on information through visualisation in its simplest form but the opportunity exists in making other aspects of safety and job briefs to be presented in similar forms.

Figure D - Passing on Information through visualization

In the same way as assembling manuals on some flat pack goods show the instruction by the use of diagram's and not written words drawing from users experiences as well as their logic,

cost saving in translation into many languages for international companies as well as addressing the needs of those that cannot read. It also saves paper and time therefore benefits the environment.

The use of visual metaphors is effective for knowledge communication. Eppler [2003] describes six advantages: (i) to motivate people, (ii) to present new perspectives, (iii)to increase remembrance, (iv) to support the process of learning, (v)to focus attention and support concentration of the viewer, (vi) to structure and coordinate communication. [Eppler, 2003]

10   OUTCOME OF THE RESEARCH

A process was developed from the principals of this research for the safety department that have been used to great effect within the sponsoring construction company. The use of graphics in the induction and risk assessment process, following are a few snap shots of the system
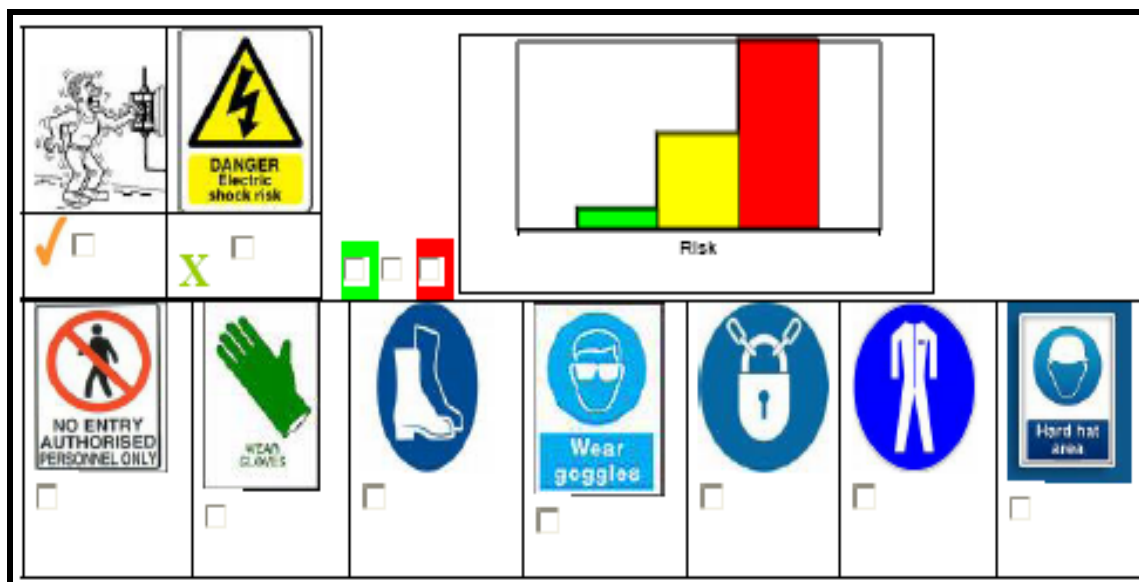
Figure P4 (20) Risk assessment screen shot E
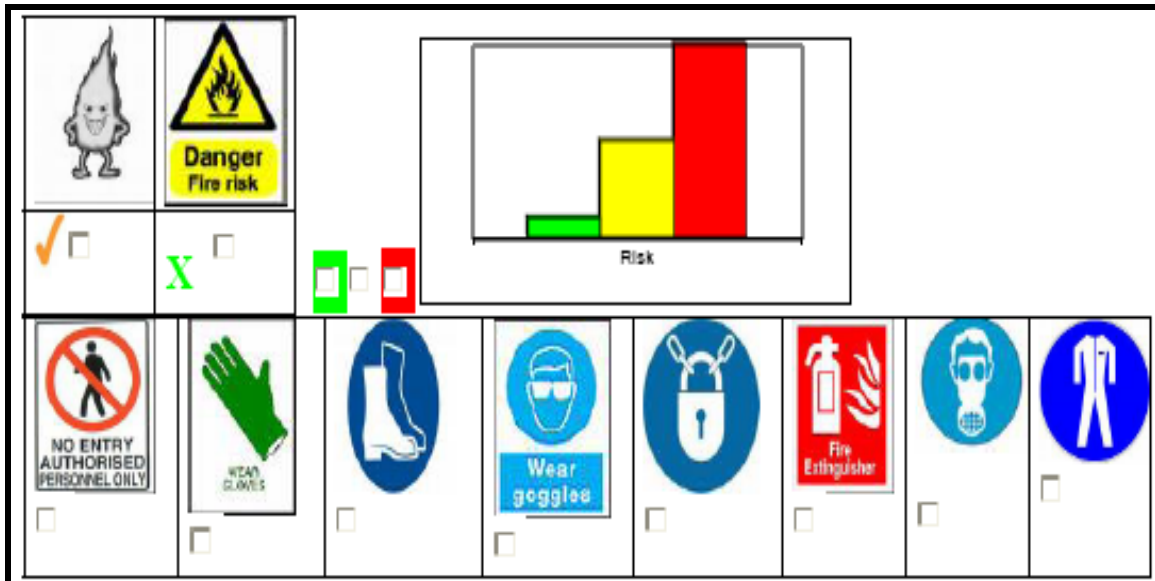
Figure P4 (21) Risk assessment screen shot F
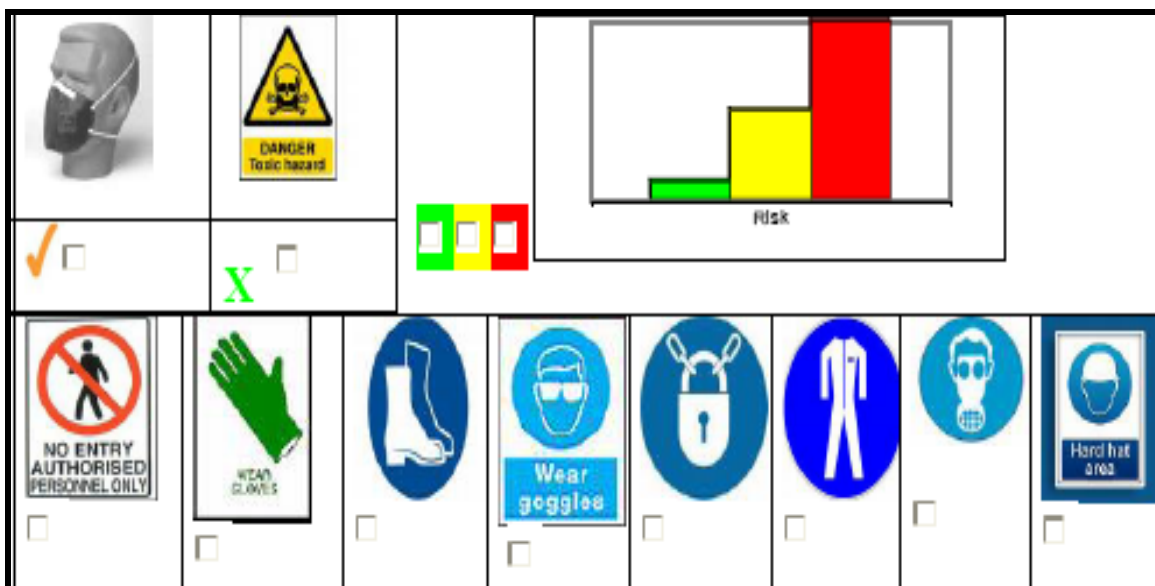
Figure P4 (22) Risk assessment screen shot G

The process works by presenting the users with graphics rather than written words to ensure that regardless of language and education the user understands the risks involved in certain operations. This method starts by presenting graphics and safety symbols to the user and also presents the user with the options of selecting yes or no to identify if there are hazards to a

particular operation. It then asks the user to identify the scale of the risk that they think they and those around them maybe exposed to. The program then proceeds to identify the protection required for a particular operation and gives the user the option to elect the equipment they should have in the given situation. The system than evaluates the responses against an agreed parameters for a particular risk and if the user has identified the right equipment for the risk .It will then issue a permit showing the safety equipment that should be used to ensure safety of those that are affected by it, which can be inspected by the supervisors at any time.

The data gathered from individuals will be held in the data base for future analyses .The database will highlight the operations that had elements of risk associated with them, it can also be used to understand which elements of work have caused accidents and what part of the design could be improved to do away with the risks associated with those elements highlighted.

This method not only ensures that everyone, regardless of their understanding of language and education understands the safety messages but also covers the employer in ensuring that the safety messages get through to its employees without having to translate it into 21 languages , as requested by a UCATT spokesman.

This is a small step in introduction of graphics back into learning process in construction industry, the authors have also produced other means of using graphics for people with some understanding of English language and those that cannot be bothered to read pages of text to explore the companies knowledge base system with great rate of success.

9   CONCLUSION

The times are changing, laws and regulations are becoming stricter, more complicated and vague at the same time building works are more sophisticated and specialised and with ever demanding clients and shorter construction periods to complete projects the need for new methods of information and knowledge transfer is becoming essential in the success and wellbeing of employer and employees alike.

New ways of communication can help save lives and enhance performance and profitability. But any change that may result in divergence from statuesque may result in resistance. Set against this is the need to adapt to the times.

It is not right to expect that the inductions, risk assessments and even a safety message potentially should be translated into 21 languages before it is understood by all. At times like this academia and industry should join forces to embrace new ideas and dictate change to ensure the safety and performance are not compromised and they are not forced to seek new ways because of accidents ,tragedies and subsequent new laws, regulations and law suits.

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Appendix E

Questionnaire on Existing System

Research Questionnaire

NAME OF ORGANISATION: NAME OF EMPLOYEE:

DESCRIPTION OF BUSSINESS ACTIVITY:

EMPLOYEE'S ROLE:

Following questions are designed to give an understanding in how you look for
information through your company's IT system.

COMPANY INTRANET

1. How often do you use your company's Intranet?

   Few times a day   Daily   Weekly   Monthly   never

2. What type of information do you generally look for ?

Directory   Documents   procedures & policies   Never use it   Others(Please
specify below)

3. Generally how quickly can you find the information you are looking for ?

Less than Couple of minutes   more than couple of minutes Long time   often give up

4. Are there any information that you like to see included in your companies intranet?, please specify:

No it's perfect   Yes I like to see more…   Too many to list   Don't use it
(Please give reasons)

          (Please specify below)

_____

_____

5. In what way do you think the system could be made more user friendly ? If you select more than one option please number in order of priority;

Graphics rather words(if Possible   Spoken word option   Better search engine   Quicker response

6. Do you have any suggestion for improving the system? Please explain

_____

_____

Collaborative Systems

7. Have you ever used a collaborative system i.e. BuildOnLine, ProjectNet, Humming Bird etc. Please specify the system(s):

Never   Once   more than once

   Always

8. Generally how do you rate the systems you have used,(1 being the lowest and 5 the highest)

1   2   3   4   5

9. What do you think are the main advantages of using this kind of systems, please specify in order of priority
 (1 Heights , 4 Lowest)

Accessibility   Connectivity   Speed   Ease in distributing information

10. Is there any specific information you would like to see included in these systems, please specify :

_____

_____

11. If you have used more than one collaborative system ,which one do you find more useful:

_____

Finding Information on the Web

12. Do you ever use the web for finding information about products or companies etc.?

Always   Often   Sometimes   Never

13. What search engine do you normally use, Please specify?

    _____

    _____

14. What information do you generally look for? Please priorities(1 most - 5 least)

Products   Services   laws & regulations   Contacts & Addresses

   Maps   Others(Please specify)

    _____

15. All being equal what attracts you most to a particular web site? Please priorities in order of preference (1 best-4 least)

Layout   graphics   use of sound   Speed of connection

16. How often do you find the information you are looking for on the web?

   Every time   sometime   not very often   never

17. Please list 4 categories of information, (in order of priority) ,you would like to have access to on the Net.

    _____

Thank you for taking the time to complete this questionnaire, Please contact
barry.nowbati@wates.co.uk If you have any queries or would like to know the outcome of this
survey .

SCREEN SHOT A

SCREEN SHOT B

Appendix F

Questionnaire New System

Research Questionnaire

NAME OF ORGANISATION: NAME OF EMPLOYEE:

DESCRIPTION OF BUSSINESS ACTIVITY:

EMPLOYEE'S ROLE:

Following questions are designed to give an understanding in how effective the alternative route to finding information has been.

18. How difficult was it to load up the software ?

  Very easy   Relatively easy   quite hard   Very hard   Couldn't load it

                         (Please specify)

19. Did you have any training before you used the software ?

No   A little   some   A lot

20. Generally how quickly did you find the information you were looking for ?

Less than Couple of minutes more than couple of minutes Long time   often gave up

21. Compared to other systems you have used how do you rate this software ?

Excellent   Good   Same   Worse Couldn't use it (please give reasons)

22. In what way do you think this software could be made more user friendly ? If you select
more than one option please number in order of priority;

Graphics rather than words(if Possible)   Spoken word option   Better search engine
Quicker response

23. Do you have any suggestion for improving this software?

_____

_____

24. Did the new software make the use of Collaborative systems any easier ?

Yes   No   Made no difference   Didn't use
it

25. Generally how do you rate the software you have used,($\underline{1}$ being the lowest and $\underline{5}$ the
highest)

1   2   3   4   5

26. What do you think are the main advantages of using this kind of software, please specify
    in order of priority
    (1 Highest , 4 Lowest)

Accessibility   Connectivity   Speed   Ease of use

27. What do you think are the main disadvantages of using this kind of software, please
    specify in order of priority
    (1 Lowest , 4 Highest)

Not logical   complicated   slow   Not user friendly

28. Is there any specific information you would like to see included in the software, please
    specify :

    _____

    _____

29. Do you think your company would benefit by using this software or would you say this is
    yet another new software that may not have a future? Please explain your reasons.

    _____

30. Do you think this software could have a personal use ?

Yes   No   maybe   Don't know

31. Do you think this software could be used for all your IT activities ?

Yes　　　　No　　　　　　　Maybe　　　　　　　Don't know

Please give your reasons

_____

_____

32. What information did you generally look for? Please priorities(1 most - 5 least)

Products　　　　　　Services　　　　　laws & regulations　 Contacts & Addresses

　　　Maps　 Others(Please specify)

_____

33. Would you recommend the use of this software ?

Yes　　　　　　　No　　　　　Maybe　　　　　　Don't know

y

34. If you had to choose one reason for liking or disliking this software what would that be
　　and why?

_____

_____

_____

Thank you for taking the time to complete this questionnaire, Please contact

barry.nowbati@wates.co.uk If you have any queries or would like to know the outcome of

this survey .

Screen shots of the new system