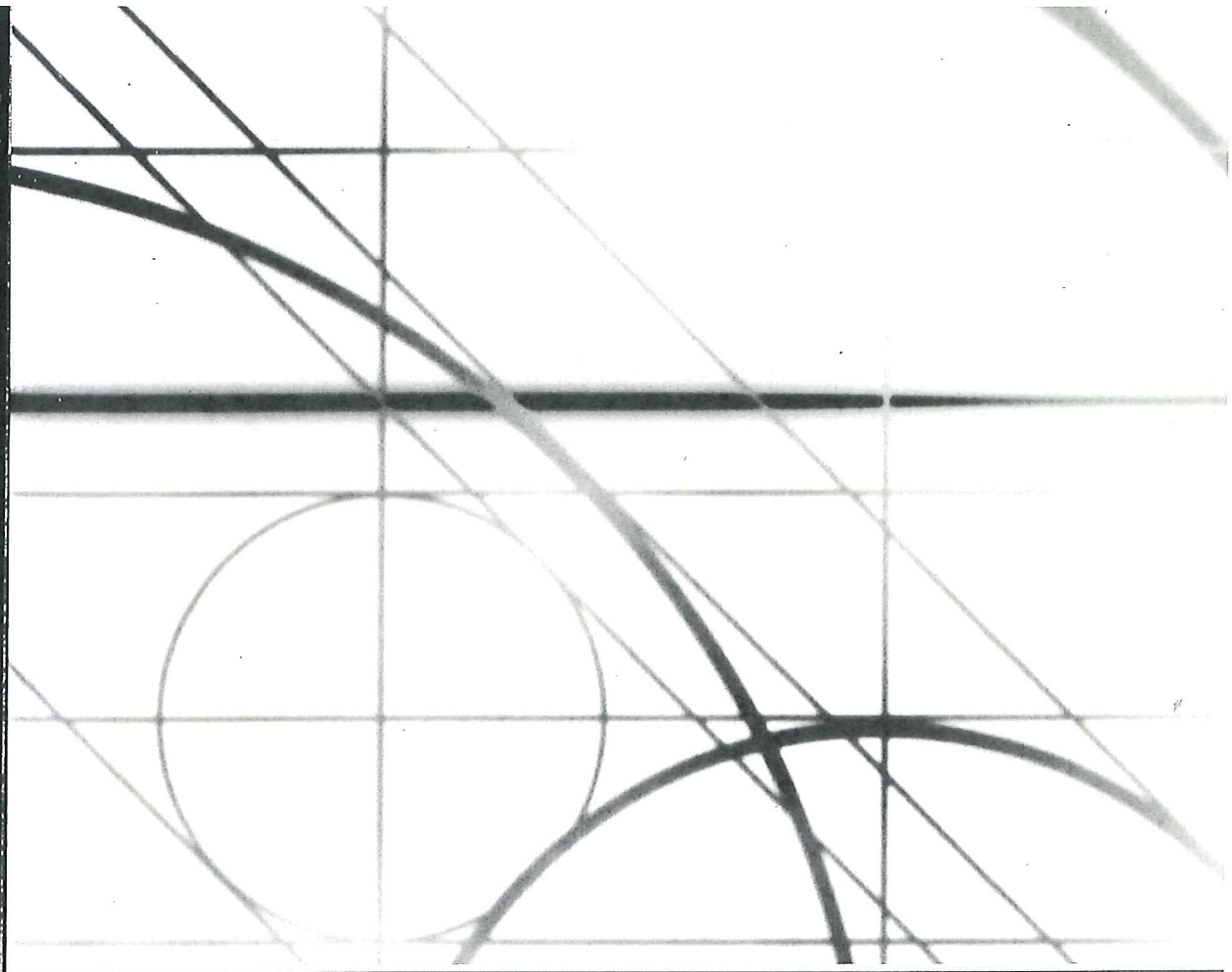


Application of GIS to Labour Market Planning in Construction

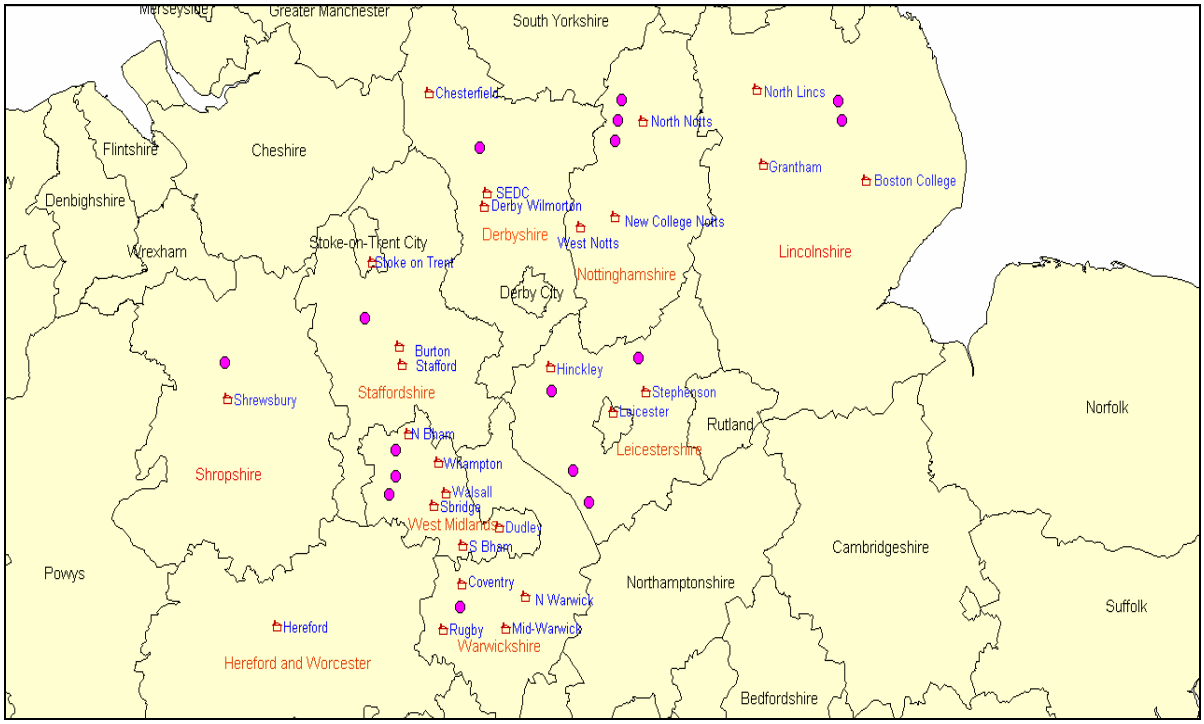
Claire Anumba

CICE

Loughborough University

Application of GIS to Labour Market Planning in Construction

Claire Anumba



CITB-ConstructionSkills
Midlands Area
Belton Road Industrial Estate
20 Prince William Road
Loughborough
Leics, LE11 5TB

Centre for Innovative and Collaborative Engineering (CICE)
Loughborough University
Loughborough
Leics, LE11 3TU

Loughborough University

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APPLICATION OF GIS TO LABOUR MARKET PLANNING IN CONSTRUCTION

By
Claire Anumba

A dissertation thesis submitted in partial fulfilment of the requirements for the award of the degree, Doctor of Engineering (EngD), at Loughborough University

April 2006

CITB-ConstructionSkills
Midlands Area
Belton Road Industrial Estate
20 Prince William Road
Loughborough
Leics, LE11 5TB

Centre for Innovative and Collaborative Engineering (CICE)
Loughborough University
Loughborough
Leics, LE11 3TU

ACKNOWLEDGEMENTS

I would like to express heartfelt thanks to a number of people who have supported and made this research possible. Firstly I would like to thank staff at CITB-ConstructionSkills in the Midlands (especially Ms Amanda Sergeant my industrial supervisor) for their help and support and making me feel part of the team during the research.

I would also like to thank my academic supervisors, Drs Andrew Dainty and Stephen Ison for their commitment, support, patience and guidance which has been invaluable. I am also grateful to the CICE Centre staff (Jo, Colette and Sara) for their administrative support.

I also extend my thanks to my family especially my husband Chimay without whose love, support, help, wisdom and encouragement I would not have been able to complete this journey. I am also indebted to my mum for help with childcare, and my daughters Nmachi and Kenechi who have this amazing ability to make everything alright no matter the circumstances. Above all, I want to thank God for seeing me through and teaching me to depend on Him always.

ABSTRACT

The fluctuations in the demand for construction work have often resulted in skills shortages. This has led to the need for effective construction labour market planning strategies, which enable the construction industry to meet its skills requirements, particularly in periods of peak demand. Existing approaches to construction labour market planning have several limitations. They do not shed light on the socio-economic and spatially influenced issues within which the industry's skills shortages are rooted. There is, therefore, a need for more appropriate decision-support mechanisms that can take account of spatial problems in terms of skills demand and supply influences. Through industry involvement, this research has explored how GIS can enhance the labour market planning process in construction. The research briefly reviews the nature of labour market planning in construction, introduces geographic information systems, and highlights the opportunities they offer for overcoming the limitations of existing approaches. The implementation of the GIS-based system and its application to a specific labour market planning initiative is then presented. The evaluation of the system by prospective end-users reveals the enablers, barriers and benefits of the system implementation. Organisational issues that had a bearing on the implementation are also examined and recommendations made for further research.

KEY WORDS

Labour Market Planning, Geographic Information Systems, Construction, System Implementation, Spatial Data

PREFACE

This thesis is a result of the research conducted in requirement of an Engineering Doctorate (EngD) at the Centre for Innovative and Collaborative Engineering (CICE), Loughborough University. The research was sponsored by the CITB-ConstructionSkills in the Midlands, the Sector Skills Council for the Construction Industry in the UK.

The EngD is a radical alternative to the traditional PhD, being better suited to the needs of the industry with the main essence being development of innovative thinking, while addressing real industrial problems.

The EngD is examined on the basis of a thesis that comprises at least three (but not more than five) research publications. This thesis contains a discourse of about 20,000 words supported by four refereed papers (2 conference papers and 2 journal papers). They are numbered 1 to 4 and are attached as appendices to the thesis. They must be read in conjunction with the discourse to allow the reader to have a better understanding of the research.

USED ACRONYMS / ABBREVIATIONS

CITB	Construction Industry Training Board
CIB	Council for Research and Innovation in Building and Construction
CICE	Centre for Innovative and Collaborative Engineering
DTI	Department of Trade and Industry
EngD	Engineering Doctorate
EOC	Equal Opportunities Commission
ESF	European Social Fund
GIS	Geographic Information Systems
HRP	Human Resource Planning
ICT	Information Communication Technology
IER	Institute of Employment Research
IIP	Investors in People
ILM	Intermediate Labour Market
ITN	Integrated Transport Network
LMP	Labour Market Planning
LMI	Labour Market Information
LSC	Learning and Skills Council
NET	New Entrant Training
NETO	New Entrant Training Officer
NVQ	National Vocation Qualifications
ONS	Office for National Statistics
OSAT	On Site Assessment Training

RDA	Regional Development Agency
SSC	Sector Skills Council
UK	United Kingdom

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LIST OF PAPERS

The following papers have been published during the research undertaken for the Engineering Doctorate. Papers one to four are included in the appendices and are submitted as part of the thesis.

Paper 1
Anumba, C., Dainty A.R.J., Ison, S.G. and Sergeant, A. (2004): The Utilisation of GIS in the Construction Labour Market Planning Process. *In Proceedings of the International Conference on Construction and Building Research 'Responding to Change'*. Leeds, UK. 7-8 September 2004. Available on CD

Paper 2
Anumba, C., Dainty, A.R.J., Ison, S.G., and Sergeant A. (2005): The Application of GIS to Construction Labour Market Planning, *Construction Innovation,* 5, 219-230

Paper 3
Anumba, C., Dainty A.R.J., Ison, S.G. and Sergeant, A. (2005): GIS-Based Diversity Planning: A Case Study In Proceedings of the International Conference on Computing in Civil Engineering "Dare to Think Outside the Box; Push the Envelope; and Present the Future in Computing in Civil Engineering". Cancun, Mexico. July 12-15, 2005. Available on CD

Paper 4
Anumba, C., Dainty A.R.J., Ison, S.G. and Sergeant, A. (2006): Understanding Structural and Cultural Impediments To ICT System Integration: A GIS-Based Case Study – accepted for *Engineering, Construction and Architectural Management Journal.*

ADDITIONAL PAPERS (NOT INCLUDED IN THESIS)

Anumba, C., Dainty A.R.J., Ison, S.G. and Sergeant, A. (2003): Towards GIS-Based Employment and Training Needs Forecasting in the Construction Industry. In Proceedings of 3rd International Postgraduate Research Conference in the Built and Human Environment. Lisbon, Portugal. April 3-4 2003

Anumba, C., Dainty A.R.J., Ison, S.G. and Sergeant, A. (2006): Integrated Construction Labour Market Planning using GIS. In Proceedings of the ASCE 2nd Speciality Conference on Leadership and Management in Construction and Engineering 'international perspectives'. Grand Bahama Island, Bahamas. May 4-6 2006.

Chapter 1: Introduction

1.1 Introduction

This chapter presents the background to the research undertaken in this thesis. It provides a general introduction to the subject domain, justifies the need for the research detailed within the thesis and sets it within the industrial context. The structure of the thesis is presented to provide clarity and direction to the reader. A synopsis is provided of each of the published papers that have been produced over the four years of the EngD, that should be read alongside the discourse.

1.2 The Construction Industry Labour Market

The construction labour market is complex and diverse due to the many professions involved and its transient workforce. This makes planning for the future extremely difficult. According to the DTI (2006), the United Kingdom (UK) construction industry is one of the strongest in the world, with output ranked in the global top ten. It has been going through a period of sustained growth, for example, in the second quarter of 2005 the total volume of construction output rose by 6% compared to 2004 (DTI, 2005). Such high rates of growth place considerable pressure on the industry's labour market and there are widespread concerns that it will not have the manpower to cope with such growth (Delargy 2001, Crates 2001). This is supported by the Construction Industry Training Board (CITB) ConstructionSkills Employers' Skills Needs Survey carried out in 2003, which clearly showed the impact of the industry's skills shortage. The survey revealed that nearly 70% of the respondents said they were experiencing recruitment difficulties, with craft trades presenting the most problems. With regards to the skill levels of their current workforce employers were mainly happy, but stated that the skills of new recruits were more of a problem. As a result of this, the attraction and retention of skilled construction workers has become a top priority that the industry needs to address (Yankov and Kleiner, 2001).

1.3 Labour Market Planning

There are several terms used to describe the concept of planning for the future of the labour force or workforce. These include Labour Market Planning (LMP), Manpower Planning and Human Resource Planning (HRP). The term Human Resource Planning is usually used to refer to planning for the needs and future of an organisation's workforce while Labour Market Planning and Manpower Planning refer to the planning for a larger workforce such as that of an industry (Idris and Eldridge, 1998). However, there appears to be some confusion as to the precise meaning of the terms within the literature. For example, Zeffane and Mayo (1994) state that HRP consists of a range of tasks designed to ensure that the appropriate number of the right people are in the right place at the right time, whereas Lynch (1982) states that human resource planning ensures the optimum use of the personnel currently employed and provides for the future of

staffing needs of an enterprise in terms of skills, numbers and ages. This definition is more focused on organisations rather than the industry as a whole.

Synthesising these definitions of the planning process, it appears that labour market planning basically comprises a means of trying to understand and predict what the future needs of the labour market will be, and developing strategies for addressing these needs. This includes predicting how many workers will be needed, in say, the next five years, what skills they will require and where in the country they will be needed. These questions can only be answered through labour market analysis, forecasting and planning activities. According to Gritzioyis and Stoll (2002) LMP enables the industry to:

- Develop better human resource strategies;
- Better determine future human resource requirements;
- Create more targeted training programmes;
- Provide more base-line information for labour relations;
- Give employers and workers a competitive edge; and,
- Assist builders and developers to plan major projects.

One of the main limitations of current labour market planning processes is the extent to which they take account of the geographical or spatial influences that affect labour market issues. The information is usually disaggregated at regional level and no further. This can make accessing information below the regional level quite difficult. Although the industry is trying to address these issues through the Observatory (the aim of which is to be the single source of construction labour market information (LMI)) that is being set up, it will take some time before it is operational and useful in a labour market planning sense. There are also issues with the available data as Labour Market Information tends to be produced with diverging frequency from a variety of sources, with implications on the accuracy and variation of the data and its accessibility. Bennison and Casson (1984) refer to the planning process as the “Manpower Map” which takes into account the various scenarios apparent to planners and is subject to continuous revision as circumstance change. There are several factors that affect planning for a workforce and these can be classified into internal and external factors (Zeffane and Mayo, 1994). The internal factors include an organisation’s or industry’s policy on growth from within or by means of recruitment, policy on pay and remuneration, and training. The external factors include technology, competition, legislation and government regulation and the changing social norms and expectations. Both sets of factors need to be taken into account in the labour market planning process. The current approaches used in LMP are discussed in more detail within the next section.

1.3.1 Current Approaches Used In Labour Market Planning

The most common approaches used in planning for a workforce include environmental scanning, interpretation of strategic objectives, audit of the internal human resource, econometric forecasting and formulation of human resource objectives. These are discussed in turn below (it must be noted that some of these approaches are used by individual organisations rather than at an industry wide policy planning level):

1.3.1.1 Environmental Scanning
This entails the identification and analysis of key trends in the external environment having a potential impact on the management of the workforce. This requires the development of consistent patterns in the streams of decisions being made by planners (Mintzberg, 1983). These changes (such as economic changes, government legislation) are monitored as they can have a major impact on future strategies put in place to deal with the labour market (Idris and Eldridge, 1998). It is also important to monitor demographic trends, which have not only a spatial dimension but age, gender, racial and other considerations.

1.3.1.2 Interpretation of Strategic Objectives
Changes in the future of an organisation or industry may involve substantial shifts in the profile of employees required and their jobs. The nature and potential of an industry's human resource are determinants of its ability to adapt to these changes. The role of the analysis is to define the capabilities required to implement the industry's strategy and capacity to adapt to change and still be a competitive force (Walker, 1990).

1.3.1.3 Audit of the internal human resource
This is an inventory exercise which is divided into a micro and macro level. The micro level analysis is made up of current number of employees, their job-related skills, demographic make up, performance levels, management competencies and work attitudes. This helps to identify human resource strengths and weaknesses. The macro level involves the culture and climate of an organisation/industry, performance orientation, and quality of work life, current status and effectiveness of personnel systems of an organisation or an industry (Ekamper, 1997).

1.3.1.4 Econometric Forecasting
This method relies on quantitative methods (such as supply and demand models), which can generate staffing requirements in some detail. Most models used for this approach utilise time series data and employ econometric techniques such as regression models, long run vs short run models to carry out the computations (Briscoe and Wilson, 1993).

1.3.1.5 Formulation of Human Resource Objectives
The aim of this method is to define an organisation or industry's desired human resource position and to put in place programmes or strategies necessary to move in that direction. Short-term strategies for achieving this include attracting potential employees, assessing and assigning employees to jobs. Intermediate-term strategies include readjusting employees' skills, attitudes and behaviours to fit major changes in the needs of an organisation or industry (Idris and Eldrige, 1998).

Despite the usefulness of these approaches in highlighting skills gaps, they do not shed light on the socio-economic and spatially influenced issues within

which the industry's skills shortages are rooted. For example, a certain geographical area might be experiencing recruitment problems linked to a particular upsurge in activity, but the present approaches are unlikely to shed little light on the local and regional labour market issues that might be affecting these areas. Similarly, such models cannot forecast a lack of quality or productive labour within a regional area (Briscoe and Wilson, 1993). This renders their accuracy questionable and undermines their use at a local labour market planning level. There is, therefore, a need for more appropriate decision-support mechanisms that can take account of geographic problems in terms of skills demand and supply influences (Anumba *et al.,* 2005). Geographic Information Systems (GIS) can help to flag up inconsistencies in the data, as the data it requires needs to be structured.

Another limitation of the current approaches is problems with the data that is being used. The data is sometimes inadequate in terms of timeliness, accuracy and fitness for purpose. Frequently, the data available is lacking, often they have been collected for a different purpose and are therefore less than ideal for the planning process (Briscoe and Wilson, 1993). Reliable labour force data is vital to ensure accurate models. Although a variety of labour force information is usually available from many sources, many are unreliable, or too general to provide accurate signals on a specific industry. Agapiou *et al.* (1995) and Jaywardane and Gunawardena (1998) have suggested that a single reliable source of construction labour force information will help to deal with the unreliability in the data.

The emergence of Geographic Information Systems (GIS) offers the potential to better address the spatial dimension in labour market planning. In this context, different and varied datasets can be integrated in order to produce new visual information through highly detailed maps that can be analysed together rather than singularly. This means that there is considerable potential for new information and knowledge to be generated from the analysis of spatial patterns that result from integrating disparate datasets. The scope for improved *decision-making* can be enhanced and an understanding of the issues facing the industry in each geographical region is facilitated. Thus GIS, used to complement other approaches, can enhance the construction labour market planning process. The key components and concepts of GIS are discussed in the next section.

1.4 Geographic Information Systems

1.4.1 Definitions

Several definitions have been put forward for Geographic Information Systems and some of these are:

- A powerful set of tools for storing and retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes (Burrough, 1986);

- Geographic Information Systems are a specialised class of database management systems that allow users to analyse, relate and display the spatial attributes of data in addition to conventional relational data (West, 2000);

- Geographic Information Systems are essentially digital maps linked to database management systems which can be used for the purposes of displaying and querying information, carrying out spatial analysis and assisting in the *decision-making* process (McMahon, 1997);

The above definitions vary slightly in emphasis, although they all acknowledge the spatial focus of GIS and its considerable potential to facilitate analysis and decision making. Within the context of this thesis, the following working definition has been adopted:

Geographic Information Systems are management systems that allow for the integration of disparate spatial datasets to reveal the complex patterns and relationships that can be seen when analysed together rather than singularly (Anumba et al., 2005)

1.4.2 Main Concepts of a Geographic Information System

There are variations in the literature on the concepts of a GIS. Figure 1.1 illustrates the main components of a GIS. These are briefly explained below:

GIS Database: The database enables both spatial and non-spatial data to be stored and retrieved. Spatial data have a physical geographical location associated with them. The database is a fully integrated relational database with the additional capability to link with a graphical user-interface (GUI).

User Interaction: The user of a GIS system has the capacity to interact with the GIS database. He/she can input data, query the database or update the information stored. 'What if' analysis can also be conducted through an appropriate combination of queries to generate useful information.

Outputs: The information requested by the user can be produced in different formats such as maps, charts, tables and reports.

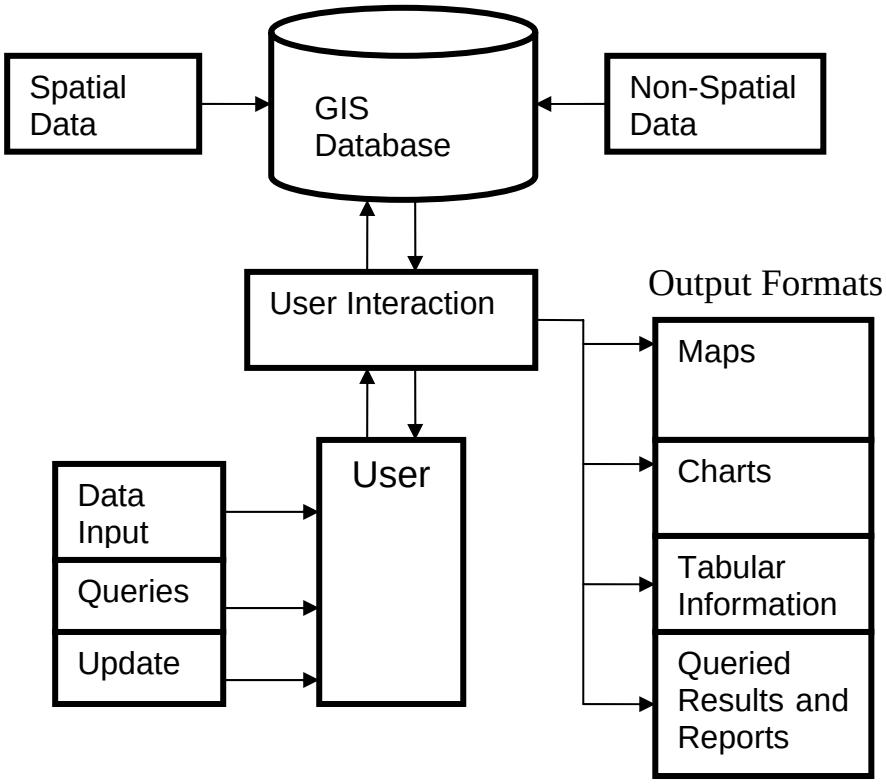

Figure 1.1: Main Components of a GIS (adapted from .Sadiq et al.)

1.4.3 Benefits of GIS

As previously alluded to, Geographic Information Systems offer numerous benefits. Burrough (1996) outlines the following benefits of GIS in labour market planning:

- There is ease of data distribution and access - as a central resource for construction labour market information it will be easy to access and distribute the information to users;

- There is ease of data integration and analysis - different labour market information can be integrated and analysed to reveal the patterns and relationships that exist within the different datasets;

- It has the ability to create highly detailed maps to enhance presentations and aid *decision-making* - having labour market information on detailed maps can give a greater understanding of the geographical issues that affect labour market planning;

- It reveals patterns and trends in the data that cannot be readily seen - the same data over a period of time can reveal geographical trends in labour market information that aid *decision-making* for the future;

- The option to convert and combine manual records to bring to light errors and omissions that might exist in certain datasets - manual records can be inaccurate due to human error. Converting and combining manual labour market information to populate a GIS database will bring to light errors and omissions that exist in the dataset or information. Most GIS systems will allow users to access data from most databases, which saves time that might be required to input data into the software;

- The query mechanism allows different scenarios to be viewed, which will enable decision-makers to come up with positive solutions - asking questions such as “What is there?” “Why are they there?” “What will happen if?” “What might happen if?” Of the data to simulate different scenarios and help strategists when planning for the future of the labour market.

Despite these benefits, the performance and utility of a GIS is wholly dependent on the quality of data. Inadequate or incomplete information will dilute the extent to which a GIS application can deliver the above benefits. Data must also be structured in a way which accords with the input requirements of the system.

1.4.4 Examples of GIS Applications

There are numerous examples of GIS applications in a variety of industry sectors and for a wide range of planning and decision making situations. These are discussed in some detail in Chapter 2 but it is helpful to present a brief set of examples here. Table 1.1 shows these examples of GIS applications in different industries and their key benefits. These are drawn from The Ordnance Survey’s website: www.ordnancesurvey.co.uk.

Although the examples of GIS applications are from different industries, the benefits can also be realised in construction labour market planning. GIS as a central resource of labour market information can produce complete, accurate and up to date data, if the system is updated regularly. The data can also be easily accessible which will save labour time. This means that up to date labour market data can be accessed easily and quickly. Most GIS applications complement information in other databases, which means it can provide an essential and informative geographic context to existing labour market information. GIS will allow users to select, add and integrate various data for analysis to give them a greater understanding of the geographical contexts or issues affecting the labour market. For example the integration of construction unemployment and new work orders figures can help to identify likely under/over capacity in the labour market in the future (see Paper 2).

Table1.1: Applications of GIS (Ordnance Survey, 2006)

Industry	Example of Application	Key Benefits
Local government	Birmingham City Council digitised their polling district boundaries on screen against colour-coded electoral addresses on large-scale map data. By integrating various sources of data with mapping a number of anomalies, including addresses in locations detached from the polling district to which they belonged were identified.	• Reduced labour time for employees • Complete, accurate and up to date data
Healthcare	Healthmap Solutions System is a GIS application used by the Primary Care Trust in Maidstone Weald. It has a user friendly interface that enables the fast and accurate depiction of designated geographic areas at varying scales, and electronic file exchanges with individual GP practices and other project partners to articulate and quickly define relevant catchment areas and addresses-related care service issues.	• Easy to use • Provides central access to map, boundary and site location data for users • Complements and informs existing datasets to provide an essential an informative geographic context. • Enables users to select, add and integrate data.
Transport	Oxfordshire County Council uses the GIS Integrated Transport Network (ITN) layer which is designed to provide flexible representation of Britain's infrastructure in a series of themes. The current ones are the Road Network and Road Routing Information themes, and they comprise of full topological junction links.	• Integration of data makes for efficient management and planning. • Easy access to available up to date information. • Reduced labour time for employees.

Industry	Example of Application	Key Benefits
Insurance	Norwich Union is using a national digital flood map designed to pinpoint the risk to individual properties based on height data, digital terrain modelling and flood trends analysis. To ensure that the height and terrain data delivers maximum benefit, Norwich Union needed to replace the reliance on postcode banding with more detailed address geography for both residential and commercial properties. By focusing down to individual address level, the company establishes which properties within any given postcode area are on raised ground and away from the threat of flood water. The database involves Ordnance Survey's address data which uniquely pinpoints or 'geocodes' more than 26 million addresses recorded in the Royal Mail Postcode Address File (PAF). This instant link between address and location specifically enables highly targeted insurance activities beyond the postcode level such as assessing risk, setting premiums and settling claims. As well as flooding, the link can apply to other peril models.	• The use of individual address rather than postcode data means Norwich Union can make sure the flood risk affecting billions of pounds' worth of property is calculated more accurately. • Policies can be priced more competitively, attracting new customers and growing market share. • Information will be used to amend existing customers' premiums at renewal. • Many people who previously could not obtain flood insurance or faced the prospect of higher premiums can now be covered. • Householders and business owners will be better informed about the risk of flooding.

1.5 The Research Context

1.5.1 The Author

The author, with a background in Information Technology, spent most of the four years of the Engineering Doctorate research working as a researcher in the Strategy Department of CITB-ConstructionSkills in the Midlands region of the UK.

1.5.2 The Industrial Sponsor

The Construction Industry Training Board ConstructionSkills (CITB-ConstructionSkills) is the statutory training board for construction which was set up under the auspices of the Industrial Training Act in 1964. In September 2003 in addition to it being a Training Board it also became a Sector Skills Council (SSC). SSCs are independent, employer-led organisations responsible for

tackling the skills and productivity needs of their industry sectors UK-wide, and have been set up to decide how training is delivered and funded in the UK. ConstructionSkills is a partnership between CITB-ConstructionSkills, the Construction Industry Council and CITB Northern Ireland. This partnership covers the whole UK industry, and all of the skills-related issues that the industry faces. The primary case study unit for this research project is the CITB-ConstructionSkills' Midlands Office. The office is based in Loughborough and employs about 60 people. Given the organisation's responsibility for tackling skills, productivity and training related issues in the industry, the organisation required a GIS system that will enhance their labour market planning processes.

The aim of the research project, from CITB-ConstructionSkills' point of view, was to develop a system which would aid the organisation to ensure that the industry has the right people with the right skills, in the right place and at the right time. It was envisaged at the start of the project that using GIS as a decision support tool would be of benefit to the organisation. GIS offered the opportunity for different and varied datasets to be integrated in order to produce new visual information through highly detailed maps that can be analysed together rather than singularly. This would aid *decision-making* and facilitate understanding of the issues facing the industry and the organisation and indeed the region. The GIS was also seen as a central resource that would hold all the organisation's relevant data to provide easy use and access.

1.6 Scope of the Research, Aims and Objectives and Research Design

1.6.1 Research Scope

This research project is primarily concerned with exploring how GIS can contribute to labour market planning in the construction industry. Although GIS is being widely used in various areas, there is very little evidence to show it has been used in construction labour market planning. GIS has the potential to act as a central resource for labour market information and with its ability to integrate different data for analysis it can help in making the labour market planning process more robust. It also provides an appropriate platform for overcoming some of the limitations of conventional approaches (as discussed in Section 1.3.1).

1.6.2 Aims and Objectives

The main aim of this research study is 'To explore the potential of GIS to inform labour market planning in construction'.

The specific objectives are as follows:

1. Explore current approaches to labour market planning and the datasets used to inform policy;
2. Explore the potential utility of GIS in supporting labour market planning policy *decision-making*;

3. Trial and evaluate the use of GIS to enhance and inform a labour market policy measure;
4. Identify enablers and barriers to the use of GIS as a tool to improve labour market planning

1.6.3 Research Design

The steps that were taken as part of this research include the following:

- The identification of the current approaches to labour market planning and exploring how GIS can enhance these.

- The development of a GIS application to trial its use to enhance a labour market policy measure.

- Identification of factors (both internal and external to the organisation) which affect the uptake and use of the technology as an aid to the LMP process.

The project commenced with a literature review that explored the current state of the industry with regards to its labour market, and GIS as a technology and its use in the industry. The next stage was to identify the requirements of CITB-ConstructionSkills in the Midlands with regards to GIS, and this led to two prototype applications developed. When the organisation decided that they needed a GIS tool to enhance their *decision-making* processes, it was decided that it should be trialled with a labour market policy measure in order to assess its practical utility. An appropriate policy area was identified and the GIS application developed accordingly. The system was evaluated and tested with the user group (CITB-ConstructionSkills Midlands Office staff), after which barriers and enablers to its use were identified. The results from the different stages of the project are published as papers in refereed journals and conferences (see Appendices) and the summary at the end of this chapter). Details of the research project with respect to its aim, objectives, methodology, work undertaken, findings and conclusions are included in the subsequent chapters of this thesis. The next section outlines the structure of the thesis.

1.7 Structure of the Thesis

This thesis documents the work undertaken in the research project. It is structured as follows:

Chapter 1 introduces the EngD research project, provides an introduction to the general subject domain, justifies the need for the research, sets it within an industrial context and introduces the steps undertaken for this research.

Chapter 2 provides a background to the research by reviewing related work on GIS applications and construction labour market planning. It also highlights the contribution of the research in demonstrating innovation in the application of GIS to labour market planning within the context of the construction industry.

Chapter 3 reviews a range of potential research methodologies including qualitative, quantitative and triangulation methods. The specific research methods used are presented and the reason for their choice justified. Efforts made to overcome the potential limitations of these methods are also stated where appropriate.

Chapter 4 details the work undertaken to meet the aims and objectives of the project. This includes details of the development of the GIS application and its deployment in a specific labour market planning initiative – The STP Initiative. The system operation is also illustrated using screen shots and querying examples.

Chapter 5 concludes by summarising the key findings of the research, sets out how the project has contributed to knowledge and practice and identifies the impact of the research on both the sponsor and the wider industry. It also presents areas suitable for further research.

The Appendices contain the peer-reviewed published papers that resulted from and support this research. These papers are an integral part of the work and should be read in conjunction with the discourse. Throughout the discourse, references are made to the papers, which contain further details of the work.

1.8 Synopsis of Papers

All of the papers completed as part of this research, and included in this thesis, are listed in Table 1.2. Alongside the title, status and place of publication for each paper, a brief description is provided highlighting its contribution to the fulfilment of the research aim and objectives. Each paper has been identified by number together with its location within the appendices.

Table1.2: Synopsis of Papers

ID	Title	Journal/ Conference	Status	Description
Paper 1 Appendix1	The Utilisation of GIS in the Construction Labour Market Planning Process	Proceedings of the International COBRA conference, September, Leeds, UK (2004)	Published	This paper describes the key features of GIS and details how it can enhance the planning process by its ability to integrate different and varied spatial datasets to provide a more informative and wider understanding of the current state of play.

Paper 2 Appendix 2	The Application of GIS to Construction Labour Market Planning.	Construction Innovation (2005)	Published	This paper explores the potential of GIS in providing such a mechanism for enhancing the labour market planning process by strategically combining a range of datasets in order to reveal regional nuances in labour demand and supply which would be difficult to discern without the use of such a tool.
Paper 3 Appendix 3	GIS-Based Diversity Planning: A Case Study.	Proceedings of the ASCE International Conference on Computing in Civil Engineering. (2005)	Published	This paper describes the development of the GIS application to facilitate the implementation of a labour market initiative aimed at diversifying the construction industry's work force.
Paper 4 Appendix 4	Understanding Structural and Cultural Impediments To ICT System Integration: A GIS-Based Case Study	Engineering, Construction and Architectural Management	Accepted	This paper describes the barriers and enablers to the use of the GIS technology and details the evaluation and findings of the GIS STEP database.

1.9 Summary

This chapter has provided a general introduction to the subject domain and justified the need for the research and set it within the industrial context. The structure of the thesis was presented and a synopsis provided of each of the published papers that are to read alongside the discourse. Chapter 2 details the background to the research.

Chapter 2: Background to the Research

2.1 Introduction

This chapter sets the background to the research undertaken. It summarises the results in the literature review carried out in order to provide a sound knowledge framework through which the context of the subsequent research project can be established. In accordance with the problem definition set out in chapter 1, the primary areas of research explored were labour market planning in the construction industry and Geographic Information Systems and how they are being used in the construction industry.

2.2 The Labour Market in the Construction Industry

The UK Construction Industry provides a tenth of the UK's Gross Domestic Product and employs 1.5 million people (DTI 2006). The industry has grown at a steady rate over the past 10 years since the recession of the early 1990s, and most industry forecasters agree that the construction industry will carry on expanding in the next two years (DTI 2006). Despite this positive outlook, the industry faces several challenges in its aim to remain successful, the most important one being organising and planning for its workforce. According to Rowlings *et al.* (1996), many of the challenges faced by the construction industry arise through a need to maintain a skilled and competitive craft workforce. The industry is unique compared to other sectors because of the effect of contracting arrangements and the problems of uncertainty in a constantly changing business environment, (Bresnan *et al.*, 1985; Ball, 1988; Bon 1989; Wong *et al.* 2005).

The economic situation at any one time determines the industry's strategies for its workforce. The majority of construction workers are hired on a project basis and made redundant on project completion. As a result the industry is characterized by a pool of local labour who work for a variety of contractors in different branches of the industry. Contractors will employ workers from the labour pool and when no longer required will make them unemployed forcing them back to the labour pool (Uwakweh and Maloney, 1991). In the absence of strategic labour market planning the size of the labour pool fluctuates causing shortages and surpluses. This changing economic environment combined with rapid changes in the social organizational, technological and demographic environments have led to labour and skills shortages over the years (Ashworth and Harvey, 1993; Druker and White, 1996; Dainty *et al.,* 2000; Mackenzie *et al.,* 2000). This is due to the fact that the industry continues to depend heavily upon the adequate supply of a manual skilled labour force.

According to CITB-ConstructionSkills (2004) each year the industry requires around 15,000 new apprentices to maintain a sufficient supply of trained and competent people across the various sectors within the industry. They estimate that this demand is likely to increase annually to around 19,000 new entrants over the next three years. This presents a significant challenge for the industry and one for which it requires robust labour market analysis in order to plan for.

Due to the industry's poor public image (Strategic Forum, 2002), it is extremely difficult to recruit from certain groups of the labour market. The industry is generally seen as a young white male dominated industry (Equal Opportunities Commission ((EOC)), 2005), and over the years recruitment has been concentrated on this group in the labour market. In Spring of 2005 the proportion of women in the construction workforce was 15% (ONS, 2005). Women view the industry as a male dominated and threatening environment, with an ingrained culture characterised by masculinity, conflict and crisis (Gale, 1992; Briscoe, 2005). Drucker and White (1996); Clarke and Wall (1998) and Byrne *et al.,* (2005) suggest that the reluctance of women and ethnic minorities to enter the industry severely delimits the labour pool from which the industry can recruit. In the same period the proportion of ethnic minorities was 2.6% (ONS, 2005). According to Cavill, 2000, 39% of ethnic minorities in the construction industry have been subjected to racist comments in work and felt that their employment opportunities were fewer than their white colleagues.

According to Rethinking Construction (2000) during the late 1980s and 1990s, 33% of the workforce was under 30 years old; this proportion has fallen to 25%. In terms of the existing construction workforce the ONS Labour Force Survey (2004) reveals that there has been a steady ageing of the workforce profile in recent years. This is reflected in a decline in the 16-24 age group and an increase in those aged 45 and over. The industry faces a strategic difficulty because the section of the population from which it traditionally recruits (young males between the ages of 16 and 19) has seen a considerable demographic downturn in the labour market in recent years. The number of people recruitable from this age group is declining because many more of them continue with academic study and others are put off by their perception of the industry as one that offers poor working conditions, unexciting work and questionable career prospects (CITB ConstructionSkills, 2004). Part of the consequence is that the industry is now more reliant than it used to be on the less able members of that age group for its recruits and foreign labour (Ehrenberg and Smith, 2003). This threatens to create problems in later years, when too few workers might be available to take on higher skilled and supervisory work. This raises issues in terms of the construction industry having to compete with other sectors for the skills it requires.

The industry faces other human resource issues such as problems with its health and safety record, mobility and incorporation of new technology (McKenzie *et al.,* 2000). These issues have wider implications that may not just affect construction, but also have the potential to threaten the UK economy as a whole. Construction is a vital supporting sector for many other industries that rely on it for the buildings and infrastructure that they require to operate and grow. This current labour market context therefore presents many challenges for those with responsibility for labour market planning. These include the need to predict how many workers will be needed in the future, what skills they will require and where in the country they will be needed. These questions can only be answered through labour market forecasting and planning activities. If the industry is to be able to deal with these challenges it must have sound labour

market planning processes in place that will enable it to plan strategically and positively for the future of its labour market.

2.3 Current Labour Market Planning in Construction

Labour market planning in construction is usually undertaken by using two types of forecast information; aggregate industry forecasts and company level forecasts (Briscoe and Wilson, 1993). Aggregate industry forecasts are those produced by organisations such as the CITB-ConstructionSkills, the Department of Trade and Industry (DTI), and the Learning and Skills Council. These involve the whole industry and are for public consumption.

The forecast model being used by CITB-ConstructionSkills at present was originally developed by the Institute for Employment Research (IER). This has now been modified and redeveloped by Business Strategies (CITB-ConstructionSkills, 2004). The present version of the model takes into account regional output and unemployment data, but it uses fixed proportions for determining the share of regional employment across the 22 construction sector occupations (CITB-ConstructionSkills, 2004). Labour demand is approximated by total employment plus 5% to take into account long running vacancies. Labour supply is defined as all in employment in construction plus the unemployed or people working in other industries with construction skills. Information from the labour force survey allows for an estimation of what proportion of people joining construction employment can be assumed to be part of the labour supply and therefore do not need training, although they are unlikely to be qualified e.g. migrant workers (CITB-ConstructionSkills, 2003). The key input statistic that drives the CITB model is the assumed rate of annual output growth in the construction sector (Business Processes Resource Centre, 2004). This is populated by a range of labour market datasets from the Labour Force Survey, output figures from the Department of Trade and Industry, output growth predictions from forecasting agencies and training supply data measured from surveys of formal training provision. Although this represents an ostensibly top-down forecasting model, it is also informed by an employers' skills needs survey and expert opinion from academics and forecasters. The resulting forecast provides a cumulative growth requirement based on a variety of growth scenarios, which are subsequently disaggregated to individual geographical regions. The output of the model can be further informed by other econometric forecasts.

Other groups such as the Institute for Employment Research at Warwick University, Cambridge Econometrics, Experian Business Strategies/Construction Forecasting Research, Construction Products Association and Hewes and Associates produce construction employment forecasts as part of a national economy-wide forecasting exercise. Company level forecasts are those produced by individual firms to suit their individual objectives and are owned by the company. These are generally not made public and so are rarely taken into account in regional and national forecasts (Briscoe and Wilson, 1993).

2.4 Geographic Information Systems

The literature on the history of GIS is sparse. Pickles (1995) states that GIS itself has a poorly developed archive and virtually no critical history of its own. Coppock and Rhind (1991) support this assertion by suggesting that GIS is a field in which history is anecdotal. Despite this, Tomlinson (1988) has traced the roots of GIS to the 1960's, and states that the first GIS on record was the Canada Geographic Information System developed by the government of Canada to support the mapping and assessment of Canada's land base. However, although GIS has been commercially available for over forty years, it has only had a widespread implementation in the last couple of decades CCTA, 1994). Some of the reasons why its adoption into the market had been slow include;

- Low awareness of the role. potential and benefits of GIS
- A lack of suitable technology at an economic cost
- The difficulty, time and resources needed to acquire the appropriate data in digital form CCTA 1994).

Over the past decade, however, interest in GIS has provided a significant incentive to developers, and the range of products that call themselves GIS has grown, which shows an enormous diversity of capabilities and approaches (Goodchild, 1995; Amdahl, 2001). GIS has now become established in a wide range of fields and is being used routinely by researchers in many disciplines. Although some of the disciplines such as archaeology, geology or transportation science, have traditionally employed a spatial perspective, in others the technology has generated a new interest in space and spatial thinking. Some of the more interesting applications of GIS in social sciences are emerging in history, sociology, criminology and economics; all disciplines in which spatial thinking has played a very minor role in the past (Goodchild, 1995). GIS has a wide range of applications mainly because of its ability to integrate data. Integration is the ability to combine analysis of all geographic information no matter what their characteristics. It can integrate data of different themes, of different resolutions, with different models and represented graphically in different ways (Parker, 1996, Greene, 2002).

The literature on GIS has varied over the years. Some have examined GIS and its impact on the discipline of geography (Clark, 1992, Goodchild, 1995; Taylor and Johnson, 1995; Murayama, 2001; Jordan 2002). Others have examined the social and political implication of GIS (Pickles, 1995; Clark, 1997; Openshaw 1997; Harris and Weimer, 1998; Lake, 1993; Taylor and Johnston, 1995). The literature also depicts the issue of making GIS available to community organisations for community empowerment (Barndt and Craig, 1994; Elwood, 2001; Obermeryer, 1995; Ghose, 2001). This trend follows the principle that effective access to information creates more opportunities for better government and community empowerment. However, GIS has rarely been used in the area of labour market planning. This is an area into which it can be adapted to make a positive impact. A good proportion of the literature is devoted to specialist GIS applications being used in other disciplines (Martin,1991). Some of these applications have been used over the years in the construction industry to

provide a spatial dimension to planning. Some of the best known applications are summarised below and are categorised according to their functionality or application area.

2.4.1 Thematic Mapping Applications

Thematic mapping is the use of colours or styles to systematically represent different forms of data. The ability of a GIS to overlay thematic layers has been used to produce positive results in construction. King and Kiremidjian (1996) have developed a GIS-based seismic risk estimation tool for assessing, mitigating and managing seismic risk to the built environment in order to reduce losses in future earthquakes. A number of different and disparate thematic layers were overlaid on a map and the graphical representation of the datasets analysed to provide answers to the complex relationships between the numerous thematic layers. In a related study Etzion *et al.,* (2000) developed a GIS-based methodology for recording and analysing modifications in residential buildings using this capability of the technology. Data such as the number of rooms in a house, landscaping features, walls were overlaid to analyse and understand post–occupancy changes in residential buildings. Other construction applications based on the concept of thematic mapping include site suitability analysis, extracting dominant trends, and investigating different solution scenarios to complex spatial problems (Herzog, 2000). There is considerable scope for the use of thematic mapping in LMP as data on various demographic or labour market variables can be displayed on different thematic layers and overlaid to reveal patterns or relationships that exist within the datasets.

2.4.2 Topological GIS Applications

A GIS contains tools for determining distance, proximity, direction, adjacency and connective relationships between mapped features. These are called topological tools or buffers. They are useful in determining all the objects of one class within a specific distance of another type of object (Easa and Chan, 2000). This capability of the software has been utilised to assess the archaeological potential of a development site in Hertfordshire, England (Needham and Macklin, 1992; Zerger *et al.,* 2003). The GIS was used to reconstruct the prehistoric landscape and search for indirect indicators of ground conditions that accompany archaeological remains. While there is no similar topological dimension to Labour Market Planning, it may be possible to use this feature to plot labour market data in an interesting way, such as how far a trainee has to travel to his or her job, or to attend college or university.

2.4.3 GIS Query Applications

Geographic Information Systems have the ability to answer spatial questions through their query tools. The query mechanism allows users to ask different questions of the data and create different ‘what if’ scenarios. This ability has been utilised in the following construction projects:

- The remediation design of a former industrial area and gas works in the UK (Griffin, 1999)
- The design of a large shopping complex in Prague, Czech Republic (Hellawell *et al.*, 2000)
- The evaluation of the most suitable technique for the construction of a retaining wall for a new railway in Hong Kong (Hellawell *et al.*, 2000).

The query tool in the GIS was used to present different 'what if' scenarios to aid developers in their analysis of the best options for the projects. This could be useful in LMP as it would provide various options for planners to consider when planning for the future and make decisions based on what is more likely to happen in the future.

2.4.4 GIS Integrated with other Applications

The process where a GIS function can be isolated and embedded in almost any other programme as a control code has been utilised in the industry for analysing complex spatial relationships and problem solving. Li *et al.* (1996) developed a GIS-based system for tracking pavement compaction. The system maps the movement of a compaction machine and transforms the result into a geometrical representation. The GIS technology is integrated with a real-time positioning system to analyse this geometrical representation by tracking the coverage of the machine.

In another interesting application, Cheng and Chen (2000) have developed an automated schedule monitoring system for the erection of prefabricated structural components in precast building construction. A GIS was integrated with a database management system (DBMS) to form the expert system ArcSched. The GIS was useful in storing descriptive information as attributes of graphical features and its query function used in analysing the data. Rylatt *et al.,* (2003) also developed a GIS-based prototype for general domestic energy modelling. The GIS was integrated with an expert system (BREDEM-8) to enable the prototype to estimate the baseline energy consumption for houses in a given geographical area. Expert systems being integrated with GIS take advantage of the GIS's capacity for storing data in an organised way. The expert system provides a set of rules for the GIS to follow in order to analyse the data, much in the same way as an expert would dissect a complex problem (Easa and Chan, 2000). This results in a powerful system, which can be effective in many situations where the problem being tackled by the expert system has a spatial dimension.

2.5 Further GIS Applications

GIS technology is being widely used in many disciplines primarily because conventional database systems do not have any information related to the geographic location of the data in relation to data taken at different locations (Oloufa and Ikeda, 1995). A major advantage of the GIS software that makes it

attractive to many disciplines is its ability to maintain data associated with different entities in separate layers that are based on the same geographic referencing system which can be superimposed spatially to support data queries and analysis (Star and Estes, 1990). The following are examples of how some disciplines use the technology to support decision making:

In environmental engineering, GIS is being used for selecting and locating of waste sites which are constrained by the location of housing areas, the habitats of endangered species, production of facilities, and highways. A GIS is used to analyse a map of the city where the waste site is needed, and identify the possible locations which meet the criteria for the site (Oloufa and Ikeda, 1995).

In geotechnical engineering, the display of the locations of boreholes on digital maps on the computer screen helps the geotechnical engineer in selecting boreholes according to their proximity to the general location of a new investigation (Oloufa et al. 1994).

In construction engineering, GIS is being used for site layout and the location of temporary facilities. The technology may also be used in Global Positioning System (GPS) to identify locations of utility lines (Oloufa et al. 1991).

In transportation engineering, GIS is being used to reach decisions about traffic planning. It is used to display the densities of origin/destination, noise complaints, or trip generation rates. The topological capabilities of GIS are also used to answer queries about the shortest routes between destinations, adjacency of highways to municipal boundaries, or the intersection of streets with a specific highway (Oloufa and Ikeda 1995).

Below are some specific GIS applications that have been developed in specific disciplines to help in their decision making process.

2.5.1 Use of GIS in Geotechnology

GIS is being used extensively in geotechnology. According to Ong (2003), In Singapore, the Land Transportation Authority (LTA) have implemented an intranet-based application call the Geotechnical Database Information System. In this system a GIS map of an area contains links to images of boreholes, which are scanned images of existing boreholes. In other words it functions as a document management system, rather than as a database management system.

Kunapo et al. (2005), have used the technology in the same discipline but differently by developing a geotechnical information system (GeoInfoSys) in which three-dimensional geotechnical information is stored in digital form and distributes information over the internet. The development of the GeoInfoSys system includes:

- The design of the database based on a standard geotechnical data structure;
- Efficiently digitising and archiving nationwide borehole data;
- Optimising data analysis and visualisation options by interfacing Web-GIS;
- Development of software to support online generation of borelogs and cross sections.

2.5.2 Use of GIS in Environmental Engineering

Gomez-Delgado and Tarantola, (2006), have used GIS with multi-criteria evaluation in the location of a hazardous waste landfill site in Spain. GIS was used to develop and evaluate a spatial model to aid in the localisation of the landfill site. Tsanis and Boyle (2001) have also made use of GIS to develop a computer program IDOR 2D GIS which simulates the currents and pollutant transports in lakes and coastal areas. Like other environmental simulation models, hydrodynamic/pollutant transport modelling requires functions for data input, processing, and output of spatially distributed information. Many of these functions are inherent in GIS making it an ideal tool to be used in this area. The model is a closely-coupled two dimensional, hydrodynamic/pollutant transport GIS model that operates within Arc-View GIS. The use of the GIS based interface model, facilitates the improved communication of the basic patterns and relationships associated with hydrodynamic/pollutant transport simulation and the application of this information to water resources, planning and management.

2.5.3 Use of GPS and GIS Applications in Transport Research

The introduction of Global Positioning Systems (GPS) has offered new opportunities to transportation researchers for the assessment of driving behaviour on highways. Using GIS and GPS for mapping has increased accuracy, decreased costs, reduced project completion time, and improved overall map quality (Czerniak, 2002). Numerous GPS and GIS applications have been reported in the literature in the general field of transportation engineering. Taylor et al. (2000) have integrated GPS-GIS system for collecting on-road traffic data from a probe vehicle. The system proved to be reliable and pertinent because of: (1) its ability to obtain second-by-second position data and simultaneous speed profile data; (2) the spatial display and analysis of data in the GIS environment for ease of interpolation, analysis, and integration with other datasets; and (3) the ease of transferability of GPS equipment from vehicle to vehicle. Both GPS and GIS technologies have also been proven to be very useful tools for collecting, storing and analysing the data required to manage traffic congestion and to monitor the performance of existing transportation networks (Quiroga, 2000). As an application, GPS data-including

travel time, speed, latitude, longitude and satellite navigational data were collected at regular time intervals. Using the collected GPS data, a complete "Congestion Management System" was developed in the GIS environment. Another potential area for GPS-GIS application in transportation engineering is collection and analysis of collision data. The current practice of crash data collection through police reports has been reported to be time consuming and inaccurate (Pisano and Paniati 1996). Errors that occur during various steps of data collection diminish the value of the data as the data do not necessarily reflect the actual circumstances of the crash. These errors propagate through the system, affecting the quality of the safety analysis, as well as the value of any decisions based on these analyses. To overcome the problem the Federal Highway Administration in America set up a program that includes the applied research of advances technologies to improve highway safety (Imran and Hassan 2006). The main focus of the program is to improve the methods to collect and analyse highway safety data, primarily through the application of technology, including hardware (computers, GPS, image-based measurement tools) and software (GIS, Statistical Analysis System etc.).

2.5.4 Use of GIS in Multi-criteria Decision-Making (MCDM)

The techniques of multi-criteria decision making originated in the early 1980s. The main objective of MCDM is to help decision-makers solve complex problems concerning criteria that are usually conflicting and qualitative (Knezic and Mladineo, 2006). MCDM is being implemented widely in tackling a wide range of problems involving selection, sorting and ranking as well as in various fields of research. The theory of combining GIS with multi-criteria tools is not new as a significant number of problems from many fields can be characterised as both multi-criterial and spatial (Malczwski, 1999). Martin et al. (1999), have used a vector-based GIS as a means of improving the outcome of human decision-making as a tool to capture and transfer the technical process of watershed management.

2.5.5 Use of GIS in Civil Engineering

Civil engineers solve problems through modelling, design, planning and evaluation. Instrumental to these processes are the tools that they employ to accomplish their tasks. A tool that has proliferated within civil engineering in recent years is GIS (Miles et al., 1999). Specifically applied to modelling civil engineering phenomena, GIS has been recognised in a majority of the civil engineering disciplines as a beneficial technology. Wong et al. (1997), have embedded an empirical data model into vector GIS, specifically, ARC/INFO running on a UNIX platform, for analysing the Santa Monica Bay California watershed. The model used data on local rainfall, land use, drainage and local and national water quality to estimate pollutant loadings. Wong et al. (1997), view the GIS as back-end database management tool and an interface to the urban runoff model.

A geomorphic-based hydrologic and sediment transport model was embedded into a raster GIS by Mashriqui and Cruise (1997). The modelling approach was based on the grouped response unit concept. The approach was seen as less data intensive that most grid-based methods and, thus more efficient and easier to execute over large areas through GIS. The model employed the chemical runoff erosion from agricultural management system model, which is composed of a set of simple equations. Spatial parameters of the model include drainage area and slope.

Waste collection comprises a significant part of the expense of municipal solid waste management; therefore, collection optimisation has the potential to yield large savings. For metropolitan regions, one issue is how to effectively distribute the collection crew and vehicles. Chang et al. (1997), studied the ability of GIS used with a multi-objective programming model for vehicle routing and scheduling to analyse the optimal path between a given origin and destination in a waste collection network. In this context, optimisation seeks to minimise total collection distance, costs and time.

2.5.6 Use of GIS in International Development

The United States Agency for International Development USAID is using GIS extensively in its work in Guinea in West Africa. The organisation and its partners have discovered GIS as a tool that combines ordinary statistics with geographic location to create meaningful, clear and attractive maps and applies them to development needs. In Education, access to primary school facilities is evaluated using detailed school/demographic maps. Maps showing national enrolment for boys and girls are also being used to look at gender differences in primary school enrolment, and to demonstrate the disparity between low rural and higher urban primary school enrolment in prefectures throughout Guinea. Every two months, the Educational Development Corporation (EDC), a USAID/Guinea partner, collects data on the level of teacher participation in bimonthly in-service training sessions for elementary school teachers. That data is analysed and an average yearly percentage attendance established for each sub-prefecture. In 2001-2002, the data was used in a GIS to produce a four-coloured map indicating the average attendance for each sub-prefecture. The maps provide a powerful visual comparative analysis of the degree of teacher participation in in-service teacher training sessions organised and delivered at the local level. It also allows USAID and its partners to monitor the impact of the in-service teacher training initiatives offered in their areas (USAID 2006).

In the health sector, USAID have used GIS to indicate sales points of condoms in the capital of Guinea, Conakry. They have also created GIS maps to monitor a possible yellow fever outbreak, and they are also using GIS maps to show the results of various vaccination campaigns and visualise the status on micro-nutrient deficiency among the Guinean population (USAID 2006).

The GIS has provided the EDC with a powerful tool for synthesizing and representing data. Each year data is collected on the quality of national radio

reception at hourly intervals between 8.am and 5.pm in all sub prefectures and communes in Guinea. That information is synthesized with the assistance of the GIS database, the represented visually on a series of 9 maps of the country. Each sub-prefecture and commune is colour-coded to indicate the quality of radio reception (good, average, poor or nor reception whatsoever) for that particular hourly interval during the day. By scanning the maps, one can easily see when the quality of radio reception begins to deteriorate in each sub-prefecture (USAID 2006).

GIS has provided USAID and its partners in Guinea with the tools necessary to present complex, comprehensive data in an attractive, user friendly format.

2.6 Contribution to Research

GIS has been used variedly in the construction industry. For example, the International Council for Research and Innovation in Building and Construction (CIB) has set up a number of Task Groups to look at the issue of GIS in Construction. In 1998 TG 20 was set up and currently W106 is exploring GIS and Portfolio/asset Management (CIB 2006). Despite this, however, there is very little evidence to show that it has been used in labour market planning. The use of Geographic Information Systems offers the potential to better address the spatial dimension in labour market planning. In this context, different and varied datasets from different parts of the industry can be integrated in order to produce new visual information through highly detailed maps that can be analysed together rather than singularly. This will aid *decision-making* by facilitating understanding of the issues facing the industry in each geographical region. The purpose of this study is, therefore, to explore the practical utility of GIS as a labour market planning tool and to evaluate its capabilities to a complex labour market issue - diversity. It aims to establish the practical utility of GIS in supporting policy planning decisions which account for the geographic nuances of both industry output and labour market conditions. The research also addresses the issues surrounding the implementation of Information Communication Technology (ICT) within an organization. Mandefrot (2002) states that organisational issues and computing infrastructures are often viewed in isolation and taken for granted as being ready to meet the end user's needs. How a technology resonates with the core values and culture of an organisation is important for its successful implementation and take-up. These aspects form the core components of this research.

2.7 Summary

This chapter has summarised the background to the research and produced an overview of the relevant aspects of the research. The next chapter discusses the methodology adopted for this research.

Chapter 3: Project Aim, Objectives and Methodology

3.1 Introduction

This chapter states the overall aim of the EngD research project and details the objectives that were defined to meet this aim. It also briefly outlines some of the methodological approaches that are available. It then provides a research map of the overall research design and details the research approaches that were used, and sets out the reasoning behind the approaches selected for this research.

3.2 Project Aim

As indicated in Chapter 1 the main aim of this research study is 'To explore the potential of GIS to inform labour market planning in construction'. In order to satisfy this aim, four objectives were defined. The outputs for each of the objectives are identified in the form of publications and the Eng D thesis. The four identified project objectives are stated in the next section.

3.3 Objectives

The specific project objectives are as follows:

1. Explore current approaches to labour market planning and the datasets used to inform policy;

2. Explore the potential utility of GIS in supporting labour market planning policy *decision-making*;

3. Trial and evaluate the use of GIS by using it to enhance and inform a labour market policy measure; and

4. Identify enablers and barriers to the use of GIS as a tool to improve labour market planning.

3.3.1 Objective 1

Explore current approaches to labour market planning and the datasets used to inform policy.

This was the exploratory phase of the project which focused mainly on researching the state of the labour market within construction and the different approaches used in the industry. The following tasks were undertaken to meet Objective 1:

- Identify the state of the labour market within construction by carrying out a detailed literature review including datasets review;

- Identify and establish problems within the construction labour market such as skills shortage and recruitment problems;

- Identify labour market planning models being used currently in the industry and their limitations;

- Conduct interviews with CITB-ConstructionSkills staff both locally and nationally to gain more insight into the construction industry and to establish their requirements for the GIS; and

- Identify how GIS can benefit the labour market planning process in construction.

The output from this objective is Paper 1 in Appendix 1.

3.3.2 Objective 2

Explore the potential utility of GIS in supporting labour market policy decision-making.

Objective two covered the exploratory and investigative phases of the research project. It focused on creating prototypes of the system for certain information processes and using construction labour market information from industry in order to determine its scope and potential. The following tasks were undertaken to meet Objective 2:

- Review of GIS applications in labour market planning and in construction;

- Identify requirements of Departmental Managers in CITB-ConstructionSkills as to which datasets they think would be useful in a GIS system; and

- Developed trial applications for demonstration.

The output from this objective is Paper 2 in Appendix 2

3.3.3 Objective 3

Trial and evaluate the use of GIS by using it to enhance and inform a labour market policy measure.

The following tasks were undertaken to meet Objective 3:

- Identify labour market initiative on which to trial GIS;

- Develop GIS STEP application;

- Trial prototype;

- Explore user satisfaction; and
- Train the user group.

The outputs from this objective are Papers 3 and 4 in Appendices 3 and 4.

3.3.4 Objective 4

Identify enablers and barriers to the use of GIS as a tool to improve labour market planning.

The following tasks were undertaken to meet Objective 4:

- Critical reflection on lessons learnt from research process and its limitations;
- Further discussions with CITB-ConstructionSkills staff; and
- Recommendations for future development.

The output from this objective is Paper 4 in Appendix 4.

3.4 Research Methodology

This section presents an overview of research methods, while the specific methods and approaches used for this research (and the justification for their use) are presented in Sections 3.5 and 3.6.

A research methodology describes the principles and procedures of logical thought processes applied to scientific investigation (Fellows and Liu, 1999). Research methods can be classified in various ways. For example, Yin (1994) highlights 5 strategies of research: experiment, survey, archival analysis, history and case study. Robson (1996) identifies the research methods that can be adopted as including: interviews, questionnaires, one-to-one discussions, observation, and experiments. However, one of the most common distinctions is between qualitative and quantitative research methods. These are discussed below.

3.4.1 Qualitative Research

Qualitative research is an exploratory study (to explore an unknown sector, identify the main dimensions of a problem, draw assumptions, and understand motivations) or an operational study based on in-depth analysis of interviewee responses (in a group or individually). It tends to be ‘subjective’ in nature and consists of ‘detailed descriptions of situations, events, people, interactions and observed behaviour’ (Patton, 1992). It most often deals with a restricted sample of individuals that does not necessarily need to be representative. It may be the

preliminary phase of a quantitative study or stand-alone research (Burns, 2000). Hancock (1998) lists the following as the main methods of collecting qualitative data:

Individual interviews - An interview is a verbal interchange, often face-to-face (though the telephone may be used), in which an interviewer tries to elicit information, beliefs or opinions from another person (Burns 2000).

Focus groups - Focus groups are a form of group interview that capitalises on communication between research participants in order to generate data (Kitzinger 1995). Although group interviews are often used simply as a quick and convenient way to collect data from several people simultaneously, focus groups explicitly use group interaction as part of the method. This means that instead of the researcher asking each person to respond to a question in turn, people are encouraged to talk to one another: asking questions, exchanging anecdotes and commenting on each others' experiences and points of view (Powell and Single, 1996). The method is particularly useful for exploring people's knowledge and experiences and can be used to examine not only what people think, but how they think and why they think that way (Gibbs 1997).

Direct observation - Direct observation refers to observing and studying those participating in a research study. It is usually used when data collected through other means can be of limited value or is difficult to validate (Hancock 1998).

Action research – This generally involves active participation by the researcher in the process under study, in order to identify, promote and evaluate problems and potential solutions (Fellows and Liu, 1997).

Case Studies - The case study approach is used to gain in-depth understanding of the subject, focusing on process rather than outcome, on discovery rather than confirmation (Burns 2000).

Interviews, direct observation, action research and case studies are discussed in detail later on in Section 3.5 as they are part of the adopted methodology for the research.

Advantages and Disadvantages of Qualitative Research Methods

Qualitative research has a number of advantages and disadvantages. One of the main benefits of using qualitative data is that it gives a richness of data and a deeper insight into the phenomena under study (Hancock 1998). The beliefs, understanding, experiences, opinions and views of the respondents are investigated. There is scope for the researcher to gain an insider’s view of the field, revealing subtleties and complexities that could go undetected through the use of more standardised (or quantitative) measures (Burns, 2000).

The disadvantages of qualitative approaches relate to the problems of adequate validity and reliability of the data collected due to its subjective nature and the

relatively small sample sizes (Burns, 2000). Data collection can be time-consuming and consequently data is collected from smaller numbers of people than would usually be the case in quantitative approaches such as the questionnaire survey. The data collected is usually unstructured and analysing it tends to be difficult, often requiring a lot of filtering, sorting and other 'manipulations' (Fellows and Liu, 1997).

3.4.2 Quantitative Research

Quantitative research seeks to gather factual data and to study relationships between facts and how such facts and relationships accord theories and findings of any research executed previously (Fellows and Liu 1997). Quantitative research involves an inquiry into an identified problem, based on testing a theory, measured by numbers, and analyzed using statistical techniques. The goal of quantitative methods is to determine whether the predictive generalizations of a theory hold true.

Quantitative research is most commonly encountered as part of a formal or conclusive research, but it is also sometimes used when conducting exploratory research. It differs from qualitative research in the following ways:

- The data is usually gathered using more structured research instruments;
- The results provide less detail on behaviour, attitudes and motivation;
- The results are based on larger sample sizes that are representative of the population;
- The research can usually be replicated or repeated, given its high reliability; and
- The analysis of the results is more objective.

The most common quantitative research techniques include (SJI 1999):

1. **Experiments:** These are experiments characterized by random assignment of subjects to experimental conditions and the use of experimental controls.

2. **Quasi-Experiments:** Quasi-experimental studies share almost all the features of experimental designs except that they involve non-randomized assignment of subjects to experimental conditions.

3. **Surveys:** These include cross-sectional and longitudinal studies using questionnaires or interviews for data collection with the intent of estimating the characteristics of a large population of interest based on a smaller sample from that population.

The analysis of quantitative research is usually based on the use of statistical techniques, given the large sample sizes.

Advantages and Disadvantages of Quantitative Research Methods

The main strengths of quantitative methods lie in precision and control. Control is achieved through the sampling and design; precision through quantitative, repeatable and reliable measurement (Burns, 2000). They are considered more objective, and the larger sample sizes also provide a firm basis for generalisations about the wider population.

The disadvantages of the quantitative approach lie in the fact that while it can illustrate patterns in the datasets, it may not necessarily be able to explain them or provide the deeper understanding that a qualitative approach can. It is considered unsuitable for 'unbounded' problems in which the variables involved are unknown and cannot be hypothesised with some confidence (Fellows and Liu, 1997).

3.4.3 Triangulation

Triangulation can be defined as the use of two or more methods of data collection in the study of some aspect of human behaviour (Burns 2000). Using this method, theories can be developed qualitatively and tested quantitatively (Khalfan, 2001). Triangular techniques attempt to map out and explain more fully, the richness and complexity of human behaviour by studying it from more than one standpoint and/or using a variety of methods. It contributes to verification and validation of qualitative analysis by: checking out the consistency of findings generated by different data-collection methods and checking the consistency of different data sources within the same method. By collecting and analysing these viewpoints, the evaluator ensures that the final evaluation report reflects the multiple realities of specific social relationships.

3.5 Adopted Research Process

The decision on which type of research strategy to follow depends on the purpose of the study and the type and availability of the information which is required (Naoum, 1998). In determining the most appropriate method to be used, it is important for the researcher to understand what kind of research questions (Who? What? Why? Where?) the project will be asking, the degree of control the researcher will have over the process. Table 3.1 provides a useful categorization for selecting the most appropriate method.

Given the fact that the Engineering Doctorate took place within an industrial context, the methodology has had to evolve throughout the research to align itself with the evolving environment in which it finds itself. The primary aim of the research as stated earlier is to explore the potential of GIS to inform labour market in the construction industry. The objectives that were defined to meet this primary aim gave a clearer perspective on how the research would be approached and defined the scope.

Table 3.1: Relevant Situations for Different Research Strategies

Strategy	Form of research question	Requires control over behavioural events?	Focuses on contemporary events?
Experiment	How? Why?	Yes	Yes
Survey	Who? What? Where? How many? How much?	No	Yes
Literature Review	Who? What? Where? How many? How much?	No	Yes/No
History	How? Why?	No	No
Case Study	How? Why?	No	Yes

(Source: Yin 1994)

At the beginning of the research a number of approaches were adopted to meet the goals of the individual project objectives. The overall methodology was to divide the research into three phases: investigation, synthesis and application adapted from Morse (1994). Each phase was divided into separate stages (see Table 3.2).

Table 3.2 Research Phases and Stages

Phase	Stage
Investigation	Preliminary Information Gathering Secondary Information Gathering
Synthesis	Secondary Information Gathering Develop GIS Prototypes Trial System Design
Application	Trial System Implementation Observation

(Adapted from Morse 1994)

The investigation stage involved the review of literature and acquisition of data from various sources to get an in-depth understanding of the subject matter of the research which are GIS and labour market planning in construction. Analysis of this data identified shortcomings in the research subject and further aspects that needed more research. Once the investigation stage was

completed, further objectives and work tasks were identified during the synthesis phase. Several small prototypes were developed to ascertain the potential of the technology. A labour market initiative was then chosen on which the GIS could be trialled. This led to the trial system design. After the design of the trial system the project then entered into the application phase which included the system implementation and observation of its use.

Table 3.3 is a research map, which presents the overall research methodology and demonstrates where various research methods were used during the different stages of the research. It should be noted that several of the work tasks occurred concurrently. The table identifies the objectives and the work tasks against the stages of the research.

3.6 Approaches used for this Research

Quantitative approaches were not considered appropriate as the research did not deal with a large population. Also, the nature of the problem being investigated was such that a deeper understanding of the key issues affecting the potential of GIS to inform labour market planning in construction was necessary. It was also important to work closely with the staff of the sponsoring company to understand the organisational enablers and challenges to GIS deployment. In order to overcome the validity and reliability problems associated with qualitative methods, the researcher conducted multiple interviews and used a combination of qualitative methods (which enabled a degree of co-relation). It was also necessary to capture the context of the views and opinions obtained so as to avoid inappropriate generalisations of the research findings. Other measures taken are included, as appropriate, in the description of the individual research methods below.

3.6.1 Literature Review

According to Fellows and Liu (1997), it is essential that in the early stage of any research that a search is carried out to identify potentially relevant theory and literature. The literature review helps to stimulate for the thinking of the researcher on the previous work that has been carried out in the subject domain (Fink, 1998). The literature review is a sounding board for ideas, as well as finding out what is already known and what specific methodologies have been used. It is often the case that research reports based on a literature review identifies additional questions that would be fruitful to pursue (Burns, 2000).

The literature review was therefore used to:

- Define the problem;
- Highlight previous research so reinventing the wheel is avoided;
- Highlight methodologies that have previously been used;
- Reveal gaps in previous research; and,
- Suggest areas for further research (Bowden 2005).

Table 3.3: Research Map

Overall Aim: To Explore the Potential of GIS to Inform Labour Market Planning in Construction

OBJECTIVES	WORK TASKS	METHODOLOGY STAGE	METHOD	OUTPUT
1.Explore current approaches to LMP and the datasets used to inform policy	1. Identify and establish problems within the construction labour market	Preliminary information gathering	LR	Paper 1
	2. Identify labour market planning models currently being used in the industry and their limitations	Preliminary information gathering	LR, IN	
2. Explore the potential utility of GIS in supporting labour market policy *decision-making*	3. Review of GIS in construction	Preliminary information gathering	LR	Paper 2
	4. Identify dataset requirements of GIS	Secondary information gathering	IN	
	5.Developed trial applications, demonstrate and gain feedback	Secondary information gathering	AR	
3. Trial and evaluate the use of GIS by using it to enhance and inform a labour market policy measure	6. Identify policy measure for GIS trial	Secondary information gathering Trial system proposal	IN PM	Paper 3 Paper 4
	7. Design and trial of GIS STEP application	Trial system design Trial system validation	AR S	
	8. Explore user satisfaction	System implementation Observation	IN, O	
	9.Train user group	System implementation	AR, O	
4. Identify enablers and barriers to the use of GIS as to tool to improve Labour market planning	10. Critical reflection on learning points from research process and its limitations	Preliminary information gathering System Implementation	LR AR, O	Paper 4 EngD Thesis
	11. Further discussion with staff	System implementation, Observation	IN	
	12. Recommendations for future development	Observation	AR, IN	

Key

AR - Action Research
IN - Interviews
LR - Literature Review
O - Observation
PM - Process Mapping
S - Survey

The literature review for this research was done using academic and industrial literature. The initial literature review examined the state of the construction labour market, labour market planning methods in construction, GIS and how it has been used in the industry. At the final stage a literature review of ICT implementation was carried out to help in identifying the barriers and enablers in the use of GIS as a tool.

3.6.2 Interviews

Interviews can be structured, semi structured or unstructured, with the approach used dependent on both the stage of the research and the nature of the data or information being sought. The various types are described below:

3.6.2.1. Structured Interviews

Structured or standardized interviews are used predominantly in surveys and opinion polls with consequent quantitative analysis. Every interviewee receives the same questions in the same specified order to achieve statistical comparability. The questions tend to require specific answers and are closed-ended. There is no latitude or flexibility allowed to either the interviewer or the respondent.

3.6.2.2. Semi-structured Interviews

Semi-structured interviews can be used either as part of a structured interview or an unstructured interview. An interview guide may be developed for some parts of the study without fixed ordering of questions so that some direction is given to the interview. The content is focused on the crucial issues of the study. This gives greater flexibility than the closed-ended type and permits a more valid response from the respondent's perception of reality.

3.6.2.3. Unstructured Interviews

An unstructured interview takes the form of a conversation between the respondent and the researcher. It focuses, in an unstructured way, on the informant's perception of themselves, or their environment and of their experiences. There is no standardised list of questions. It is a free flowing conversation, relying heavily on the quality of the social interaction between the researcher and the respondent that can be subtly redirected by the interviewer if it should stray too far off the track of the research study. Thus while it is made to be as natural as possible, the direction of the conversation is always controlled somewhat minimally to ensure the focus stays relevant to the problem.

Interviews for this research were carried out mainly with CITB-ConstructionSkills personnel during the three stages of the project (investigation, synthesis and application). These were mainly *one-to-one* semi-

structured interviews. Details of these interviews are discussed in Chapter 5. *One-to-one* interviews were carried out because it was the best way to acquire the information as the interviewees were few and easily accessible. The interviews focused on perceptions and experiences; the fact that it was less structured and relaxed allowed the researcher to get more information than if the interviews had been structured. The semi-structured nature also enabled a degree of comparability between the questions asked but allowed room for each interviewee to go into greater detail on issues of particular relevance to him/her. All the interviews were recorded and later transcribed.

3.6.3 Direct Observation

The accurate observation of participants is key to the success of this method and determines the validity of the findings. Ackroyd and Hughes (1992) describe four roles of observation and from participant to complete observer (see Table 3.4).

Table 3.4: Participant Observation Roles

	Role	Description
1	Complete participant	The role in which the observer becomes a fully fledged member of the group under study, any research purpose being concealed
2	Participant as observer	Both researcher and subjects are aware of the facts that there is a fieldwork relationship
3	Observer as participant	Involvement with the subjects is deliberately, or for a number of practical reasons, kept to a minimum
4	Complete observer	Requires investigators to insulate themselves from any social contact whatsoever with the subjects

(Source: Ackroyd and Hughes 1992)

The observation in this research was of type 2 - the ‘participant as observer’ role - due to the fact the researcher was embedded within the industrial sponsor’s office for most of the research period. All the people involved in the project were aware of the researcher’s role. This allowed the researcher to have an in-depth understanding of the organisation’s culture and environment while working unobtrusively as a ‘semi-detached’ member of the team. One of the difficulties encountered with this approach was the fact that, on occasions, the researcher’s role became more involved (type 1) or more detached (type 4), in line with the demands of the research stages. This instigated slight changes in attitudes by the subjects, but this was overcome by explaining the research process more.

3.6.4 Case Studies

A case study must involve the collection of very extensive data to produce understanding of the entity being studied. It is the preferred strategy when ‘how’, ‘who’, ‘why’ or ‘what’ questions are being asked, or when the researcher has little control over events, or when the focus is on a contemporary

phenomenon within a real life context. In a case study the focus of attention is on the case in its idiosyncratic complexity, not on the whole population of cases (Burns 2000). The STEP initiative was used as a case study to trial the use of GIS in labour market planning. The case study approach was considered the most appropriate method for this as a detailed understanding of GIS potential was required rather than a general attitudinal survey. Its main disadvantage stemmed from the fact that only one detailed case study could be undertaken during the study period. This limited the nature of the generalisations that could be made from the findings based on the STEP initiative. To overcome this, the detailed contextual issues associated with the application of GIS to the STEP initiative were captured such that the critical issues could be isolated and taken into account when implementing GIS in another labour market planning situation.

3.6.5 System Evaluation

Evaluation is a very important aspect of IT system development and a range of techniques are available for undertaking this (O'Leary et al 1990, Gashnig et al 1983, Scott 1997). Many of these techniques are flawed in one respect or the other, with many system developers adopting 'fitness for purpose' (established through performance evaluations) as the principal criterion for determining the success or otherwise of a system (Anumba and Scott, 2001). Miles et al (2000) advocate performance evaluations involving potential end-users, and consider this the best way establish the utility of a given system.

In addition to self evaluation (conducted by the researcher at various stages to ensure that the GIS system was performing as intended), an end-user evaluation approach was adopted. This was designed to obtain feedback from CITB-ConstructionSkills personnel involved in labour market planning initiatives, as they would provide very good insight into the effectiveness of the GIS system. An evaluation proforma was designed and used during the evaluation of the prototype system. The proforma contained questions relating to both the system's functionality and user-interface to ensure adequate feedback on both the usefulness of the GIS application and its user-friendliness. A mixture of closed and open-ended questions were included. The closed questions required the evaluators to rate the system using a 5-point Likert scale, which is considered appropriate by many researchers for use in evaluations of this nature (Scott 1997, Aziz 2005). The open-ended questions enabled the evaluators to make suggestions and comments on aspects of the system.

A demonstration of the system was given to departmental managers and personnel responsible for STEP to obtain feedback on the system. Although the sample was small and predetermined (based on the participants' job functions), it was representative of the people who would be directly affected by the implementation of the system. The feedback and other information obtained were also used for further refinement of the system. Further details of the evaluation proforma and the evaluation results are given in Chapter 5.

3.6.6 Process Mapping

The Process Mapping concept is used to describe, in workflow diagrams and supporting text, every vital step in a business process. It is considered to be a visual aid for picturing work processes which show how inputs, outputs and tasks are linked (Anjard 1998). It also helps to better understand current processes and to eliminate or simplify those requiring change (Hunt 1996). Peppard (1999) defines the advantages of process mapping as:

- They are deemed to be usable, insofar as they give a clearer explanation of a process than words ('a picture paints a thousand words');

- The mere fact that individuals are working on maps means that a greater understanding is gained of the tasks and problems that are faced within the organisation.

There are six commonly used methods of process mapping IDEF0, IDEF0v, IDEF3, Petri Nets, scheduling method and simple flow method (Karhu 2000). The format adopted for this research was the simple flow method which can be characterised in the forms of Input, Transformation and Output. Although it lacked the sophisticated representation methods of the other methods, the simple flow method was chosen because it was considered straightforward and easy to explain to the various personnel within CITB-ConstructionSkills. Process mapping was used at the beginning of the synthesis phase when STEP was chosen as the labour market initiative on which the GIS would be trialled. STEP is being used by the construction industry as a way of attracting females and ethnic minorities to the construction industry. The simple flow method was primarily used to illustrate the information process of the STEP initiative as a simple graphical representation that can easily illustrate how GIS can fit into that process. To enable the researcher to map out the information process of the initiative several interviews were conducted with CITB-ConstructionSkills staff and staff from labour market organizations who were involved with STEP. Chapter 5 provides more details of the process mapping activity undertaken.

3.6.7 Action Research

Rappoport (1970) describes action research as a research method that 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. Bryman (2001) describes it as an approach in which the researcher and a client collaborate in the diagnosis of a problem and in the development of a solution based on the diagnosis. Proponents of action research state that to make academic research relevant, researchers should try out their theories with practitioners in real life situations and real organizations (Avision *et al.*, 1999). This aligns closely with the project aim and objectives, which involved practical research carried out within an industrial environment. Henry (2000) states that due to the nature of action research, three primary requirements exist:

1. A trust-based relationship built up beforehand and accepted by all parties;

2. The researcher will have fully accepted the organisation's objectives for innovation or change by having negotiated the extent to which they will be involved and their freedom as regards access to information and interpretation;

3. A research and innovation project will be jointly drawn up which must be open-ended with regard to the problems to be explored, but very precise in terms of methodology.

The EngD project satisfied all three requirements, as the researcher was embedded within the sponsoring organization for four years and was involved in defining the scope of the project and the methodology used. Action research allowed the researcher to put into action the hypothesis that GIS can be used in labour market planning. It also allowed the research to be monitored and evaluated with the aim of discerning whether or not that action produced the expected consequences. Being closely involved within the sponsoring organisation had the potential to introduce an element of subjectivity and bias in the researcher's assessment of the applicability of GIS to labour market planning. This was largely overcome by using others (i.e. potential end-users) as the final evaluators of the GIS system. The evaluation proforma included an objective set of measures and a scale for the estimation of the end-user preferences.

3.7 Summary

This chapter has discussed the overall aim of the research and the objectives that were defined to achieve this aim. It has also briefly discussed the main methodological approaches that are available and provided a research map of the overall research process. The specific research methods and approaches that were used were also discussed in detail and a justification for their use provided, as appropriate.

Chapter 4: Research Undertaken

4.1 Introduction

This chapter presents the research undertaken to meet the aim and objectives of the EngD project that have been stated earlier. The research was undertaken using the methodology outlined in Chapter 3 (specifically Tables 3.2 and 3.3). The chapter has been divided into three parts; the investigative, synthesis and application stages. It must be noted that where references are made to appended papers the reader is requested to read each paper in its entirety and then return to the thesis.

4.2 Investigative Stage (Work Tasks 1-5)

4.2.1 Overview

This involved the preliminary and secondary information gathering stages where an initial literature review was undertaken to identify the following:

- The state of the construction labour market;
- Labour market planning in the construction industry, the different methods used and their limitations; and,
- Use of GIS within the construction industry and if there are any studies to show that it had been used in labour market planning.

It was pertinent to review these areas so that a better understanding of the construction industry and its labour market could be achieved, identify gaps in the construction labour market planning process and highlight previous research so that reinventing the wheel is avoided. During the investigative stage, a literature review on ICT implementation was carried out which examined the issues involved in ICT implementation in the construction industry and in general. Chapter 2 provides details of the literature reviews undertaken (work tasks 1-3). See also Papers 1 (sections 1– 3) and 2 (sections 1-4). The next sections (4.2.2 and 4.2.3) describe work tasks 4 and 5, which focused on identifying the dataset requirements of the GIS application, and development of trial/prototype applications to demonstrate GIS potential and gain end-user feedback.

CITB-ConstructionSkills' overall purpose is to ensure the industry has the right people with the right skills in the right place at the right time. The situational analysis presented is of an organisation that consists of four different departments with each having its own policies and procedures. The departments include:

a) ***Company Development Team***, which has responsibility for advising employers in the construction industry on CITB-ConstructionSkills' products and services that support and encourage the business case for training. It also advises on and administers the organisations' grant application process for training.

b) ***Education Department***, which is responsible for facilitating partnerships between local authorities, schools, employers and construction colleges to deliver the concept of construction into the school curriculum.

c) ***New Entrant Training Department*****,** which has responsibility for assisting employers in the industry who decide to enter into a contract with CITB-ConstructionSkills Managing Agency to make a commitment to train new entrants to industry standard.

d) ***Strategy Department,*** which is responsible for actively engaging in regional debates that concern or have implications for the industry. It is also involved in the effective Implementation of the Sector Skills Agreement (a series of agreements between training providers, employers and government designed to address the construction industry's current and future skills needs) in the East and West Midlands.

At the initial stage, a strategic planning process for the project was developed to provide a direction for the GIS its implementations and operational activities. Figure 4.1 illustrates the strategic planning process used in this study. The key elements of the process are described below:

Driving Forces: This involved identifying the external and internal forces that have a bearing on the organisation's business processes (such as government legislation, organisational changes, etc.);

Management: This involved an analysis of the management of the organisation including issues such as culture, organisational structure, systems, data sets, etc.;

Situational Analysis: This is the process of developing and understanding the present state of an organisation contemplating GIS implementation (Huxhold and Levinson 1995). To achieve this, the researcher carried out *one-to-one* interviews with the area manager and heads of the different departments in the regional office to understand how their individual departments work and their vision of the GIS, as well as observing the organisation's culture, its management style. Interviews were also carried out with senior figures from head office to gain an industry-wide perspective on the project as well as a national CITB-ConstructionSkills perspective.

Strategic Vision: An understanding of the organisation and how it operates was necessary in establishing a vision that would define the role GIS plays in the organisation, and its relationship to business operations. According to Huxhold and Levinson (1995), establishing a strategic vision and goals for GIS is critical to its success, whatever the scope of the implementation. The strategic vision for the GIS emerged from interaction with the key stakeholders. Its focus was to provide a mechanism, which allows integration and manipulation of diverse datasets used by each department in the organisation, so that a clearer

understanding of the geographical trends in the region will be obtained. This evolved as the project developed.

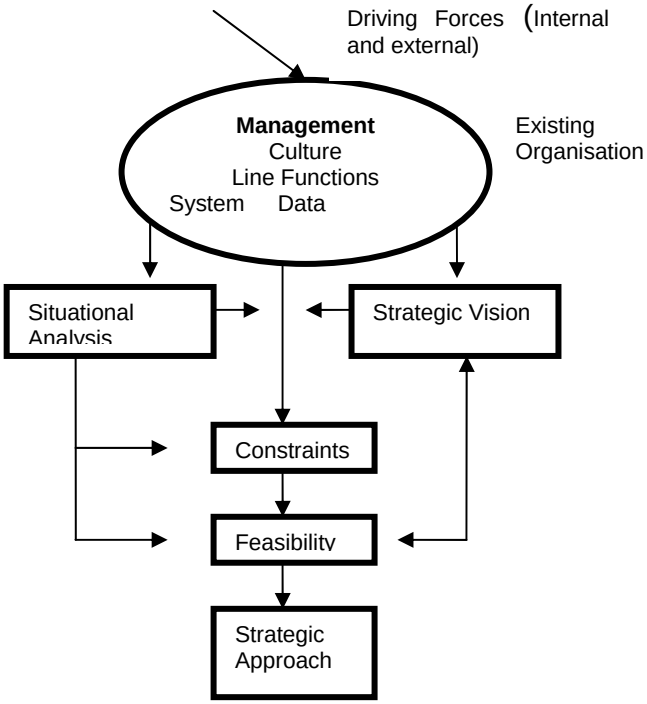

Figure 4.1: Strategic Planning Process (adapted from Huxhold and Levinson, 1995)

Constraints and Feasibility: Although it was envisaged that there would be few constraints relating to user adoption and ease of integration, the project team was satisfied that the environment within the organisation was conducive enough for the project to be feasible. Cost was not a problem as the organization already had the software that was to be used, and this was upgraded to the latest version at the time.

4.2.2 Strategic Approach

The strategic approach is determined by the strategies used for dealing with each of the four aspects of GIS development - concept, data, technology and organisation (Huxhold and Levinson, 1995).

4.2.2.1 Concept

The overall concept of the research was to identify how GIS can enhance labour market planning, through its ability to integrate different datasets and providing a graphic geographical dimension to it (see Papers 1 and 2). This involved investigating labour market planning in the construction industry, trialling the technology by using it to enhance and inform a labour market policy

measure and identifying enablers and barriers to the use of GIS as a tool to improve labour market planning.

4.2.2.2 Data

The data used was mostly sourced from within the organisation. Presentations, discussions and interviews were carried out with the different head of departments and their staff to gain their requirements of data for the GIS and to aid them in understanding how the technology works and how they can benefit from its use. The following are the requirements from the heads of departments as to what data can be used in the GIS to help them strategically plan and make decisions for the future.

Company Development Team

Rationale for having these datasets in the GIS: To enhance their strategic *decision-making* process so that they are better able to achieve their targets.

- Geographical "patches" of Training Advisers and On Site Assessment Training (OSAT) Co-ordinators, their targets and outputs – The Training Advisers and OSAT Co-ordinators are responsible for supporting and encouraging training among employers within their specific geographical location in the region. The idea was that the GIS could show each of them with their geographical patch against their targets and outputs.

- Employers in the region registered with CITB-ConstructionSkills – Construction employers register with (and are liable to pay a levy to) CITB-ConstructionSkills. Employers who are registered gain access to a range of funding and support. The idea was to have all the employers in the Midlands registered with CITB-ConstructionSkills in the GIS with their geographical locations and other information such as their size and profession.

- Employers with Investors In People (IIP) – CITB-ConstructionSkills offers a grant for a variety of training activities undertaken by companies with their employees. It is the Training Advisers' responsibility to promote IIP amongst the employers.

- Companies with Training Plans- CITB-ConstructionSkills offers grants as an encouragement to employers who have training plans for their employees

- Geographical locations of Training and Forum Groups and their members – The Training Advisers and OSAT Co-ordinators are responsible for establishing Training and Forum groups consisting of employers and key people in the industry that will contribute to the regional skills and training agenda.

Education Department

Rationale for having these datasets in the GIS: To understand the influence of the Education Department's activities and how they affect recruitment and use this knowledge to plan future promotional events.

- Schools and Curriculum Centres and their contacts that CITB has links with – The education team works closely with some schools and curriculum centres in the region.

- Individual education team members and the schools they work with – The individual members of the team are each responsible for promoting construction in different geographical areas in the region.

- High schools (12- 16yrs) in the region and the primary schools that feed into them, so that team can target their events appropriately.

Strategy Department

Rationale for having these datasets in the GIS: To be able to target funding specifically and appropriately so that they can be involved in identifying issues that concern or have implications for the industry in the region.

- Where the different funding streams are available in the region e.g. European Social Fund (ESF), Regional Development Agency (RDA) – To allow CITB-ConstructionSkills to be involved in research and projects that are concerned with construction

- The different colleges in the region and the construction courses that they offer – To better develop and maintain their links with higher education

- Community Groups and Housing Associations that CITB has links with – To better develop external links in the community

New Entrant Training (Managing Agency)

Rationale for having these datasets in GIS: To understand and identify strong and weak recruitment areas, and use the information to strategically plan and improve recruitment in the industry and promote training

- Recruitment of ethnic minorities and females – one of the challenges that CITB-ConstructionSkills has is to improve the image of the industry and one of the ways they do this is to attract more ethnic minorities and females.

- Framework Achievements – The trainees have to achieve their qualifications such as NVQs while on their training.

- New Entrant Training Officers (NETOs) and the colleges they are responsible for – The NETOs are all assigned geographical areas and they are responsible for liaising with the colleges in their areas that offer construction courses and support the trainees who attend.

It must be noted that only some of these were used in the GIS purely to explore and investigate the potential of the technology.

4.2.2.3 Technology

The organisation already had an off-the-shelf GIS software, Mapinfo Professional 5.0. This was upgraded to the latest version at the time Mapinfo Professional 7.0 to gain maximum benefit from the software and easier and faster access to information. During the project the software was on a stand alone computer in the organisation used solely by the researcher. There were plans for it to be networked at the end of the research to increase access to the technology.

4.2.2.4 Organisation

The organisation wanted a mechanism whereby they could have all their geographical information in a central resource. This will allow the different departments to easily access each others information and integrate different datasets to be able to get a full and greater understanding of the geographical picture in the region. It was sometimes the case that the departments work in isolation and use different procedures and software to store and access their information. This means it is not easily accessible to others and sometimes the departments use the same data resulting in some overlap within the organisation. The GIS will act as a central resource that holds most of the geographical information that they use and will be updated frequently to allow quicker and easier access to the information.

4.2.3 Prototype Applications

To explore the potential of the GIS and to gain an insight of how it will based within the organisation two prototype applications were carried out. One of these was a trial between the Education and New Entrant Trainee (NET) department. The organisation has as one of its challenges to improve the image and recruitment of the industry. One of the ways it aims to do this is by attracting diverse recruits through employment projects (CITB-ConstructionSkills 2006). The trial aimed to see if there is any correlation between the geographical locations of where the education department carry out their promotional activities and from where ethnic minority recruits had emerged. The datasets used were the addresses of the locations where the activities were carried out for the years 2001, 2002 and 2003, and the addresses of the homes of ethnic minority and female trainees that applied to join the industry in those years. The post code of each address was then geocoded onto a map divided into Learning and Skills Council (LSC) areas for the East and West Midlands. Figures 4.2, 4.3 and 4.4 are map layers showing the integration of all the datasets for 2001, 2002 and 2003.

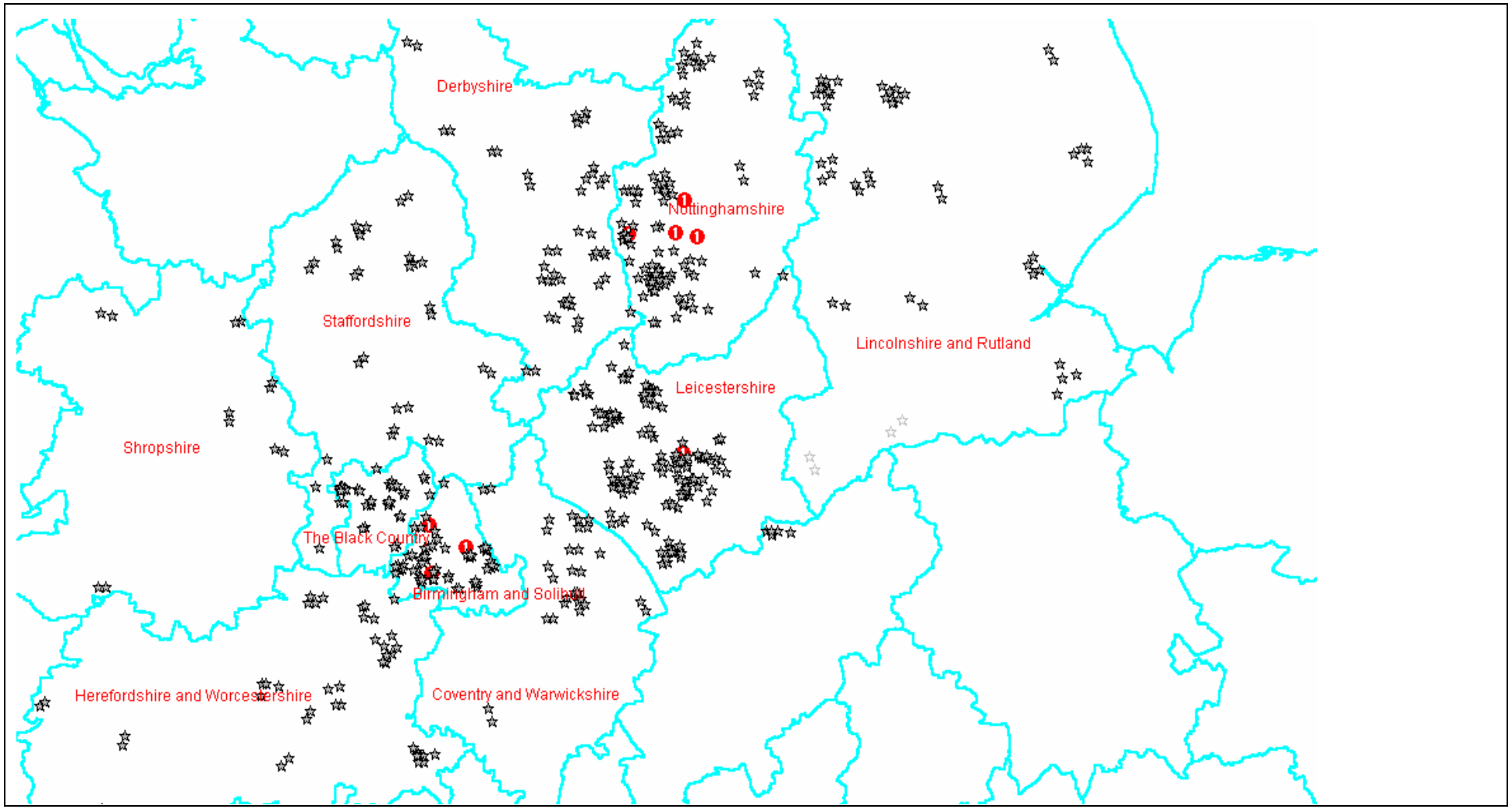

Figure 4.2: Activities carried out by education department in 2001 and ethnic minority trainees recruited in the same year

Key: ∗ = Promotional Activities; ❶ = Ethnic Minority Trainees for 2001

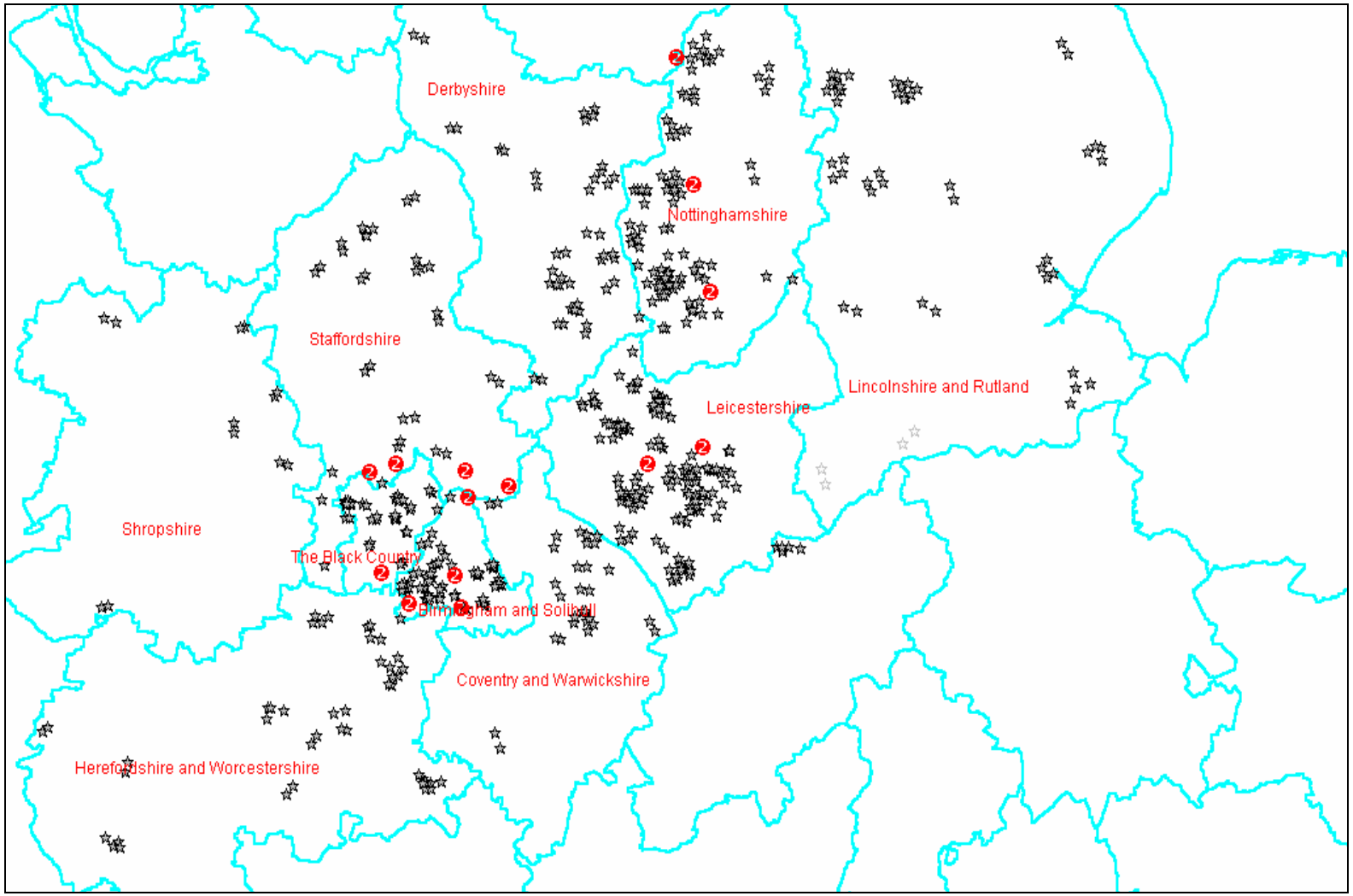

Figure 4.3: Activities carried out by education department in 2002 and ethnic minority trainees recruited in the same year

Key: ∗ = Promotional Activities; ❷= Ethnic Minority Trainees for 2002

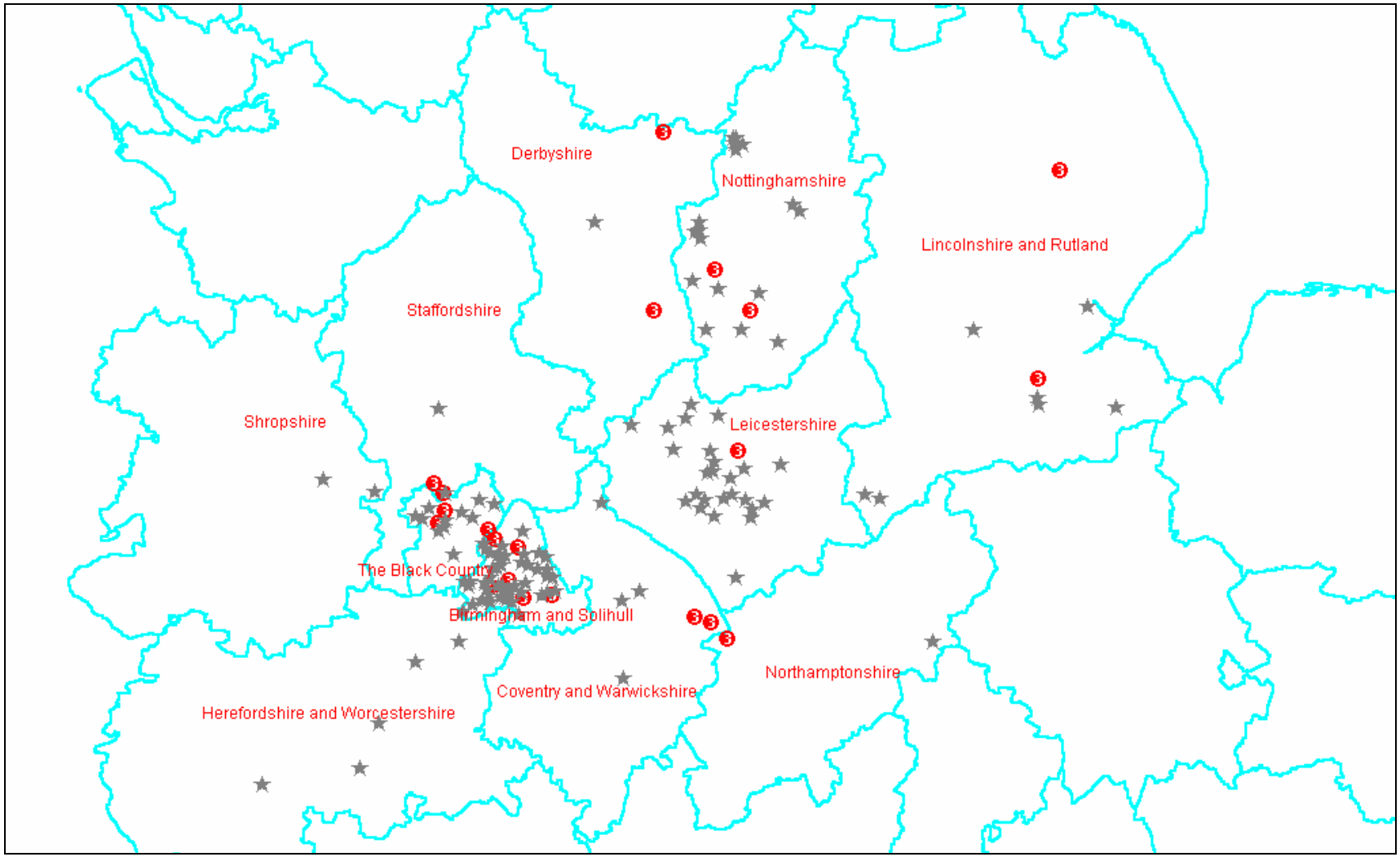

Figure 4.4: Activities carried out by education department in 2003 and ethnic minority trainees recruited in the same year

Key: ✳ = Promotional Activities; ❸= Ethnic Minority Trainees for 2003

The figures can be interpreted from different perspectives. 2001 to 2003 shows that the ethnic minority recruits tend to come from, by and large, the same areas, namely Nottinghamshire, Leicestershire, The Black Country, Birmingham and Solihull. This is not surprising as these areas have a high population of people from ethnic minority backgrounds compared to the other counties. It could also be argued that the ethnic minority trainees come from where there is a cluster of promotional activities which might indicate that the education department is achieving its objectives. It can also be argued that for the number of activities carried out in some areas there should be more ethnic minority trainees joining the industry. There are some areas where activities have been carried out but no applications from people from an ethnic minority background. The GIS therefore provides a platform upon which further investigative studies can be carried out.

The other application was related to a recruitment process for the NET department. A post had come up for a New Entrant Training Officer (NETO). The application showed an integration of the geographical location of all the colleges in the East and West Midlands that offered construction courses and that CITB-ConstructionSkills worked with, and the home addresses of the current training officers at the time and the number of trainees they are responsible for geocoded on a map of the different counties in the East and West Midlands. Fig 4.5 is a map layer showing this information. This GIS helped in strategically choosing which geographical area the newly appointed training officer will be responsible for, by giving an overview of the geographical locations of the colleges and where the New NETO can be strategically placed.

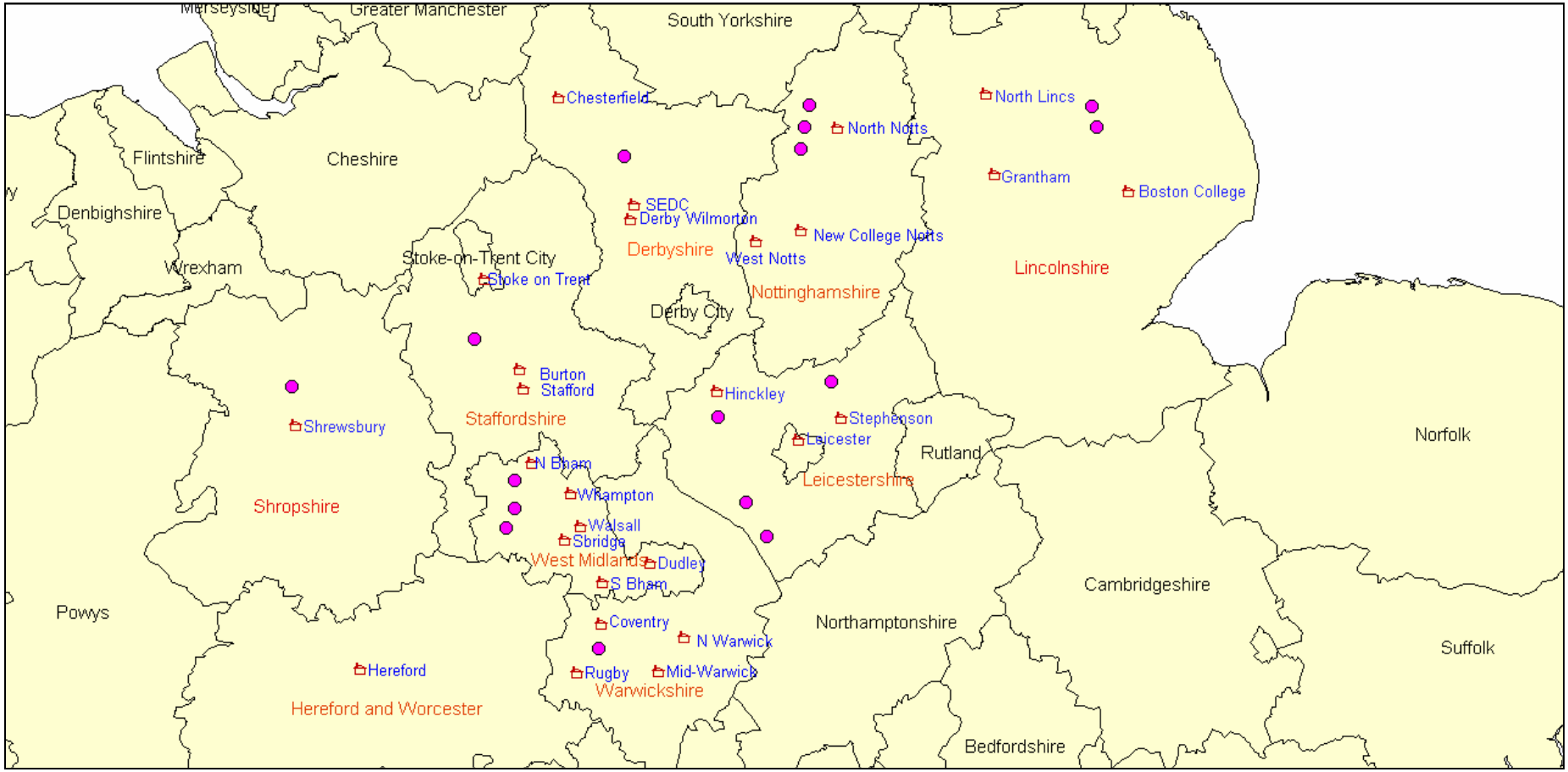

Figure 4.5: A map layer showing geographical location of colleges and NET Officers

Key: = Colleges; ● New Entrant Training Officers

4.3 Synthesis Stage (Work Tasks 6 and 7)

The main objectives of this stage were to trial and evaluate the use of the GIS by using it to enhance and inform a labour market policy measure. The key steps in this are summarised in subsequent sections, with full details in Paper 3.

4.3.1. Identification of Policy Measure for GIS Trial

The first step was to identify the appropriate policy measure on which the technology could be trialled. Through discussions held by the researcher with the Strategy Manager who is also the industrial supervisor of the project, and the Area Manager of the organisation, it was agreed that the labour market initiative, STEP into Construction, would be an ideal policy to use (please see Paper 3). STEP is being used by the industry's Sector Skills Council in the UK (CITB-ConstructionSkills), to attract females and ethnic minorities to the construction industry. It has been suggested that the reluctance of women and ethnic minorities to enter the industry severely limits the labour pool from which the industry can recruit (Druker and White, 1996; Wall, 1997). With the STEP initiative, if an employer guarantees an interview for a job vacancy, CITB-ConstructionSkills provides support for a trial period of six weeks for adult ethnic minority and female candidates. Recruitment at the end of the trial is based on merit alone and is at the discretion of the employer. CITB-ConstructionSkills supports associated costs such as short-term childcare, diversity training for staff and site supervisors, or an equal opportunities recruitment campaign aimed at finding suitable candidates.

The rationale for applying GIS to the STEP initiative was based primarily on a review of the initiative, which recommends that the focus of STEP should be on 'job outcomes' (i.e. the candidate securing a proper job at the end of the trial). In order to achieve this CITB-ConstructionSkills has to recruit suitable candidates and employers to participate in the initiative, which therefore requires information on the geographical distribution of both eligible candidates and employers. However, the current process does not readily have access to this information, so there is scope for the use of GIS to model this and explore a variety of scenarios. The review also concluded that because attracting females and ethnic minorities to the industry is a priority the STEP initiative had to be the responsibility of the organization as a whole i.e. the four departments rather than one department as it was before.

STEP was the sole responsibility of the Strategy Department, with the new system every department had to contribute something to STEP i.e. data and GIS would allow this to happen by acting as a central resource for the initiative.

Discussions were carried out by the researcher with the heads of the different departments and key staff in the departments to establish how their departments can contribute specifically to the STEP initiative i.e. which of their

data would be needed and the mechanisms and procedures that would have to be followed by both the researcher and the departments to achieve the GIS STEP. It was agreed that the data provided by the departments would be as follows:

a) Company Development Team, provides details of employers who are interested in participating in STEP.

b) Education Department, provides contact details of colleges, universities, and training providers with female and ethnic minority students who have expressed an interest in the industry.

c) New Entrant Training Department**,** provides leads on interested employers and their details; details on female and ethnic minority trainees who have applied for new entrant training but have not been placed with employers. They also provide information on universities and colleges in the region who offer construction courses with a view to finding out if they have females or ethnic minority students on their courses who are willing to participate in the STEP initiative and to secure a permanent job.

d) Strategy Department, does not provide information per se, but is responsible for overseeing the initiative and its processes.

Discussions were also carried out with the Intermediate Labour Market organizations (ILMs - employers who get sponsored and are committed to employing and training new recruits to the industry) that were involved with the process to understand their information processes with regards to STEP and key staff in the Strategy department who had responsibility for the initiative. The information derived from these interviews was used to document the current STEP information processes with the use of Process Mapping. Fig 4.6 is a simplified illustration of the STEP process without the use of GIS. It is characterised in terms of the Input, Transformation and Output of the process. The input to the process is the candidate, while the transformation is the six week training process that the candidate undergoes with an ILM. The output is simply the result of the training process in terms of helping the candidate secure a job. The ILMs were heavily involved in STEP as they produced the candidate and did the trials and the output was recorded on a form to show the outcome of the trial. There was no guarantee that the candidate would secure a job at the end and enter the industry. The emphasis was placed on the number of people who went through the trials rather than the number of candidates who actually joined the industry by obtaining a job as a result of the STEP trial.

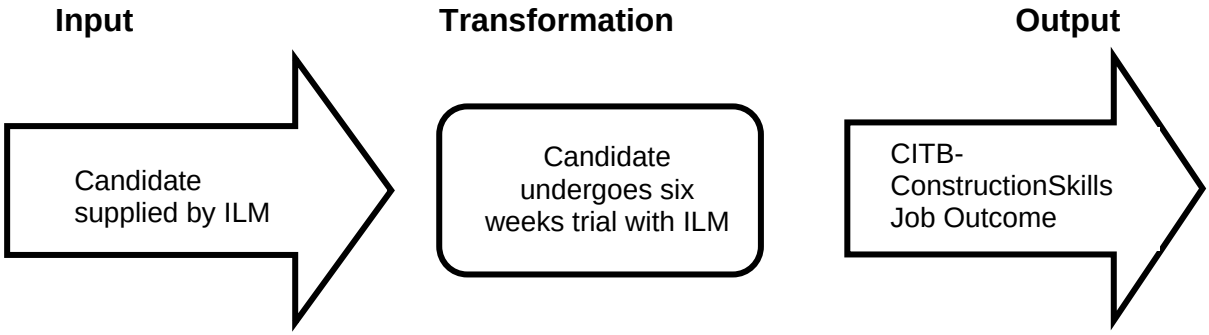

Figure 4.6: STEP Process before GIS

The new GIS-based STEP process was designed to allow CITB-ConstructionSkills to match an appropriate employer with an appropriate candidate. The candidate is then placed with the employer for a six-week trial and they are able to monitor the progress of the candidate. At the end of the six weeks the trial is only recognized as an outcome if the candidate secures a job with the employer. Table 4.1 summarises how the introduction of the GIS was intended to improve the STEP process.

Table 4.1: GIS-enabled Improvements to the STEP Process

Limitations of Current STEP Process	GIS-enabled Improvements
No central resource for STEP data	A central resource which provides easy access to complete accurate and up to date data. This reduces labour time for employees
No easy mechanism for matching prospective employers and candidates	GIS through its ability to integrate different datasets facilitates the matching process, which make for an efficient management of the process
No mechanism for keeping track of the progress of candidates	The system provides essential information on the progress of the candidates on the STEP trial
The process involves many manual steps such as form filling and filing.	The process is automated in order to facilitate better integration, accessibility and enhanced utility

4.3.2 Development of GIS-Based STEP Application

This section outlines the objectives of the application, the development procedure and the implementation of the system. The operation of the system is also described and illustrated using screen shots of the system in use.

4.3.2.1 Objectives of GIS Application

The objectives of the proposed GIS-based process were:

- To automate the STEP process in order to facilitate better data integration, accessibility and enhanced utility;

- To create a central resource that holds all the necessary information required for the STEP initiative, which will help in the tracking and monitoring of successful job outcomes and the recording of retention rates;

- To introduce better integration of operations and collaborations with other entities (i.e. other departments in CITB-ConstructionSkills);

- To create a better customer service to candidates and employers, as it will have an available and up-to-date database with all the necessary information;

- To enable CITB-ConstructionSkills to match appropriate candidates and employers geographically;

- To facilitate cross-departmental working between the different departments within the CITB-ConstructionSkills; and

- To generate representations of datasets that show which geographical areas are benefiting from STEP and which are not.

4.3.2.2 Development Procedure

The GIS platform used was the Map Info Professional 7.0 operating on a Pentium-based PC in a Windows NT environment. The primary map layers of the system include a UK postal code overlaid by UK counties. Both sets of data were obtained from the Ordinance Survey and converted into the MapInfo format. Both map layers (postcodes and counties) have an attribute data file with information on each postcode area and county linked to them. Seven databases were then created to hold all the data required by the STEP intiiative:

- An eligible employer database;

- An eligible candidate database;

- A database of candidates currently on the STEP trial and their progress;

- A database of candidates who have finished the trial period and the outcome of the trial;

- A database of universities and colleges as CITB works closely with them to enable the right candidates to be attracted to the STEP initiative;

- A database of all female schools in the region; and,

- A database of schools with a high proportion of ethnic minority students.

The GIS-based STEP application was organised into these seven databases, each with input and output facilities. The information in the databases can be manipulated and analyzed via the user interface with Microsoft commands and tools. The output of the application can be in the form of a map, graphs, reports, and integrated datasets due to overlay information.

The appropriate information was collected from the different departments and entered into the databases. The databases were then used to create map layers showing the geographical locations of employers, candidates and colleges/universities by a point (these are shaped differently so they can be easily differentiated). The system is open and expandable, and allows for additions of fields and descriptors to each of the different databases if necessary. It also allows for updating of the information. For more details on the design and operation of the system please refer to Paper 3.

4.3.3 User Interface Development

A user friendly interface to the STEP GIS database was designed to make it easier for users to access the different component databases. A GIS makes considerable demands on the user: due to the wide variety of data types recorded in digital maps, the complex data structures used to organize them and the range of operations available, these amount to a formidable obstacle for most users with standard requirements (Raper and Bundock 1991). As such, the quality of interfaces for GIS has taken on a considerable importance in terms of awareness, training and usage, both to the providers of GIS software and users of GIS alike (Rhind *et al.* 1989). The quality of a GIS user interface is also an important factor in the acceptance, uptake and efficiency of the system (Willis and Nutter 1990).

Ease of use is a vital criterion for the selection of an appropriate GIS (Rhind and Mounsey 1989). When implementing a GIS the ‘ease of use’ factor is key control over how quickly the system can be implemented. Beard (1989), states that GIS was an important but neglected aspect of quality control in GIS. The user interface is therefore a vital element of any GIS.

The Mapinfo GIS already has Microsoft commands and tools which allows for the information to be manipulated and analysed. The GIS STEP user interface does not make use of some of the Microsoft tools, only the ones which the researcher ascertained vital to the user for accessing the database. This makes the interface less crowded and therefore not off putting to the user. It also has a list of the databases on the toolbar which allows the user direct access to all of them and they can easily integrate the databases to suit their purposes. Figure 4.7 is the system structure of the GIS STEP user interface. It contains two main modules. (A) is the graphical user interface with the commands which allow the user to carry out a task or spatial operation and view the result of their command. It contains the screen interfaces, dialogues and spatial command processor. The main menu headings (File, Edit, Tools, STEP Information) and the command toolbar are accessible from the graphical user-interface. (B)

contains the different databases for the STEP GIS. A 'Reset' command allows the user to clear the screen and start a new task.

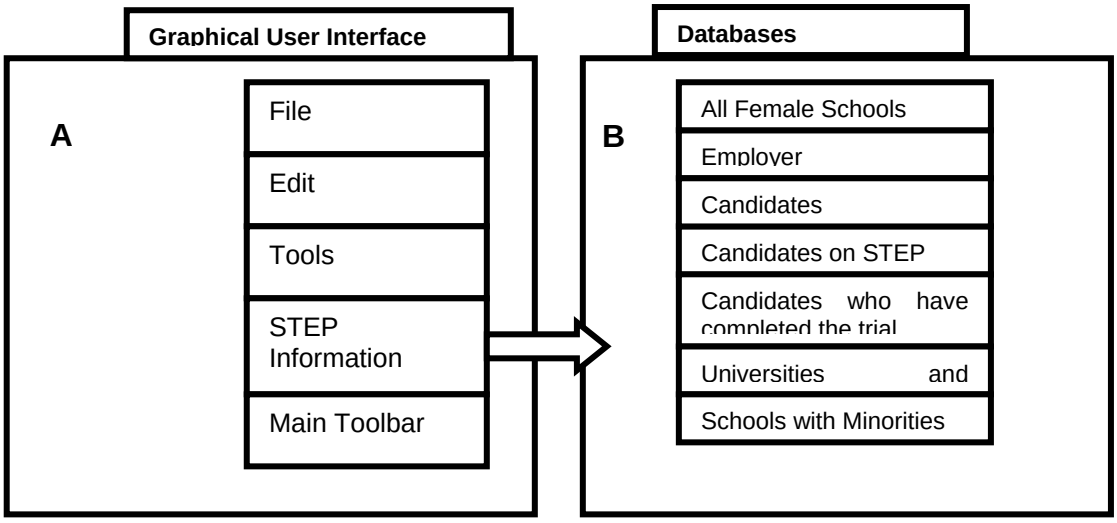

Figure 4.7: System Structure for STEP GIS User Interface

If the application is networked then it would be easy for employees from different departments to access the information for reasons other than STEP. The design of the interface was done with the Mapinfo programming software called Mapbasic. Table 4.2 illustrates the different menu options. The File and Edit headings enable users to access standard Microsoft file handling and editing operations. The Tools menu options provide facilities for viewing the display, including zooming in/out, and controlling the overlay of information from the databases. The STEP Information menu heading provides a means to access the various database

Table 4.2: Microsoft Menu Commands on Interface

File	Edit	Tools
New	Undo	Zoom-in
Open	Cut	Zoom-out
Close	Copy	Grabber
Save	Paste	Info tool
Print	Clear	Layer control
Exit		

All the commands have short cut access via buttons on the Main toolbar (see Figure 4.8)

Figure 4.8 is a map layer of the user interface showing a UK map divided into the different counties recognized by the Learning and Skills Council in the East and West Midlands. It shows the commands and tools available to the user and a database of some of the 'all Girls' schools in the region open.

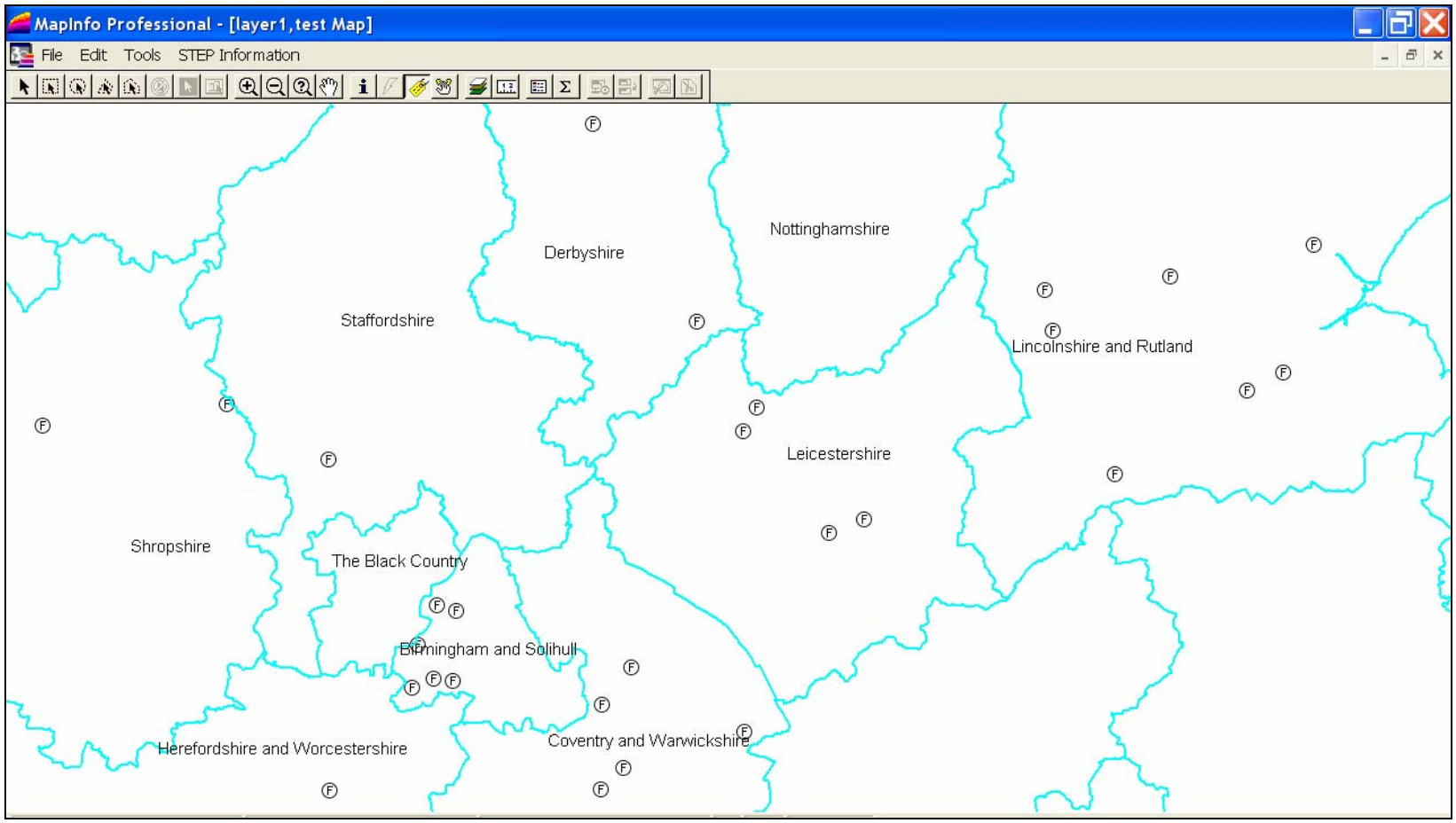

Figure 4.8: User Interface showing map with LSC areas, Commands and Toolbar

Figure 4.9 shows the different databases that can be accessed for the STEP process

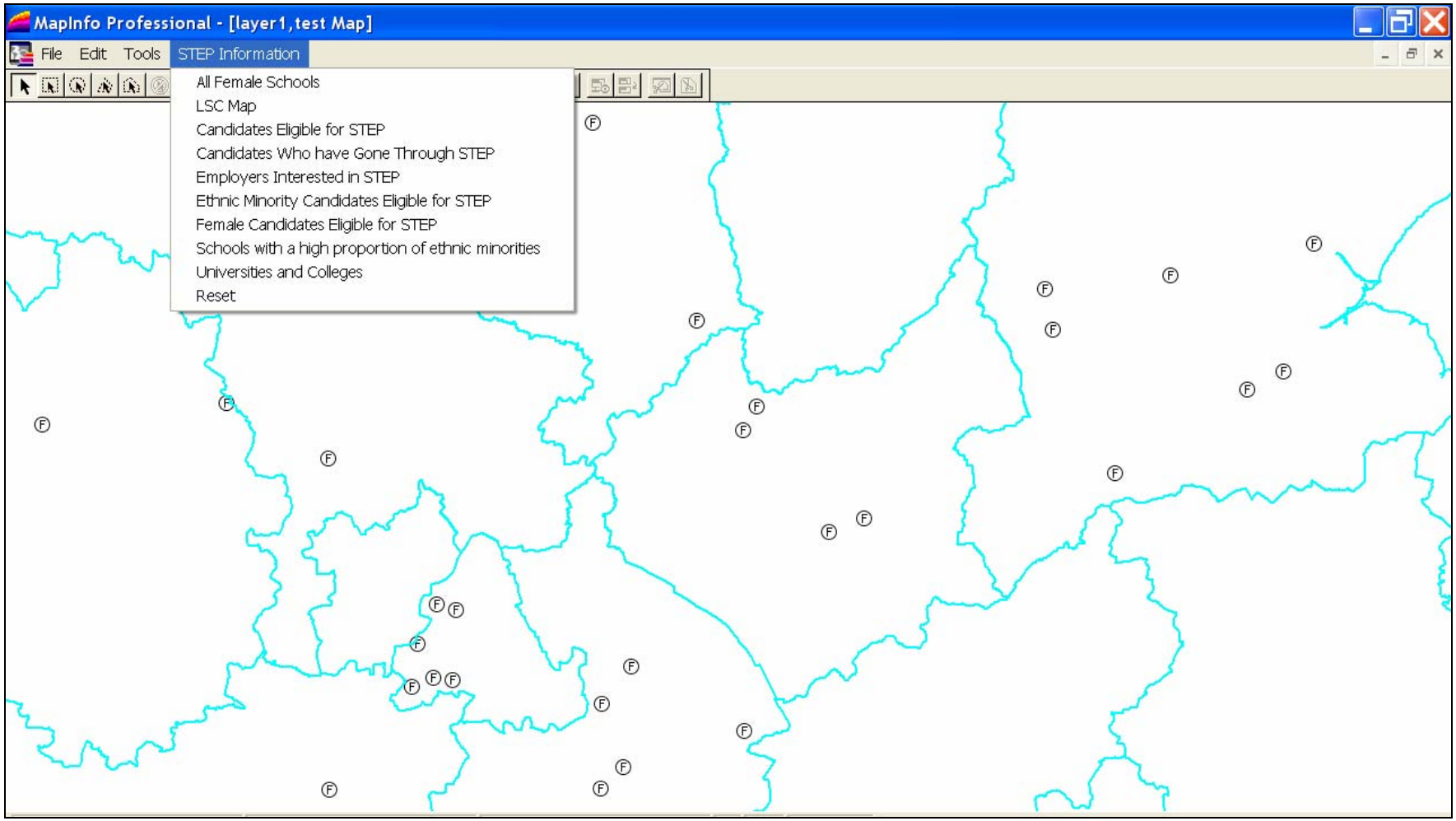

Figure 4.9: User Interface Showing a Link of the Databases Available to the User

4.3.4 System Operation and Querying Example

The GIS-based STEP application is conceptualised as a stack of floating map layers. Each map layer (i.e. database) is registered to a common map base (i.e. postcode and counties) and tied to a co-ordinate system (latitude and longitude) such that the information from the individual layers can be spatially referenced to one another. Each map layer is also linked to a data file or files through a relational database management system (DBMS). Information in the data files is associated with features on the map layer such that by querying the data files, map features can be accessed for analysis (for example, a query such as how many available candidates live in Leicestershire can be analyzed through the map features). Conversely, querying the map features can likewise provide access to the information in the data files.

Figure 4.10 shows a map layer of two databases (eligible employers and eligible candidates), with their data files. The information on the screen can help in the decision making about which candidate is most geographically suited to which employer.

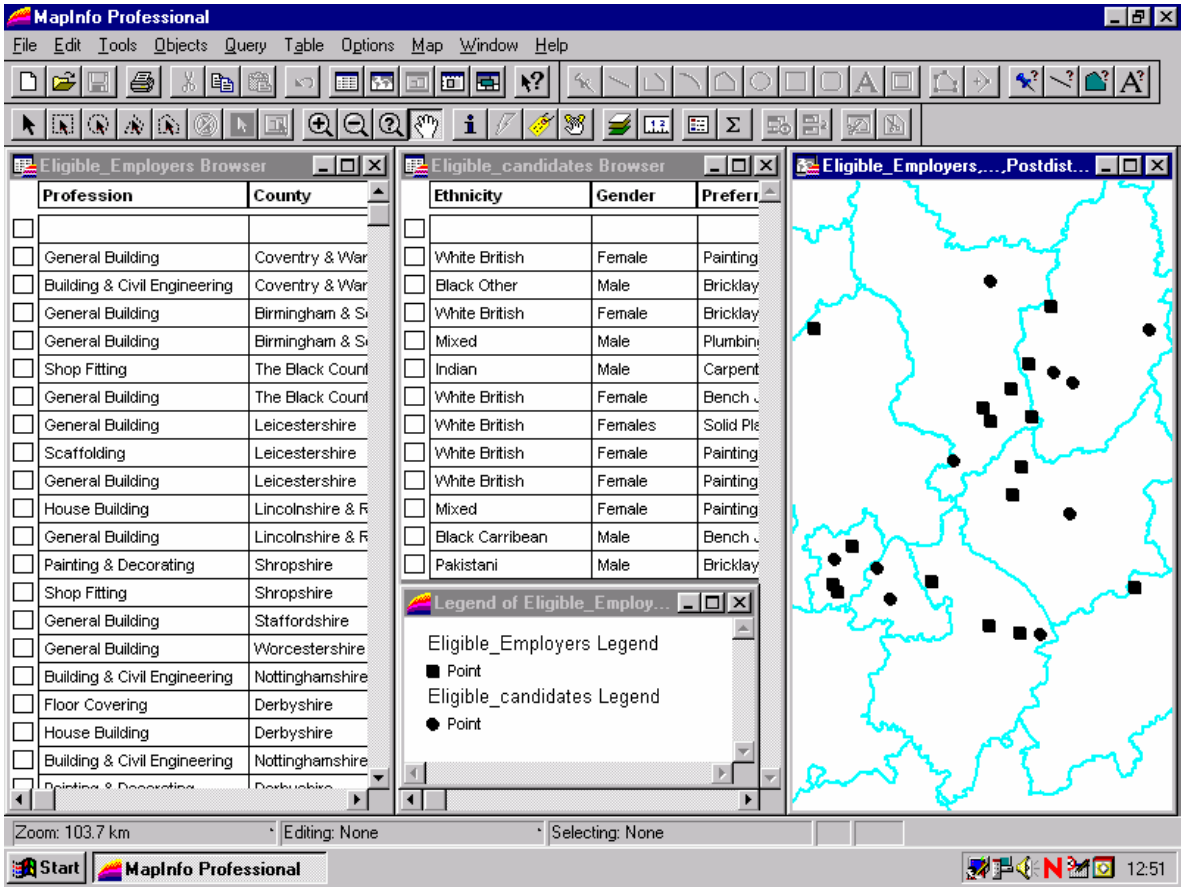

Figure 4.10: Example of a map layer showing its related data files, it also shows the integration of the eligible employer and eligible candidate databases

The screen shows a close proximity of both eligible employers and candidates, which should help in the matchmaking. It should be noted that there are other

issues outside the GIS application that need to be considered when matching the candidate to the employer such as choice of profession, and the expectations of both parties (i.e. the employer and candidate). The names of the employers and candidates have been deleted in accordance with data protection legislation.

Figure 4.11 shows an integration of the databases eligible of employers and the universities and colleges that offer construction courses. This is necessary in order that CITB-ConstructionSkills can geographically link female and ethnic minority students on construction courses who are interested in the STEP initiative to interested employers for the purposes of gaining some practical experience.

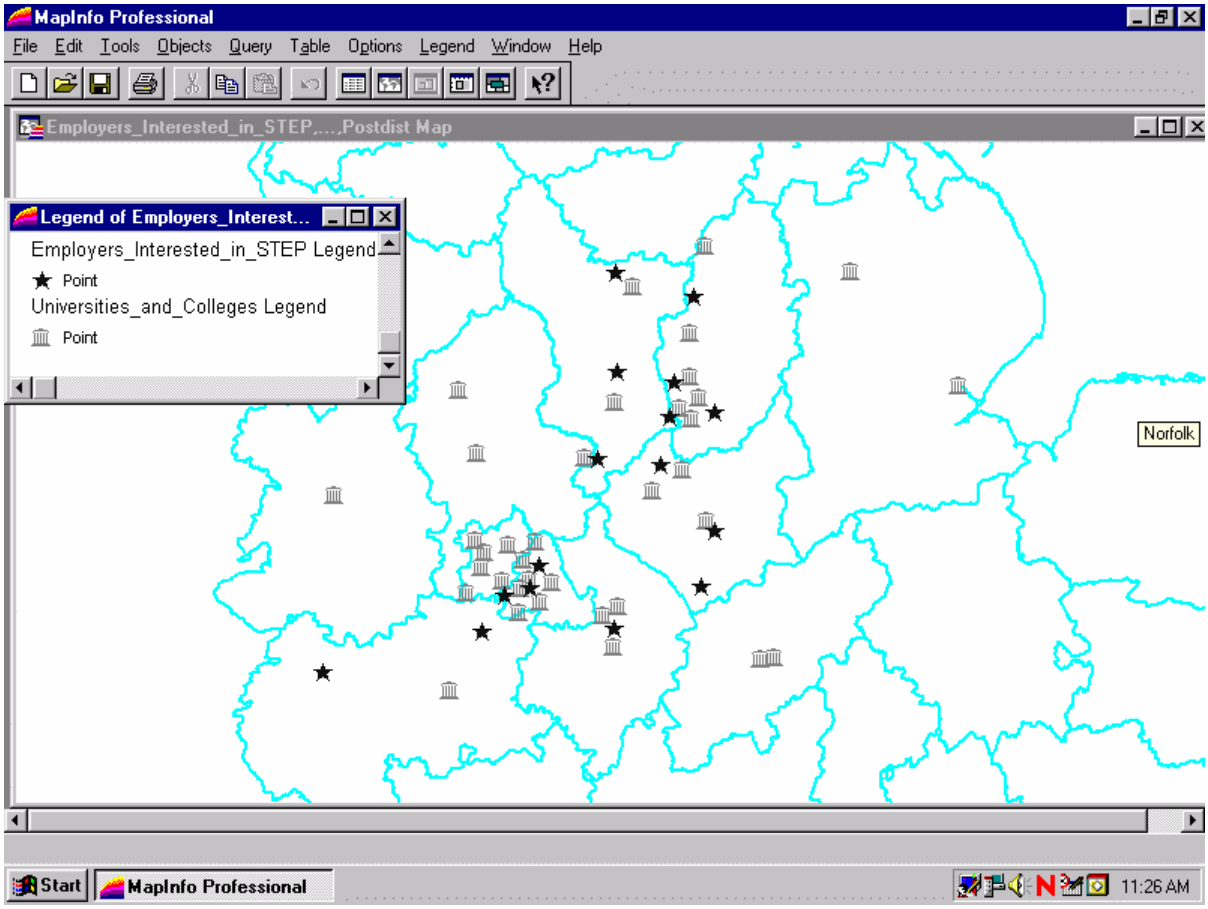

Figure 4.11: The relationship between 'Eligible Employers' and 'Universities and Colleges'.

The screen shot demonstrates that there is close proximity between interested employers and colleges, which means that students from the colleges can easily be placed with employers. There is only one employer on the left of the screen that seems to be at a considerable distance from any university or college. The attribute data files of the database map layers hold information on details such as names and addresses of the universities/colleges and the employers. In the case of the universities, there are also details of the

construction courses that they offer. The geographical location of the universities can be integrated with other information such as the density of the population of ethnic minorities. This will give an indication of universities and colleges situated in areas with high ethnic minority population that should be targeted for candidates of ethnic minority background.

Figures 4.12 and 4.13 show a query being performed on the database of candidates who have finished the STEP trial. The question asked of the database is "*How many candidates who have gone through the trial live in a geographical area called Leicestershire?*" The query has been analyzed based on both the map features and the data file. Figure 4.13 shows the symbols in the geographical area in question being highlighted; the candidates and their details in the data file are listed. The data can be queried in this way as a means of retrieving information faster than going through the same information in a paper format. The information in the different databases in the application can be manipulated individually or integrated to suit the objectives of the user.

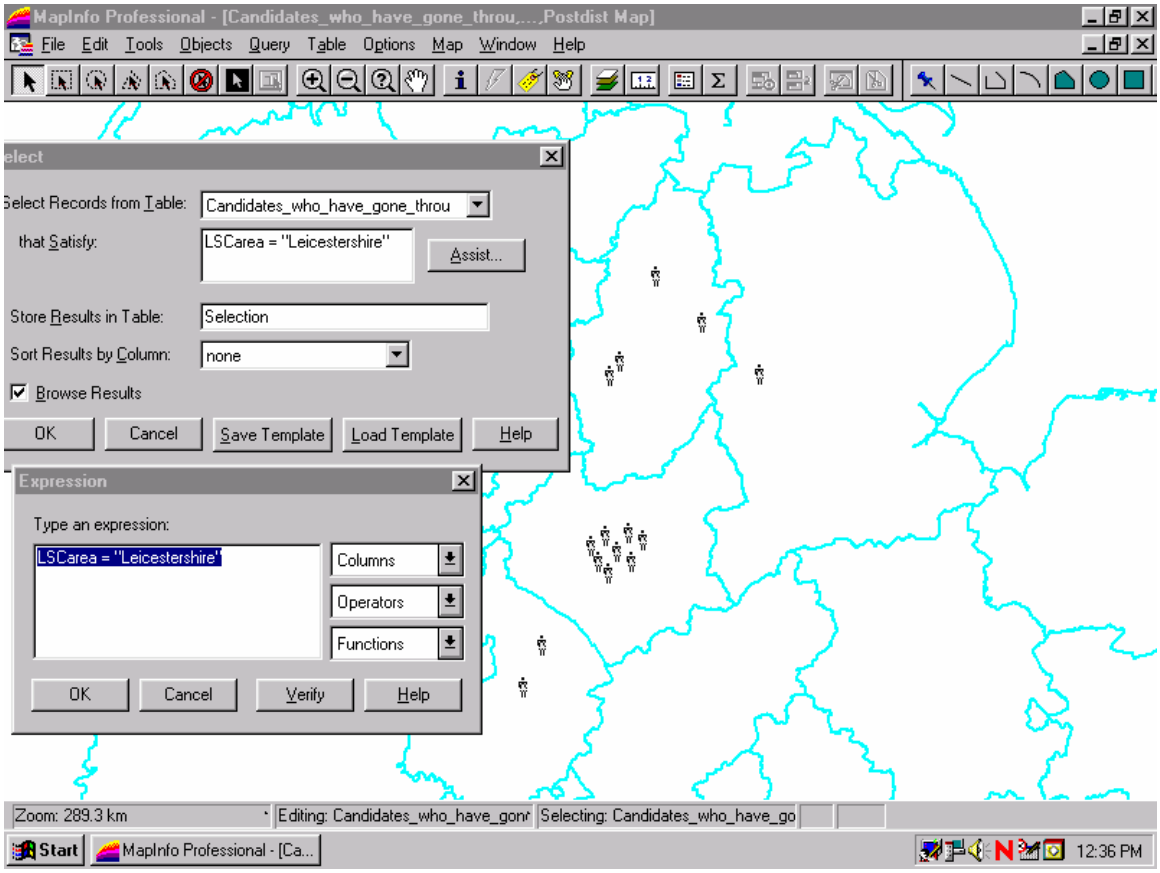

Figure 4.12: A query being performed on the both the map feature and the data file of the database 'Candidates who have gone through the STEP trial'

This section has demonstrated the current capabilities of the system, particularly with regard to integrating information from different databases and responding to user queries that require information from more than one database. There is scope for enhancing the GIS application by including more

of the organisation's databases such that more sophisticated queries are possible. Also, making the system available on the organisation's intranet would also have made it more accessible to a broader range of end-users within the organisation.

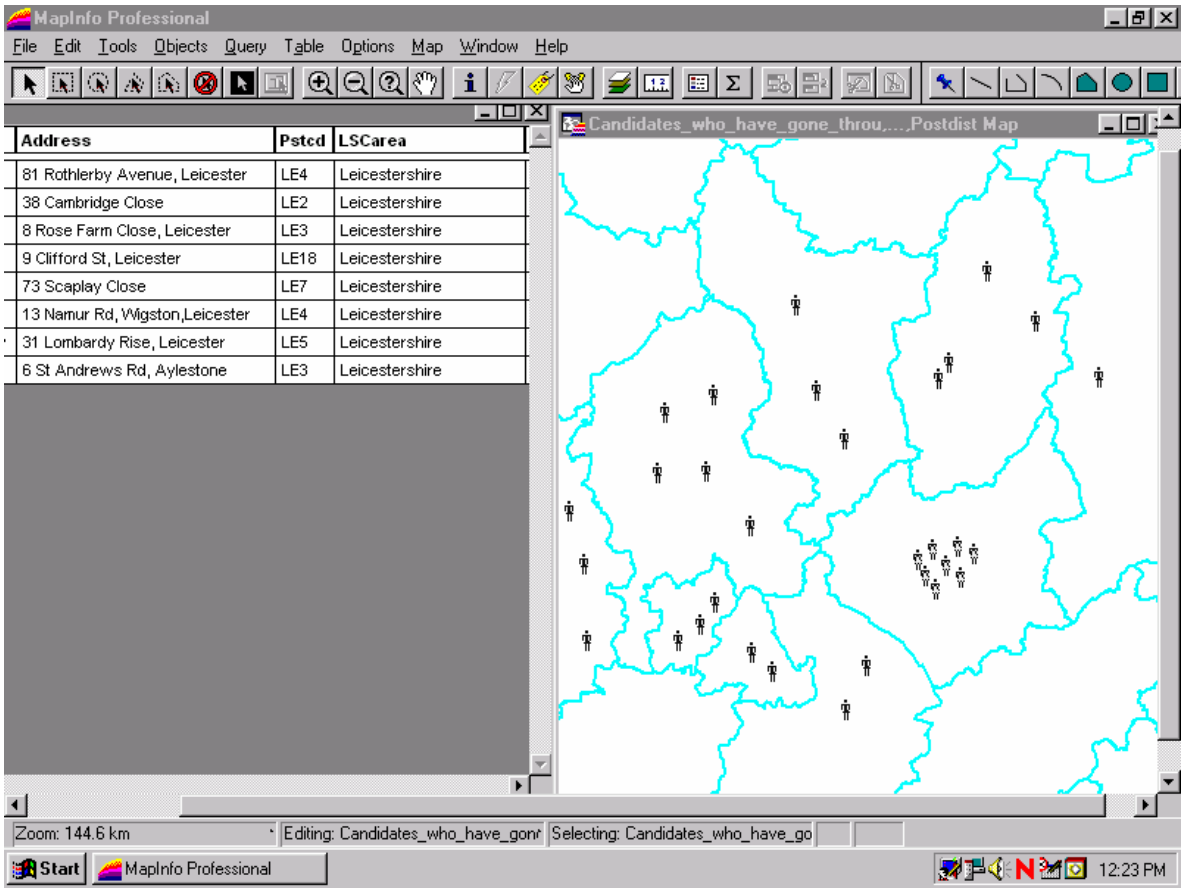

Figure 4.13: Result Of The Query

4.4. Application Stage (Work Tasks 8-12)

This stage covers five work tasks from Table 3.3 – explore user satisfaction (task 8), train user group (task 9), critical reflection on learning points from research process and its limitations (task 10), further discussion with staff (task 11), and recommendations for future development (task 12). Tasks 8 and 9 were undertaken as part of the system evaluation, which is detailed in Paper 4, and described further in Chapter 5. Task 11 was carried out by means of interviews with staff, the outcomes of which are summarised in Section 5.2.2. Tasks 10 and 12 are covered in detail in Chapter 5 as part of the critical evaluation of the research (Section 5.5) and recommendations for further work (Section 5.6). The following sections briefly describe the context for both the system implementation and system evaluation.

4.4.1. System Implementation Context

No matter how well conceived an information and communication technology (ICT) tool is the implementation process can undermine its ability to enhance the process for which it was designed (Wilmott *et al.* 1990). The literature on ICT implementation has identified some of the factors associated with the success or failure of ICT management systems (Gardner, 2000). These can relate to the nature of the user community, the processes or practices for which they are designed or structural factors which impact on its implementation. Implementation is usually seen as simply the final stage of development – during which the technology is tested out and the hardware and software are delivered to the users. However, it is more beneficial to consider implementation in a wider sense, to include consideration of all the human and organisational issues which can help make an information system successful (Grimshaw 1994). Hellman (1992) discusses the persistent failure of end-user computing to achieve its objectives because of the impact of human issues such as end users not being involved in the design of IT systems and the impact of organisational culture on the implementation of ICT.

Following its development the system was evaluated with senior management in order to establish its effectiveness in informing decisions and automating the processes of the departments involved. Brief training was carried out by the author and a member of staff responsible for the administration of STEP on a *one-to-one* basis. The implementation process is detailed in Paper 4 (section 8).

4.4.2 GIS STEP Evaluation Overview

The GIS STEP prototype was evaluated using the methodology described in Section 3. Evaluation was based on the functionality of the prototype application, its user friendliness and its relevance to its target audience, i.e. staff at CITB-ConstructionSkills in the Midlands. The evaluators comprised the area manager, the heads of the different departments and staff with responsibility for STEP and Equal Opportunities in the organisation. They were given a standard evaluation proforma covering the areas mentioned above (see Appendix 5) and were encouraged to include any additional suggestions for further enhancing the application. The findings of the evaluation are presented in Section 5.2.2.

4.5. Summary

This chapter has discussed the research undertaken to meet the aim and objectives of the EngD project. It also highlighted the main aspects of the research undertaken including development, of the GIS STEP prototype, its user-interface design and its operation (with screen shots that illustrate how the application responds to end-user queries). The context for the system implementation and an overview of the system evaluation were also presented. The key findings of the research (including the results of the GIS system evaluation) are presented in the next chapter.

CHAPTER 5: KEY RESEARCH FINDINGS AND CONCLUSIONS

5.1 Introduction

This chapter summarises the research findings and discusses its impact on the industrial sponsor and its implications for the wider construction industry. The chapter critically evaluates the research, recommendations and suggestions for future research are also given. Finally, it presents the overall conclusions of the four years of research.

5.2 Key Findings of the Research

5.2.1 Labour Market Planning

This research has established that GIS can enhance the labour market planning process in the following ways;

- It can act as a central resource by providing up to date and easy access to data. The GIS was a central resource for the STEP initiative where all the data needed from different departments were stored for easy access. It also facilitated the regular updating of the database. It offered the same opportunity of easy distribution and access to the appropriate data. Converting manual information helps bring to light errors and omissions that exist in the dataset.

- The ability of GIS to integrate different data from diverse areas of the industry provides a more comprehensive picture of what is going on geographically through the generation of detailed maps.

- It allows for different datasets to be analysed together rather than singularly. This can help in making strategic decisions for the labour market. The GIS STEP application highlighted the geographical locations of trainees, employers and colleges/training providers to aid decision makers in placing trainees with employers.

- The GIS can reveal geographical patterns and trends in data that has been collected over a certain period of time. The GIS STEP application revealed that past trainees who have gone through the initiative tended to come from a few locations within the region. This was most likely due to the fact that CITB-ConstructionSkills worked with Intermediate Labour Market organisations from these areas. The prototype also revealed where ethnic minority trainees came from where the education department held their promotional activities. This showed that, over a period of three to four years, ethnic minority trainees consistently come from the same areas.

- The research has also demonstrated that, GIS has the potential to enhance and add to the labour market planning process (see Papers 1 and 2).

5.2.2. GIS STEP Evaluation Findings

The Evaluation process was carried out in two phases. Firstly, a workshop was held with senior management and the Equal Opportunities officer who is responsible for overseeing the STEP programme, at which the system was demonstrated and its operation discussed. This provided further information on how the system could be refined to enhance its practical utility.

A simple questionnaire was used at the workshop to score the relative performance and utility of the system (See Appendix 5). The workshop involved the area manager, the four departmental managers, and the equal opportunity officer responsible for overseeing STEP as they had direct responsibility for the application. The questionnaire dealt with the functionality of the system and the usability of the interface.

Functionality of the System

With regard to the system's functionality, the system was rated effective at facilitating the STEP process. The respondents thought that the system was useful to the STEP process and to the organisation as a whole. The respondents agreed that the system represents an improvement on the existing process, particularly in helping to facilitate better integration between the departments with responsibility for implementing the STEP initiative. The application was seen as establishing a common understanding of the requirements of the STEP process amongst the different user groups. There was universal agreement that the system had great potential in being able to integrate other information processes within and across the different departments.

Interface

The second part of the questionnaire related to the usability of the interface that was designed to allow easy access to the information. The system was seen as being relatively easy to use, particularly in terms of the user interface which made it easier to perform tasks which met their individual needs. It was also thought that the system enhanced their ability to access STEP data, and helped to facilitate integration of data from the different databases. All of the respondents would recommend adoption of the interface within their departments.

General Comments

Some of the general comments on the questionnaire were very positive. For example, one user commented on the potential of the GIS in being able to overlay information as useful. Some other comments comprised observations

on its potential future utility, such as the system needing to be updated regularly for it to remain useful, and it being more useful if it is networked so more people can have access to it. Others were recommendations on how the system could further be used to enhance the process. For example it could be set up to be compatible with other systems being used in the organisation so that there could be direct transfer of information and less overlapping. Another recommendation was that some maps from the GIS application could be put on the organisation's intranet so that employees in other areas could see how it is being used.

Interviews

The interviews were *one-to-one* semi-structured interviews carried out with the departmental managers to gain further insight into contextual issues surrounding the implementation of the system. They were carried out at the end of the research when it was recognized that the system was not being used. The issues that came out of the interviews are discussed under headings extracted from the analysis of the data below.

Scheme targets and departmental targets
Although all of the departments had a responsibility for the delivery of the STEP process, not all of them had individual STEP targets. The initiative was therefore prioritised differently in different departments. This rendered it difficult to promote the scheme in some departments which meant that there was reluctance to relevant supply data.

Reliance on external agencies
In some cases where the organisation depended on external partners for the data required for the system, there were problems with the level of granularity (isolated units of data) of the data provided. Although these issues had nothing to do with the efficacy of the system to facilitate the placement process, it did undermine the commitment to the scheme amongst the user group.

Organisational change
During the development and implementation process, the organisation underwent an enormous change both internally and externally. It went through an internal restructuring and it became a Sector Skills Council as well as a Training Board for the industry. This meant it had to respond rapidly to new sets of target which made it difficult for GIS mechanisms to accommodate the quick responses to requests for information.

Resource requirements
The system's need for regular updating was a major issue for the users. In order for the system to provide accurate information, this meant there had to be someone responsible for updating it. This was seen as the system as generating added responsibility which increased their workload. Some saw it as better suited to a Head Office environment as they had more control and access to data that would be needed for the GIS.

Another issue was that the system was only installed on a single desktop PC and was not installed on to the office network. The reason for this was that only a single user licence had been purchased for the system. This affected people's interest in the system and the understanding of its capability and this probably created some aversion to it.

Timeliness of implementation
It became evident from the interviews that the technology was misaligned with the organisational priorities at the time of its implementation. Most of the interviewees felt that the GIS system has great potential as a labour market planning decision support tool, but that the implementation period was not the most appropriate for it to have been trialled. The view was also expressed that there were other systems within the organisation that met most of their requirements and it did not warrant them spending the time and effort required to learn to use it effectively.

5.3 Implications for the Sponsor

5.3.1 General

As a Sector Skills Council, CITB-ConstructionSkills has been tasked by the government to understand and articulate the training needs of employers and work with funding agencies (such as the LSC) and training providers (such as colleges) to provide a solution to these needs. GIS has the potential to make a significant contribution to the provision of a robust planning tool for training providers and funding agencies in terms of the current training and skills environment. Having a central resource for construction labour market information will encourage partnership and data sharing among agencies and communities who have responsibility for LMP. It will offer an opportunity for them to pull together and share their resources such as data, thus working together to develop and implement new initiatives and ideas for the future of the industry.

GIS has the potential to "absorb" large volumes of data pertaining to skills types needed, qualifications required and also the location geographically that they are needed; this is exactly the type of system that is needed to assist CITB-ConstructionSkills endeavours in ensuring that there are the "right people, with the right skills, in the right place at the right time". ConstructionSkills is currently in the development stage of setting up a National Construction Observatory with its regional advisory groups. The GIS has the potential to assist in the regional observatory work particularly because of its capability to demonstrate "issues" visually by geographic location. ConstructionSkills ultimate goal with the outputs of the national and regional observatory work is to have it accepted as "the" single source of labour market information. GIS could also have a vital role to play in helping to make the construction labour market information accurate and up-to-date. Construction labour market information tends to be produced with diverging frequency from a variety of sources managed by different institutions. This makes it easy to have several versions of the same data showing different

degrees of updates. The use of the GIS as a central database for holding this information should help eliminate these problems thereby improving the quality of the data and helping to avoid discrepancies. It also makes updating the information quicker and easier. A central GIS will provide agencies responsible for LMP in construction with easy and fast access to information.

5.3.2 STEP

Until the GIS application was introduced, there had been no official route of sharing STEP information between the departments. Information sharing only happened on an ad hoc basis. The GIS application can formalise the information flows, as well as assist the organisation to achieve its focus of 'job outcomes'. It will present the organisation with the opportunity for cross-departmental working to ensure that their job outcomes and targets are successfully achieved by integrating different information and work activities to culminate in a female/ethnic minority recruit potentially finding a job.

5.4 Implications for the Wider Industry

GIS has the potential not just to enhance the labour market planning process in construction, but it can address other problems that have a spatial dimensions. Most problem solving tasks require referencing both tabular and mapped data, which GIS best integrates. The ability of GIS to integrate with almost any other software and its functionality of being embedded directly into other software programs to extend their usefulness can be an added bonus to construction. This provides several flexible ways in which the technology can be used to improve the richness of construction information. The use of GIS also enables the early identification of potential problems in an information process. Through its ability to integrate different types of information and highlight patterns in the data, a GIS can indicate potential problems that might occur in the future, allowing for appropriate measures to be put in place to alleviate such problems. GIS can help flag up inconsistencies in the data as the data needed for the technology has to be structured.

The study has also highlighted the issues surrounding the implementation of new technology within a business environment. It illustrates how this can be affected if the implementation process is not well prepared enough to take account of the socio-technical system into which it was to be embedded. According to Larkin (2003) a successful implementation includes more than simply buying and installing software. It requires the management to align the users, the processes and the technology to implement a solution that meets business needs. The outcomes of which will be the realisation of the full potential of the technology investment. Thus the technology needs to be carefully managed and orchestrated. Organisations need to recognise that in order to successfully implement and benefit from new technologies such as GIS, it is essential that factors such as communication, organisational culture, leadership and commitment from senior management and environmental or organisational issues are given due consideration (these factors are discussed in detail in Paper 4, section 2). The technology within the company also needs

to be assessed in order to ensure that the organisation has the necessary infrastructure (ICT infrastructure) to use existing and new or emerging technologies successfully (Ruikar 2004). Organisations also have to realise that if they install a system without first achieving universal buy-in and a change in their business processes, they will have a software installation, rather than an implementation of a comprehensive solution to a business problem.

5.5 Critical Evaluation of the Research and its Limitations

The aim of this research was 'To explore the potential of GIS to inform labour market planning in construction'. Given that the research was spread over a period of four years in a dynamic environment, there were a number of limitations. These can be summarised as follows:

- The applicability of GIS to labour market planning has been tested on one aspect of labour market planning in construction due to time constraints. While the STEP implementation adequately demonstrated the ability of GIS to integrate disparate databases and then visually illustrate the spatial patterns in the various data sets, it would have been useful if it had been tested on other aspects of the labour market planning process to further prove its effectiveness in this area. Examples of these other aspects of labour market planning include the following:

  - Investigating the relationship between construction skills training centres, areas of skills demand, and the distribution of potential construction workers;

  - Exploring the influence of transportation options in the choice of training centre by unskilled construction workers;

  - An analysis of the data that formed the basis of previous labour market planning policy decisions to establish whether the insight provided by GIS-based manipulation of the data would have resulted in different decisions.

- The fact that there were internal and external changes within the sponsoring organisation during the project affected the organisational commitment to its implementation. For example, the initial project champions both left the organisation within the first two years of the project, and three area managers and two regional strategy advisers were appointed during the course of the work. This made it difficult to adhere to the initial vision and ensure organisational enthusiasm and active engagement throughout the research. However, it is also recognised that greater adaptability and flexibility in the research process may have enhanced the engagement of key stakeholders.

- The reluctance of the user group to fully engage with the GIS application limited the amount of feedback that could be collected on the system. It had

originally been intended that the application would be trialled in other CITB regions to identify any variations in the implementation of the STEP initiative and its acceptability within the organisation as a whole. This was not possible as there was limited motivation within the organisation (as a result of the aforementioned internal and external changes) to extend the trial in this way. The research did, however, reveal the organisational, structural and cultural constraints that must be overcome if such technologies are to be utilised in the future (see Paper 4, Appendix 4).

- The construction sector is traditionally conservative in the adoption of new technologies and CITB-ConstructionSkills is reflective of this. This inertia further exacerbated the impact of the other limitations outlined above and further limited the potential uptake of the GIS. A structured training and enlightenment programme, coupled with the early engagement of potential end-users in the system development process would have helped to overcome this problem. Time constraints and the absence of the project champions made this an unviable option.

- Poor data collection and record keeping by many of the organisations involved in the recruitment and training of potential construction workers hindered the effective use of the available data. In many cases, useful spatial information (critical for the effectiveness of the GIS application) was either missing or incomplete. This introduced delays into the development process as the relevant data had to be obtained manually and then entered into the database. This is an important issue for the wider and effective deployment of GIS for a variety of purposes within the construction industry, as many construction organisations keep inadequate records. Reliance on such poor quality data not only limits the data integration and spatial visualisation capabilities of a GIS application but severely impairs the capacity to draw useful inferences from the available datasets.

- It would have been useful to develop the GIS application as a Web-based system accessible to all parts of the organisation. This would have made it easier to demonstrate the benefits of the GIS deployment to all the key personnel in the organisation. However, this was not possible due to the restrictions imposed by the organisation's IT (Information Technology) policies and practices. There were also concerns relating to the security of the data if available via the Web. The institution of appropriate security systems and the relaxation of unnecessary restrictions will enable this to be done in the future.

5.6 RECOMMENDATIONS FOR FURTHER WORK

The research described in this thesis has successfully demonstrated the potential for the application of GIS to labour market planning in construction. Based on the research findings and the limitations outlined above, the following recommendations can be made for further work:

- There is a need to further refine the GIS application developed during the course of this research to improve its user-interface and enhance its linkage to more databases within the organisation such that the scope for data integration and information discovery is increased. This is also expected to broaden its appeal to a wider circle of potential end-users.

- Further work can be undertaken on the application of GIS to a wider range of labour market planning issues than explored in this thesis. For example, GIS can be used in tackling skills shortages and recruitment problems , as trends in certain labour market indicators can reveal that in two or three years' time there will be a shortage of a certain category of workers (e.g. carpenters/joiners) in a given geographical area. This will allow planners to put in place plans to tackle the problem (such as increasing the number of trainees in that trade or attracting workers from other geographical areas or other industry sectors).

- There is scope for further research into understanding the interplay between internal and external factors in the implementation of information systems within an organisation. Many studies on the implementation of information systems focus almost exclusively on the role of internal factors (such as culture, organisational structure/changes, training, etc.) and do not adequately consider the role of external factors (e.g. an enforced change in an organisation's focus or priorities, mergers/acquisitions, etc.) or their influence on the internal factors. This would prove invaluable to decision makers and system implementers.

- The spatial dimension in construction labour market planning has, to date, only been given limited attention. While the GIS application presented here has demonstrated the additional insight that focusing on it can bring, it has also shown that there is greater scope for GIS-based integration of labour market information with other generally available data (such as census information, transportation routes and travel information, planning approvals, etc.). This can lead to more applications that facilitate the advance planning of both labour requirements and facilities to support construction workers.

- It is generally recognised that organisational culture has an influence on the success or failure of an information system implementation. However, the system's influence on organisational culture is not as well understood. Thus, there is the need for research on the extent to which an information system should seek to support the existing culture or to influence/change it, and the key determinants to take into account.

- If GIS is to be more widely used for planning and management decision making, there is a need to better understand how construction sector organisations decide on what data to collect and what records to keep (and

in what format). Such a study should also establish the level of awareness of the importance of spatial information.

5.7 Summary and Conclusions

The main aim of this research study, as has been stated before, was '*To explore the potential of GIS to inform labour market planning in construction*'. In order to achieve this aim, four specific objectives were defined:

1. Explore current approaches to labour market planning and the datasets used to inform policy;

2. Explore the potential utility of GIS in supporting labour market planning policy *decision-making*;

3. Trial and evaluate the use of GIS by using it to enhance and inform a labour market policy measure;

4. Identify enablers and barriers to the use of GIS as a tool to improve labour market planning.

The research achieved all the above objectives, as detailed in the foregoing chapters of the thesis. The following are the main contributions of the research:

- Identified a role for GIS in the construction labour market planning process;

- Illustrated this role by developing a GIS application to aid the diversification of the construction industry;

- Highlighted the problems involved in the implementation of a GIS-based system for labour market planning.

From these main contributions it can be seen that the primary objectives above were satisfied. The first phase of the research involved exploring the current approaches to labour market planning and the datasets used to inform policy through a literature review and interviews (objective 1). The review revealed that there was scope for GIS in construction labour market planning. The next phase involved identifying the potential of GIS in supporting labour market policy *decision-making*. This was done partly through a literature review and the development of small prototype applications (objective 2). The third phase involved trialling and evaluating the use of GIS to enhance and inform a labour market policy measure, which involved the development of the GIS STEP database (objective 3). In the last phase the enablers and barriers to the use of GIS as a tool to improve labour market planning were identified through interviews and a critical reflection on both the GIS application and the research (objective 4).

The key findings of the research with regard to labour market planning and the GIS STEP evaluation findings were described in detail in Section 5.2. In addition to these, the following conclusions can be drawn from the research:

- When used alongside other labour market planning methods, GIS can enhance the labour market planning process. This has been illustrated through a specific GIS application that is being used to help in the diversification of the UK construction industry labour market.

- The ability of GIS to integrate different and varied datasets together to have a more vivid picture of what is happening geographically creates a solid platform on which plans for the future of the construction labour market can be built.

- The technology can assist the industry in refining its labour market information by eliminating redundancy and creating faster and easier access to data. It also offers opportunities for organisations interested in the construction labour market to integrate their work activities and data resources for construction labour market planning.

- The research has also highlighted the problems inherent in the implementation of a GIS-based system for labour market planning. It shows that however well intentioned and conceived as a technological tool, the implementation process is affected by internal and external factors and the socio-technical system into which the application is deployed.

- To be deployed effectively in the organizational arena and its full potential realised, an information system implementation must involve a concurrent structural and cultural realignment to take account of the integrated working which it promotes (see Sections 7 and 8 of Paper 4) .

This research has demonstrated that GIS can enhance the labour market planning process in the construction industry and its adoption will yield benefits for the industry. However, this adoption has to be well planned and all the key enabling factors – management, environment, people, process and technology must be prepared to ensure a positive and beneficial outcome.

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APPENDIX 1: PAPER 1

Anumba, C., Dainty A.R.J., Ison, S.G. and Sergeant, A. (2004): The Utilisation of GIS in the Construction Labour Market Planning Process. *In Proceedings of the International Conference on Construction and Building Research 'Responding to Change'*. Leeds, UK. 7-8 September 2004. Available on CD.

The Utilisation of GIS in the Construction Labour Market Planning Process

Claire Anumba • Andrew Dainty •, Stephen Ison • and Amanda Sergeant ∗

•Centre for Innovative Construction Engineering Loughborough University, Loughborough, LE11 3TU

∗Construction Industry Training Board ConstructionSkills, 20 Prince William Road, Loughborough, LE11 5TB

ABSTRACT

The construction industry is a large and complex industry and one that is of significant economic importance to the United Kingdom (UK). Labour market planning allows construction sector planners, decision makers and policy bodies to plan adequately and wisely to meet the challenges that the industry might face in the future. This paper reviews the use of Geographic Information Systems (GIS) in construction labour market planning. It describes the key features of GIS and details how it can enhance the planning process by its ability to integrate different and varied spatial datasets to provide a more informative and wider understanding of the current state of play. It also examines the apparent under-utilisation of GIS technology in the labour market planning process, given its potential to inform more effective labour market policy planning decisions. It concludes that GIS technology can impact positively on the planning process by helping those responsible for construction to take strategically important decisions that are necessary for the continued success of the industry.

Key Words

Geographical Information Systems, Construction, Labour Market, *Decision-making*, Development

1. Introduction

The labour market is complex in that it includes many players such as employers, organisations, the government and trade unions all playing distinctive and varying roles in the development and future planning of the market. The construction labour market is diverse and complex which renders planning for the future extremely problematic (Briscoe and Wilson 1993). Planning is however an essential aspect in order to cope with the growth and success of the industry. It is imperative that planning for the future for the labour market is as accurate as possible to ensure that shortages that might occur in the future are taken into consideration. Various planning methods have been used for the construction labour market such as econometric forecasting. While these methods are useful to the industry they posses a number of limitations, the main one being that they do not take into account the full range of labour market influences. This is because they are grounded within the socio-economic context of the way in which the industry operates. GIS provides the

opportunity to better understand geographical influences on labour market issues and therefore allows for policies for the future to be tailored to suit the individual needs of the regions.

This paper discusses an alternative method for labour market planning in construction based around the use of Geographical Information Systems (GIS). GIS provides a mechanism, which allows integration and manipulation of diverse datasets to give a clearer understanding of geographical trends. The paper begins by reviewing the current state of the labour market and briefly describes how labour market planning is currently being carried out. It then details how GIS can enhance the labour market planning process by its ability to integrate different and varied spatial datasets to give a more informative and wider understanding of the current state of play. The paper then examines the apparent under-utilisation of GIS technology in labour market planning. It then concludes that GIS technology can impact positively on the planning process by assisting those responsible for construction planning to make strategically important decisions.

2. The Construction Labour Market

The UK construction industry currently accounts for 10% of the UK's Gross Domestic Product (GDP) and employs over 2 million people – more than 1 in 14 of the total workforce (CITB 2003). The sector currently comprises of around 170,000 companies with micro companies (employing 1-13 people) accounting for 50% of direct employment and 34% of output, and large companies accounting for 20% of direct employment but 44% of output (DTI 2003). The industry has been enjoying a period of sustained growth (in 2002 increase in output was 8%) with the infrastructure and commercial sectors at the forefront of this growth trend (CFR 2003). Such rates of growth places considerable pressure on the industry's labour market and there are currently widespread concerns that the industry will not have the labour capacity to cope with its projected growth (Delargy 2001, Crates 2001). The industry is presently facing a skills shortage (CITB Employers Skills Needs Survey 2002). MacKenzie *et al.* (2000) has identified a number of reasons for this such as: The demographic decline in the number of people entering the labour market; The changing and fluctuating nature of the market and the related decline in operative skills. Other reasons include the introduction of new technologies; the growth in self-employment and the use of specialist and labour-only sub-contractors; the fragmentation of the industry; and the decline in training and related resources. As a result of these the attraction and retention of skilled construction workers has become a top priority that the industry needs to address (Yankov and Kleiner, 2001).

Due to the industry's poor public image (Strategic Forum 2002), it is extremely difficult to recruit from certain groups of the labour market. The industry is generally seen as young white male dominated industry (EOC 1996), and over the years recruitment has been concentrated on this group in the labour market. During the 1990s, the ethnic composition of the construction workforce saw little

change, with non-white employment in the industry barely rising from 1.5% in 1992 to 1.7% over the next eight years. By spring 2002 there was a further increase to 2.4%. This resulted in a total employment of ethnic minorities in the industry of approximately 49,000 compared to 1.7million in the economy as a whole (CITB-ConstructionSkills 2003). According to Cavill 2000, 39% of ethnic minorities in the construction industry have been subjected to racist comments in work and felt that their employment opportunities were less than their white colleagues. In 1992 women accounted for 11.7% of total construction employment. By spring 2002 however this figure had decreased to 9.3% (CITB-ConstructionSkills 2003). Women view the industry as a male dominated and threatening environment, with an ingrained culture characterized by masculinity, conflict and crisis (Gale 1992). Drucker and White (1996) and Clark and Wall (1998) suggest that the reluctance of women and ethnic minorities to enter the industry severely delimits the labour pool from which the industry can recruit.

In terms of the existing construction workforce the ONS Labour Force Survey reveals that there has been a steady ageing of the workforce profile in recent years. This is reflected in a decline in the 16-24 age group and an increase in those aged 45 and over. The industry faces a strategic difficulty because its traditional recruitment ground – demographic shifts have led to a reduction in the numbers of young males between the ages of 16 and 19 in the labour market. The number of people in the age group is declining because many more of them continue with academic study and others are put off by their perception of the industry as one that offers poor working conditions, unexciting work and questionable career prospects. Part of the consequence is that the industry is now more reliant than it used to be on the less able members of that age group for its recruits. This threatens to create problems in later years, when too few workers show themselves able to take on higher skilled and supervisory work. This raises issues in terms of the construction industry having to compete with other sectors for the skills it requires. The industry faces more human resources issues such as problems with it health and safety record, mobility and incorporation of new technology etc. These issues have wider implications that may not just affect Construction, but are a potential threat to the UK economy as a whole. Construction is a vital supporting sector for many other industries that rely on it for the buildings and infrastructure that they require to operate and grow.

The current labour market context presents several challenges for those with responsibility for labour market planning. This includes predicting how many workers will be needed in the next five years, what skills will they require and where in the country will they be needed. These questions can only be answered through labour market forecasting and planning activities. According to Gritzioyis and Stoll, (2002) this enables the industry to:

- Develop better human resource strategies
- Better determine future human resource requirements
- Create more targeted training programs
- Provide more base-line information for labour relations
- Give employers and workers a competitive edge

- Assist builders and developers to plan major projects

The following section reviews the ways in which current labour market planning attempts to provide this information and moreover how GIS technology could help to inform labour market projections in the future.

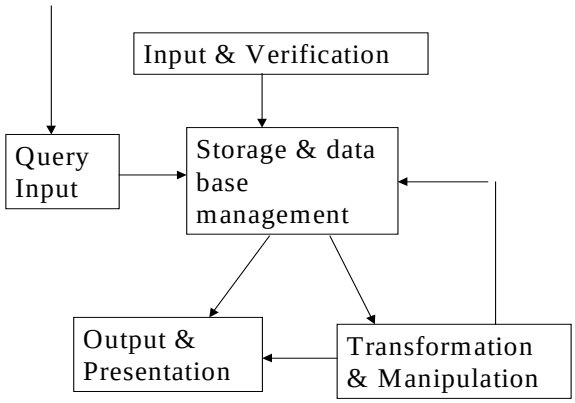
3. Current Labour Market Planning in Construction

At present labour market planning in construction is undertaken by using two types of forecast information namely aggregate industry forecasts and company level forecasts (Briscoe and Wilson, 1993). Aggregate industry forecasts are those produced by organisations such as the CITB the Department of Trade and Industry (DTI) and the Learning and Skills Council etc. This involves the whole industry and are for public consumption. The forecast model being used by CITB at present was originally developed by the Institute for Employment Research (IER); this has now been modified and redeveloped by Business Strategies. The present version of the model takes into account regional output and unemployment data but it uses fixed proportions for determining the share of regional employment across the 22 construction sector occupations. The key input statistic that drives the CITB model is the assumed rate of annual output growth in the construction sector (Business Processes Resource Centre). This is populated by a range of labour market datasets from the Labour Force Survey, output figures from the Department of Trade and Industry, output growth predictions from forecasting agencies and training supply data measured from surveys of formal training provision. The model is also informed by an employers' skills needs survey and expert opinion from academics and forecasters. The resulting forecast provides a cumulative growth requirement based on a variety of growth scenarios, which are subsequently disaggregated to individual geographical regions. The output of the model can be further informed by other econometric forecasts. Other groups such as the Institute for Employment Research at Warwick University produce construction employment forecasts as part of a national economy-wide forecasting exercise. Company level forecasts are those produced by individual firms to suit their individual objectives and are considered the property of the company. These are generally not made public and so rarely taken into account in regional and national forecasts.

Despite the success of the econometric models they do not shed light on the socio economic issues that the problems faced by the industry such as the sectors recruitment and skills shortages are usually grounded in. For example, a certain geographical area might be suffering from recruitment problems linked to a particular upsurge in activity, but the present models are unlikely to shed little light on the complex realities of local and regional labour market pressures that are affecting these areas. There is a demand for more appropriate decision-support mechanisms that can take account of geographic problems in terms of skills demand and supply influences. The recent accession of Eastern European countries to the EU has further complicated the situation as it is unclear how many qualified workers this will lead to in the medium and long term.

4. ENHANCING THE CONSTRUCTION LABOUR PLANNING PROCESS THROUGH GIS

Geographical Information Systems are essentially digital maps linked to database management systems which can be used for the purposes of displaying and querying information, carrying out spatial analysis and assisting in *decision-making* process (McMahon 1997**).** Although various GIS packages will have different features and levels of sophistication, all systems must offer a basic level of functionality**.** These basic features of the software include a database management system, tools for the input and manipulation of geographic information, tools that support geographic query, analysis and visualisation, finally a graphical user interface (GUI) for easy access. These tools assist the user in the retrieval and display of data for complex queries and thus, help to convey a diverse range of complex (and hitherto disparate) datasets in a readily understood medium. With the data stored and retrieved in a structured format, this allows the strategic combination of information to answer particular queries, which would have been impossible without the ability to analyse them within the same user environment.



(Burrough, 1986)

Fig 1 Main Concepts of GIS

Figure 1 shows the main concepts of a GIS. The data is inputted and stored as a database. The data can then be transformed and manipulated to suit the objectives of the user and the information presented through different formats such as maps and graphs. The system also allows for the data to be queried by asking different questions that can develop certain scenarios.

Geographical Information Systems have several benefits, which can be summarised as follows:

- The database management system makes access and distribution to the data faster and easier.
- They enable data integration - the ability to combine analysis of all geographic information no matter their characteristics (Parker 1996).
- They create detailed maps that enhance presentation of the information and can aid in *decision-making* and planning.
- They reveal patterns and trends in the data that cannot readily be seen on paper

As increasing number of disciplines are realising the benefits of the technology mainly because of its ability to integrate data and as a result it has no a wide range of applications. These include fields from natural sciences to the humanities such as urban planning, civil engineering, public sanitation and archaeology etc. (Murayama 2001). Within local government there is a consensus that GIS provides numerous benefits to their planning processes (Peel 1995). It aids them in making vital decisions for the future that will ensure the continued their continued existence and development. The growth of GIS uptake has been greatly enhanced by the digitisation of vast paper maps base by organisations keen to benefit from digital maps in the management of their resources

5. THE BENEFITS OF APPLYING GIS TO CONSTRUCTION LABOUR MARKET PLANNING

As was stated above the construction industry is a large and complex industry that is facing problems such as skills shortage and recruitment difficulties. Planning strategically for such an industry is an important but complicated and difficult task. Using GIS as a planning tool will benefit the industry in the future. It offers the opportunity for different and varied datasets from every facet of the industry to be integrated in order to produce new visual information through highly detailed maps that can be analysed together rather than singularly. This will aid decision-making and will facilitate understanding of the issues facing the industry in each region/locality. In light of the apparent government policy of devolving economic regeneration decision-making to regional forums, dealing with some labour market issues or problems at a regional level may yield greater benefits for the individual regions and the country as a whole.

A GIS system can also reveal patterns and trends in certain data that have been collected over a period of time. The full picture of what is happening geographically cannot necessarily be seen on an Excel spreadsheet or on a database. Having the information pictorially on a map shows which areas have a hub of activities going on and which areas have moderate activities happening or none at all.

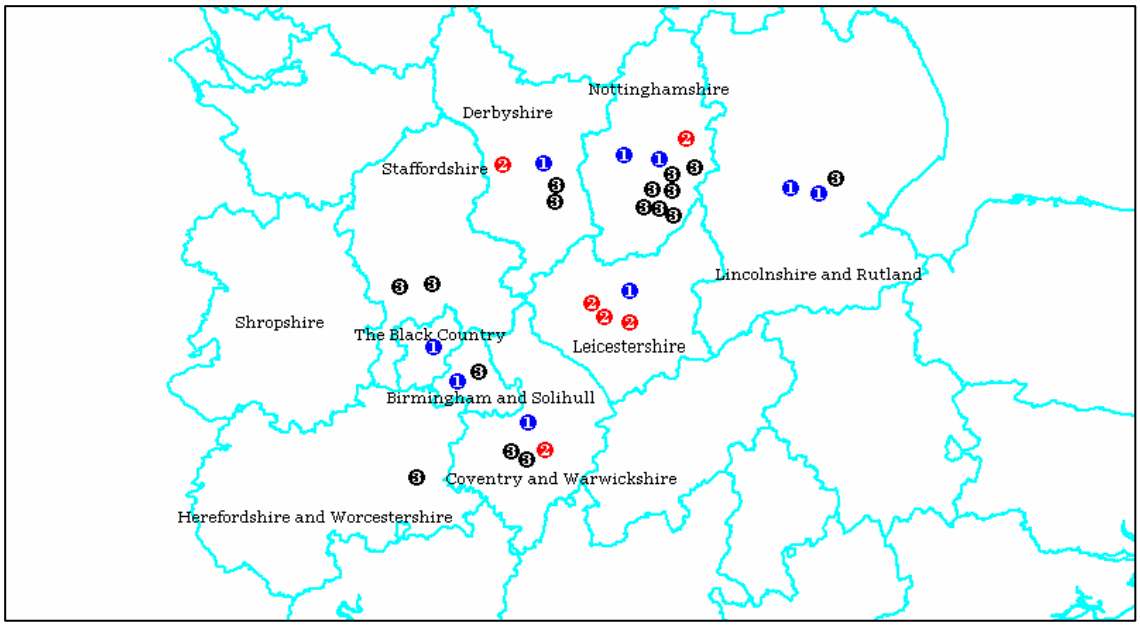


Fig 2 Female Trainees for the years 2001,2002,2003

❶ = 2001
❷ = 2002
❸ = 2003

Figure 2 provides an example of a GIS map being used to plot trends in new entrants to the sector over time. Here, female trainees that have been recruited into the industry in the East and West Midlands of the UK from 2001 to 2003 have been plotted against the postcodes where they live. The trend indicates more females come from Nottinghamshire than from the other areas. The map also shows more female trainees were recruited in 2003 than in 2001 and 2002. This gives an indication to those responsible for the recruitment of trainees of how to plan targets and policies for the future. They could look at what strategies (if any) exist in Nottinghamshire with regards to the recruitment of women into the industry and try to incorporate them throughout the region. It could also lead them to examine why more females were recruited in 2003, (for example was anything done differently that has affected the recruitment process and attracted more females). The GIS gives an indication of what is happening within the labour market and this flags up potential lines of research for examining the underlying cause of this situation. This in turn will help in making positive and appropriate decisions for the future of the industry. Most GIS systems have a Query feature that allows users to view different scenarios by asking questions. This will allow those responsible for labour market planning to ask different questions of the data and create different scenarios. This will impact positively on the decisions made for the future and it will allow for the analysis of 'what if' scenarios.

6. DISCUSSION: THE UNDER UTILISATION OF GIS IN LABOUR MARKET PLANNING IN CONSTRUCTION

Geographic Information Systems have been promoted as powerful tools for use in the construction industry for more than a decade (DOE, 1987). Indeed, they have been used to great effect on such prestigious projects as London Docklands Redevelopment (Howland, 1993), and the Channel Tunnel Rail Link (Oman, 1996). Other examples of the use of GIS can be found in practically all stages of construction activity from initial conception and site location, through to facilities management of the completed project. Planners are among the first construction professionals to realise the benefits of seamless site-centred digital mapping provided by GIS with their colour overlays, which allow for easy display of planning applications, enforcement actions, tree preservations, listed buildings etc. (McMahon 1997).

The range of applications to which GIS has been applied in construction raises questions as to why GIS has not been applied to the labour market planning process, particularly given its effectiveness in combining population, recruitment and employment datasests. This could yield rich insights into the nature of the labour market. There is very little evidence of it being used in labour market planning or construction skills and training policymaking. Although reasons for this are speculative, one of the reasons for this could be the problem that exists with the availability of data. GIS can do nothing without data. Construction labour market data exits in many forms including paper and electronic sources, but data conversion to GIS format is usually time consuming and expensive. There are strong arguments for having data in a common computer format (less storage space than paper files or maps, and easier exchange of data between interested parties' etc.). A related problem is that very often data is collected for different themes in geographical areas, which are not compatible. For example, data on a certain theme (A) has been collected for towns and urban areas while another theme (B) has been collected on a county-wide basis. These datasets would not combine effectively and so would not yield useful insights.

Clearly, going through the expensive process of labour market data translation to GIS format is expensive and time-consuming. The only way to manage this would be if all organisations responsible for providing construction labour market data store and format their information in an uninformed and consistent manner. The continued development of data exchange by Internet and Email strengthens the case for the adaptation of GIS in labour market planning in construction as this can greatly benefit the process in the future. However, such a development would firstly require parties holding such information to integrate their data management systems, which may prove problematic in an industry as fragmented as construction.

7. SUMMARY AND CONCLUSION

The paper began by reviewing the current state of the labour market and briefly described how labour market planning is currently being carried out. It then detailed how GIS can enhance the labour market planning process by its ability to integrate different and varied spatial datasets to give a more informative and wider understanding of the current state of play. Indeed the power of GIS for facilitating the analysis and synthesis of labour market data cannot be overstated. The industry is missing out on valuable labour market insights that GIS can provide.

GIS technology can impact positively on the planning process by allowing those responsible for construction planning to easily combine and process geographic labour market data to generate new and more revealing information. The ability of GIS to integrate different and varied datasets together to have a bigger picture of what is happening geographically around the country creates a solid platform on which plans for the future of the industry can be built on. If the problems facing the construction labour market are to be dealt with, then industry planners need to have in place appropriate and robust mechanisms in place that enhance their planning for the future of the industry. This in turn demands that relevant stakeholders combine their efforts to ensure that GIS technology is embraced and skills projects and robust labour market planning policies are developed in the future.

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APPENDIX 2: PAPER 2

Anumba, C., Dainty, A.R.J., Ison, S.G., and Sergeant A. (2005): The Application of GIS to Construction Labour Market Planning, *Construction Innovation,* 5, 219-230.

The Application of GIS to Construction Labour Market Planning

Claire Anumba • Andrew Dainty •, Stephen Ison • and Amanda Sergeant ∗

•Centre for Innovative Construction Engineering Loughborough University, Loughborough, LE11 3TU

∗Construction Industry Training Board ConstructionSkills, 20 Prince William Road, Loughborough, LE11 5TB

Abstract

The UK construction industry faces unprecedented skills demands which have been fuelled by sustained sectoral growth and a concurrent downturn in the numbers of young people entering the industry. However, patterns of supply and demand are not uniform across the country, with regional and local skills shortages being determined by the specific socio-economic context of the area under consideration. Thus, developing effective labour market policy demands spatially-oriented labour market information which can be reconciled against industry growth forecasts within a particular region or locality. This paper explores the potential of Geographic Information Systems (GIS) in providing such a mechanism for enhancing the labour market planning process. The paper details how GIS can aid construction labour market planning through its ability to integrate disparate labour market information efficiently, thereby placing analysts in a better position to understand specific spatial patterns. A range of datasets were strategically combined in order to reveal regional nuances in labour demand and supply which would be difficult to discern without the use of such a tool. Although the GIS output would need to be considered in combination with a range of other forecasting techniques if robust projects of labour demand and shortage are to be generated, it nevertheless offers an effective decision-support tool for informing labour market policy in the future.

Keywords: GIS, Labour Market Planning, Decision-Support

1. Introduction

The UK construction industry accounts for between 6% and 7% of the working population (DTI 2004). It is a sector which combines a wide range of craft-based and professional skills across a range of fairly disparate sub-sectors (Loosemore *et al.*, 2003). Construction activities range from large-scale civil engineering and building works to small housing repair and maintenance tasks. As both the demand for construction output and mix of work changes, so the demand for different labour skills varies. Fluctuations in construction output tend to be very pronounced and the associated movements in skill demand can similarly be strong and rapid (Briscoe and Wilson, 1993). Thus, effective labour

market planning is vital in order that shifting market demands can be met and appropriate numbers of trainees recruited to meet future shortfalls (Dainty *et al.*, 2004).

It is widely accepted that the industry currently faces acute skills shortages (CFR 2003). High output rates and continued growth have placed considerable pressure on the industry's labour market capacity, and there are currently widespread concerns that the industry will not have the resources to cope with the growth projected over the next few years (Delargy 2001, Crates 2001, CITB Skills Survey 2003). However, the current picture is not uniform across the country and patterns of demand and supply differ in terms of both individual sub-sector and occupation within different geographical areas (CITB, 2003a). Thus, in order to plan for future skills needs the industry needs to know more about its skills demands and labour market dynamics at a regional level. It requires easy access to appropriate labour market information (LMI) on existing and future skills supply and data on future market demand in order to inform decisions of where to focus resources aimed at recruiting and training an appropriate intake of new skills.

This paper reports on research which explores the potential of Geographic Information Systems to help inform labour market planning activities within the construction sector. GIS can be applied to the *decision-making* process in labour market planning through the integration and analysis of different datasets to reveal geographical patterns and trends that cannot readily be seen (West, 2000). It provides the potential for combining and processing hitherto disparate datasets and hence, for generating sophisticated analyses of both demand and supply side data. Analyses are facilitated by the geographical representation of the combined LMI which provides pictorial insights into the nuances within particular geographical regions. This, in turn, could enable more informed policy planning decisions to be made which ensure the preparedness of the sector for fluctuations in demand and output. However, despite its potential as a decision-support tool for the sector, it has yet to be adopted by sector skills policy makers.

2. The Construction Industry Labour Market

The UK Construction industry has enjoyed year-on-year growth over the past few years (DTI 2004) and most industry forecasters agree that the industry will carry on expanding for the foreseeable future (CITB 2003a, Construction Forecasting and Research, 2003). The most recent expected growth forecasts over the next five years range from 2-3% (CITB, 2003a). Amidst such strong rates of growth it is inevitable that the industry is utilising a high proportion of its available labour capacity and this can give rise to tender price inflation, poor work quality and delays in completion times (Dainty *et al.*, 2004). The Construction Industry Training Board's (CITB) Employers' Skills Needs Survey carried out in 2003 clearly shows that the industry is facing an acute skills shortage, with 79% of the employers surveyed reported that they had experienced difficulties in recruiting skilled staff.

The construction industry is currently facing a capacity utilisation (CITB 2003b). This refers to the extent to which an industry or sector is using all of the available skills within the labour market. High levels of capacity utilisation infer a tight labour market situation and one in which skills shortages are more likely. A number of indicators exist which indicate whether the industry is operating at high or low levels of capacity utilisation. High levels of utilisation are signified by rising tender prices, poor quality and delays in completion. Symptoms of excess capacity include rising unemployment and a decline in workloads.

Of the factors which compound the current labour supply situation, the most severe is the shortage of trained new entrants to the sector which are required to cope with current demand (Agapiou, Price and McCaffer, 1995). The Office for National Statistics (ONS) Labour Force Survey reveals that there has been a significant ageing of the workforce in construction (ONS 2003). The industry faces a particular strategic difficulty because its traditional recruitment pool – young males between the ages of 16 and 19 - are becoming increasingly hard to access. The number of people in this age group is declining because many more of them continue with academic study and others are put off by their perception of the industry as one that offers low salaries, poor working conditions, unexciting work and questionable career prospects (Clark and Wall 1998).

The CITB-ConstructionSkills forecast for the period 2003-2007 indicates that around 83,000 new recruits will be required each year, or a cumulative requirement of 415,000 over a five-year period. The annual requirement can be broken down into 46,000 construction site operatives, 16,000 managerial and clerical staff, 7,000 construction professionals and 14,000 building services operatives. The occupations with the largest annual requirement are likely to be the timber trades, managers, electricians, clerical, bricklayers and plumbers. The demand for such craft workers and professionals is also likely to be compounded by a concurrent demand from other sectors, with up to a quarter of trained construction operatives operating outside of the sector (ReportFinder 2003). Thus, the industry's current skills concerns have made the attraction and retention of skilled construction workers a key priority for the future development of the sector (Yankov and Kleiner, 2001).

3. Current Approaches to Labour Market Planning in the Construction Industry

In planning for the industry's future skills requirements, labour market analysts and policy makers have adopted a range of sophisticated tools and techniques for predicting likely discrepancies in supply and demand which can be used to inform decisions of where particular efforts need to be made to recruit and train an appropriate supply of new labour. Of these, the most widely adopted is econometric forecasting which uses data on construction output, the price of capital and labour wage rates to forecast construction employment (see CITB-

ConstructionSkills, 2003a). The model currently adopted by CITB takes into account regional output and unemployment data but it uses fixed proportions for determining the share of regional employment across the 22 construction sector occupations. The key input statistic that determines the demand predictions of the model is the assumed rate of annual output growth in the construction sector (Business Processes Resource Centre 2000). This is populated by a range of labour market datasets from the Labour Force Survey, output figures from the Department of Trade and Industry, output growth predictions from forecasting agencies, and training supply data measured from surveys of formal training provision (CITB 2002). The resulting forecast provides a cumulative growth requirement based on a variety of growth scenarios, which are subsequently disaggregated to individual geographical regions. The output of the model can be further informed by other econometric forecasts.

Although the model is also informed by an employers' skills needs survey and expert opinion from academics and forecasters, it is a 'top-down' model in that it predicts demand for skills based on aggregated assessments of demand and supply based on forecast levels of industry growth (CITB 2002). As such, it cannot identify specific labour market trends at a local level or provide an explanation as to why these trends are apparent. Moreover, such quantitative demand and supply forecasts cannot take into account the full range of labour market influences, many of which are grounded within the socio-economic context in which the industry operates (Courtney 2003). This limits the value of such a forecast in informing labour market policy planning, as in order to be responsive to the needs of the sector, skills training and promotional activities must be tailored to the particular needs and circumstances of the particular geographical region in question. Moreover, industry fragmentation renders the effective analysis of the industry's labour market and the underlying causes of skills shortages problematic, which can result in wide variations in the projections used to measure the skills shortage (Briscoe and Wilson, 1993).

Econometric forecasts are usually supported by a range of other approaches such as *environmental scanning* which entails the identification and analysis of key trends in the external environment having a potential impact on the workforce (Ekamper, 1997). For example, a growth in the demand for off-site fabricated components may offset skills demands within sub-sectors and so such a demand would need to be taken into account. These changes are monitored as they can have a major impact on future strategies put in place to deal with the labour market (Idris and Eldrige, 1998). Effective environmental scanning requires the development of consistent patterns in the streams of decisions being made by planners (Mintzberg, 1983). Likely future shifts are analysed to define the capabilities required to implement the industry's strategy and capacity to adapt to change (Walker, 1980). However, as with econometric forecasts, this approach fails to take into consideration the regional patterns of demand which shape skills needs in any geographical region. For example, a large project could skew demand for particular trade skills and undermine skills projections on this basis. Hence, a more robust methodology is required for improving understanding of labour supply and demand at a regional level. The use of GIS in combination with those other methods may provide such an approach.

4. Geographic Information Systems

A Geographical Information System (GIS) is essentially a digital map linked to a database management system which can be used for the purposes of displaying and querying information, carrying out spatial analysis and assisting in the *decision-making* process (McMahon 1997). Although various GIS packages will have different features and levels of sophistication, all systems must offer a basic level of functionality. These basic features of the software include a database management system, tools for the input and manipulation of geographic information, tools that support geographic query, analysis and visualisation and finally a graphical user interface (GUI) for easy interaction (Burrough,1986). These tools assist the user in the retrieval and display of data for complex queries and thus, help to convey a diverse range of complex (and hitherto disparate) datasets in a readily understood medium. With the data stored and retrieved in a structured format, this allows the strategic combination of information to answer particular queries, which would have been impossible without the ability to analyse them within the same user environment (Parker 1996). Figure 1 illustrates the main concepts of a GIS listed above.

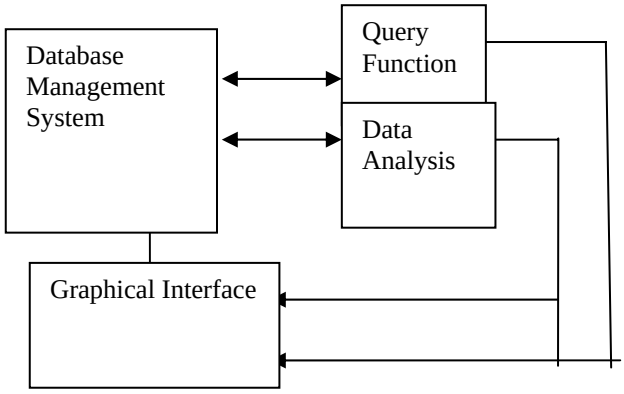

FIGURE 1: MAIN COMPONENTS OF A GIS

4.1 Database Management System

With GIS all the data can be stored in a structured and appropriate format, making access easier and less frustrating.

4.2 Query Function

The technology allows the user to generate enquiries by retrieving any selected subset of the database and then apply spatial analysis routines to data using a standard SQL (Structured Query Language) (CCTA 1994).

4.3 Data Analysis

It will allow all the different sources of data to be integrated and analysed. Geographic information can be easily combined and processed to consequently bring about benefits in the form of generating new types of information.

4.4 Graphical Interface

GIS allows data that has been stored only once to be output from different devices and in different formats. Different spatial information can be output together (layered on top of each other) to give the user a full picture of what is happening in different areas.

Using GIS as a planning tool will benefit the industry in the future. It offers the opportunity for different and varied datasets from every facet of the industry to be integrated in order to produce new visual information through highly detailed maps that can be analysed together rather than singularly. This will aid *decision-making* and will facilitate understanding of the issues facing the industry in each region/locality. In light of the apparent government policy of devolving economic regeneration decision-making to regional forums, dealing with some labour market issues or problems at a regional level may yield greater benefits for the individual regions and the country as a whole. A GIS system can also reveal patterns and trends in certain data that have been collected over a period of time. The full picture of what is happening geographically cannot necessarily be seen on an Excel spreadsheet or on a database. Having the information pictorially on a map shows which areas have a hub of activities going on, and which areas have moderate activities happening or none at all.

5. The Application of GIS for other Construction-Related Issues

GIS has been used over the years in the construction industry to provide a spatial dimension to planning. The ability of GIS to use colours or styles to systematically represent different forms of data by overlaying them over each other is known as thematic mapping. This has been used to produce positive results in the construction industry (King and Kiremidjian, 1996, Etzion *et al.* 2001). GIS contains tools for determining distance, proximity, direction, adjacency and connective relationships between mapped features. These are called topological tools or buffers. They are useful in determining all the objects of one class within a specific distance of another type of object (Easa and Chan, 2000). This capability of the software has been utilised in Construction to assess the archaeological potential of a development site (Needham and Macklin, 1992). Geographic Information Systems' ability to answer spatial questions by creating 'what if' scenarios through their query tools has also been utilitised in the industry (Griffin 1999, Hellawell *et al.* 2000).

The process where a GIS function can be isolated and embedded in almost any other program as a control code has also been utilised for analysing complex

spatial relationships and problem solving (Li *et al.* 1996, Cheng and Chen 2002, Rylatt *et al.* 2003).

The purpose of this study is to explore the practical utility of GIS as a labour market planning tool and to evaluate its capabilities to a range of complex labour market issues. It aims to establish the practical utility of GIS in supporting policy planning decisions which account for the geographic nuances of both industry output and labour market conditions. Its potential in combining both bottom-up (regionally determined) and bottom-down (nationally determined) analyses in pursuit of more robust policy *decision-making* was tested using available datasets extracted from available datasets. This shows the potential of GIS to redefine the labour market planning process in the future.

6. Methodology

In order to test the potential of GIS in informing understanding of the labour market it was firstly necessary to establish a range of available datasets to combine within the system. Data for GIS comes in two forms, geographic (or spatial data) and attribute or aspatial data (Elwood 2001). Spatial data contain an explicit geographic location in the form of a set of coordinates, whereas attribute data contain various information relevant to a particular location (e.g. depth, height, sales, figures, etc.) and can be linked to a particular location by means of an identifier (e.g. address, post code etc.) In order to test the potential of GIS within a construction labour market planning context, the datasets used in this research provide a broad picture of skills requirement and labour capacity for Great Britain. A range of datasets available at the regional level were then strategically combined in order to reveal regional nuances and influences on labour demand and supply that would be difficult to discern without the use of such a tool. The datasets used in the research were obtained from the CITB-ConstructionSkills and the Department of Trade and Industry (DTI). Regional new entrant trainees and trained output figures for 2004 were obtained from the CITB-ConstructionSkills Managing Agency which has responsibility for assisting employers in the industry to train youth new entrants to industry standard. New work order, output and unemployment figures for 2004 were obtained from the DTI. The DTI and Office for National Statistics are the two main sources of construction output and employment data in the UK. Employment estimates of employees are available from the DTI and the ONS. The ONS has two alternative estimates of employees from the Labour Force Survey and from the Annual Business Indicator (ABI). Both organisations produce estimates of output although they are significantly different due to their definition of construction output and their coverage. For the purpose of this research the DTI data has been used as it is the most comprehensive source of UK construction data (DTI, 2004). The Data Collection Branch at the DTI collect the information from construction firms on output, employment and new orders by means of periodic inquiries, targeting firms selected from the comprehensive Builders Address File maintained and updated by the Data Collection Branch.

The GIS platform used was the Map Info Professional 7.0 operating on a Pentium-based PC in a Windows NT environment. The primary map layer of the system is a map of the UK divided in government administrative regions. The data were obtained from the Ordinance Survey and converted into the MapInfo format.

7. Results and Discussion

The GIS-supported analyses are presented below together with some discussion of the implications of the findings.

7.1 Labour demand analysis: new orders and labour capacity by region

The first map (Figure 2) combines a range of data aimed at identifying likely under/over capacity in the labour market, by region, over the next year. The shading shows construction unemployment (qualified construction workers currently looking for work), new work orders (orders placed for new work in the next 12 months) and output figures for 2004. The data were obtained from the Data Collection Branch at the DTI. This provides an indication of the capacity of the construction workforce for each region over this period.

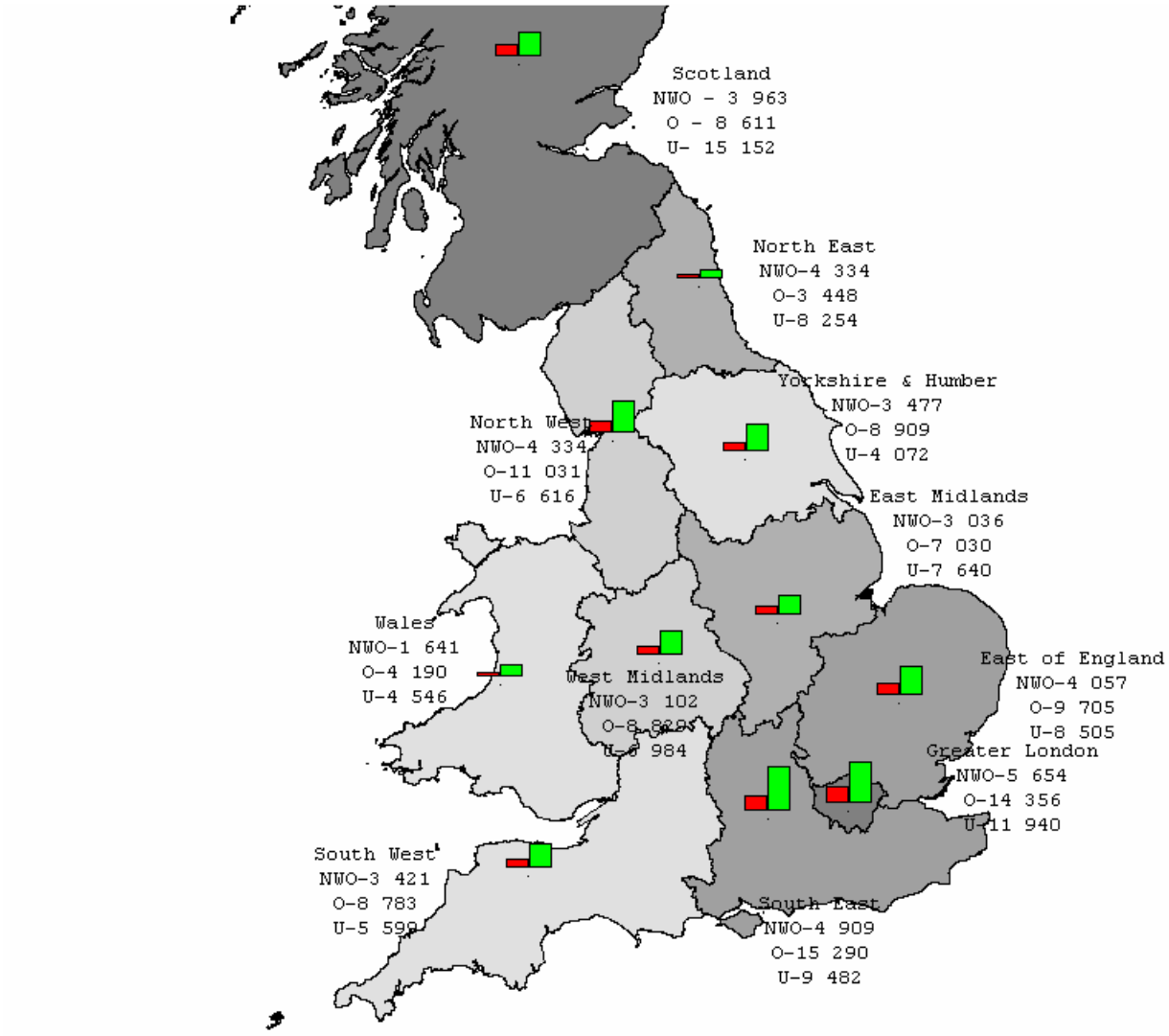

Figure 2: Construction unemployment, construction new work order figures and construction output figures for 2004 by RDA region

Key

Bar Chart = New work Order 2004 (left bar) and Output 2004 (right bar)
NWO = New Work Order
O = Output
U = Unemployment
Unemployment (the darker the shading the higher the rate of unemployment)

- 12 000 – 16 000
- 7 000 – 11 000
- 1 000 – 6 000

This analysis shows that the greatest level of construction unemployment is in Scotland and Greater London. Current levels of output are highest in the South East, Greater London and the Northwest (15,290, 14,356 and 11,031 respectively), but future orders are strongest in the South East and Greater London. Given that these regions are adjacent it is likely that a particularly acute pattern of demand is likely within this area which may draw labour from other regions particularly the East of England which has relatively high levels of

construction unemployment and relative low levels of output. However, this assumption is predicated on transience of labour, which in turn depends on how far workers are prepared to travel to take up vacancies, and the quality of the transport infrastructure between regions. For example, there might be a stronger likelihood of workers travelling from the west along the M4 corridor or South from the Midlands given the road links. Another issue to consider is that even though the map has revealed high unemployment relative to new orders and output in the South East, London and the East, this might be due to factors such as the mismatch between unemployed workers skills and job vacancies.

Other factors which could undermine the GIS analysis include major projects which produce particularly high levels of demand within a locality. Such pinch-points are particularly acute in Greater London, where there are many proposed projects over £100m planned in the next few years, such as the 2012 Olympics. This could further change the demand and supply of skilled operatives.

These caveats to the labour demand picture presented by the GIS analysis highlights the need to use the tool as *part* of a more complete analysis. For example, econometric forecasts provided by CITB-ConstructionSkills Regional Skills Foresight Report (CITB, 2004a), total construction employment in London is forecast to increase by just 0.1% annually against a cumulative requirement of 7,559 for 2004-2008. This indicates that the existing spare capacity in the region will be inadequate to meet regional demand over this period. This contrasts markedly with other regions such as Scotland, which has a proportionately high rate of unemployment and fewer large projects. Construction employment in Scotland is forecast to increase by 1.3% annually against a cumulative requirement of 412,900 for 2004-2008 (CITB 2004b). The analysis shown in Figure 2 indicates the region has the capacity to cope with the workload forecasted, and there should be spare capacity allowing regions like the North East and North West to be able to use some of the Scottish labour force to be able to cope with their proposed work. This is just an assumption as there are many factors that might influence the situation.

7.2 Labour supply analysis: first year craft intake and trained labour output by region

In order to shed more light on the labour capacity picture provided by the analysis shown in Figure 2, it is necessary to explore the supply side situation with regards the numbers of trainees and fully qualified workers entering the construction labour market. These figures provide an indication of the likely future supply of new skills for offsetting the likely shortages highlighted above. Accordingly, Figure 3 combines the number of first year intake of new entrant trainees for 2003/2004 with the number of trainees who have achieved their construction qualifications. This gives an indication of the number of new trainees entering the industry against the qualified output in every region, and provides an indication of whether the number of qualified trainees will increase capacity to a level which accords with the growth in output discussed above.

Figure 3 shows a bar chart of first year intake of new entrant trainees in the 2003/2004 academic year for technical occupations and manual skills and the output of qualified new entrants for the same year in the different regions. The shading represents the value of new orders for each region; the darker the shading the higher the value of new work orders. Figure 3 reveals that all of the regions have fairly high numbers of first year intakes with the highest numbers in the East of England and the West Midlands, and the lowest in the North East and Greater London. However, it also indicates that there is not enough trained new entrants entering the industry to ease the skills shortage problem. Regions namely the South East, Greater London, East of England, North West and Scotland had a high value of new work orders in 2004, but very low numbers of qualified trainees relative to this output growth. This underscores the severity of the skills shortage. Figure 3 also reveals the high numbers of first year trainees in comparison to those completing their qualifications. Assuming that new entrant numbers have been broadly consistent over this period, this suggests high drop out rates from construction craft courses. An implication of the data presented in Figure 3 may be that the industry has to draw on workers from other sectors or from non-indigenous sources (such as migrant workers from European Union accession states). Further analyses would be required to establish whether migration patterns are uniform across the regions or if certain geographical areas benefit from an influx of foreign labour. Again, GIS would provide a vehicle for revealing such patterns.

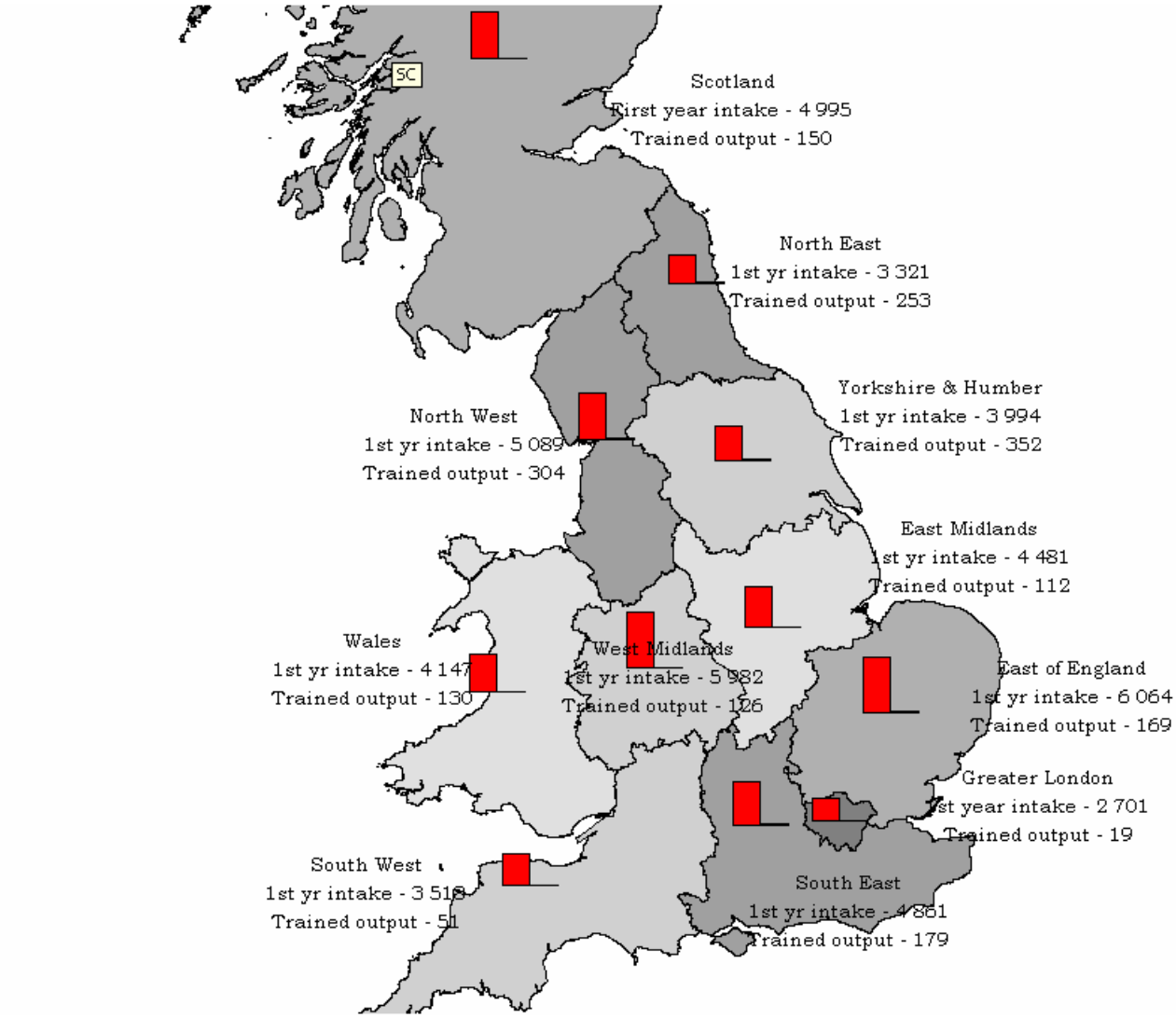

Figure 3: New Entrant Trainees 2004, Trained Output 2004 and New Work Order Figures 2004 for the different regions

Key

Bar Chart = First Year Intake 2004 (left bar) and Trained Output 2004 (right bar)

New work Order (the darker the shading the higher the figure of future new work)

3 963 – 5 654

3 102- 3 477

1 641 – 3,036

8. Conclusions

This paper has explored the potential of GIS to inform labour market policy decision-making. The illustrations provided in this paper are based on the strategic combination of datasets to reveal nuances in the labour market context, which together raise concerns over the future capacity of the construction sector to meet its labour requirements. GIS provides the opportunity for spatially oriented labour market issues to be examined so that strategic plans for the future of the construction labour market can be put in place. Although this paper has only utilised a limited number of datasets, a more extensive combination of time-series data could render it effective in

providing an indication of labour market trends and for raising potential lines of research for examining the underlying cause of the prevailing situation.

The paper has also buttressed issues such as skills shortage (Delargy 2001, Crates 2001, CITB Skills Survey 2003) and the decline of 16 – 19 age group of the workforce (ONS 2003) from previous research through some of the datasets used. As figure 3 shows, though there is a substantial number of first year intake of trainees the trained output at the end of the training period is minimal. This indicates that not enough trainees are being trained to the industry standard to cope with the growth of the industry and the number of young people joining is declining which will make for an aged workforce in the future. Though figure 2 shows symptoms of excess capacity utilisation in London, the new work order figures does not show a decline in future workload in that region. The figure shows an increase in future work which indicates that London might suffer high levels of high capacity utilisation in the future inferring a tight labour market and skills shortage as it tries to cope with all the work coming its way.

Despite the attractiveness of GIS as a labour market planning tool, a number of caveats must be raised as to its potential to inform policy making. Firstly, the GIS outputs are only as robust as the data that is input in the system. Cross-sectional information may not reveal trends in the prevailing employment climate of the industry and short-term demand cycles may undermine many of the research findings presented here. However, the system also helps to highlight inadequacies in the data used for labour market planning and can therefore be used to highlight where additional research is required. A second caveat is that tools such as GIS should be used in combination with the other labour forecasting approaches discussed above. GIS cannot replace the outputs of econometric forecasts and environmental scans, but should seek to complement them and facilitate the rapid assimilation of LMI on the part of policy decision makers.

In order for the utility of GIS to be enhanced in the future, there is a need for detailed datasets on the supply and demand of construction workers over time in order that the dynamics of the labour market can be modelled. Most of the data currently available is only national or regional in nature and does not exist at the sub-regional level required by local policy planners. A solution to this problem has been proposed in the form of the Construction Observatory that is being managed by CITB-ConstructionSkills (CITB 2003b). This will hold all datasets and information pertaining to construction and will assist the industry in refining its LMI by eliminating redundancy and creating faster and easier access to data.

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APPENDIX 3: PAPER 3

Anumba, C., Dainty A.R.J., Ison, S.G. and Sergeant, A. (2005): GIS-Based Diversity Planning: A Case Study In *Proceedings of the ASCE International Conference on Computing in Civil Engineering*, Cancun, Mexico. July 12-15, 2005. Available on CD

GIS-BASED DIVERSITY PLANNING: A CASE STUDY

CLAIRE ANUMBA[1], ANDREW DAINTY[2], STEPHEN ISON[3] AND AMANDA SERGEANT4

[1]Centre for Innovative Construction Engineering Loughborough University, Loughborough, LE11 3TU, 01509 610266; email: claire.anumba@citb.co.uk

[2]Department of Civil and Building Engineering Loughborough University, Loughborough, LE11 3TU, 01509 228742; email: a.r.j.dainty@lboro.ac.uk

[3]Department of Civil and Building Engineering Loughborough University, Loughborough, LE11 3TU, 01509 222605; email: S.G.Ison@lboro.ac.uk

4Construction Industry Training Board ConstructionSkills, 20 Prince William Road, Loughborough, LE11 5TB, 01509 610266; email: amanda.sergeant@citb.co.uk

Abstract

Although Geographic Information Systems (GIS) are increasingly being used in the construction industry, there is very little evidence to show that such technology has been used in relation to issues to do with the *labour* force. GIS is able to integrate information efficiently, thereby placing planners in a better position to review, analyze and understand specific spatial problems. They facilitate improved understanding of the information, thereby leading to improved *decision-making*. This paper presents a case study of how GIS is being used to facilitate the implementation of a *labour* market initiative aimed at diversifying the construction industry's work force. GIS is being used as a tool to facilitate the administration and implementation of the initiative, which is aimed at attracting under-represented groups in the industry such as women and ethnic minorities. The paper starts with a brief introduction to GIS and its current use in the construction industry before presenting an outline of how the GIS application is being used to facilitate the diversity planning initiative. On the basis of the case study presented, it appears that there is considerable scope for GIS to be used to facilitate data management and decision-making in relation to other *labour* market issues in the future.

Keywords

Geographical Information Systems, Construction, Diversity, Labour Market Planning

1. Introduction

The UK construction industry is one of the strongest in the world, with output ranked in the global top ten (DTI 2004). It has been going through a period of sustained growth, for example, in the second quarter of 2004 the total volume of construction output rose by 6% compared to 2003 (DTI, 2004). The sector in the UK currently has around 170,000 companies, with micro companies employing one to thirteen people accounting for 50% of direct employment in the sector and 34% of output, and large companies accounting for 20% of direct employment (in Construction) but 44% of output (DTI, 2003). The industry

contributes about 6% of GDP (£60 billion) to the UK economy approximately £40 billion of which is attributed to projects having a value of less than £500,000 (CITB-ConstructionSkills 2003). Such high rates of growth place considerable pressure on the industry's *labour* market and there are currently widespread concerns that it will not have the capacity to cope (Delargy 2001), Crates 2001). The Construction Industry Training Board (CITB) Employers' Skills Needs Survey carried out in 2002 clearly shows that the industry is facing a skills shortage, as 79% of the employers surveyed reported that they had experienced difficulties in recruiting skilled staff.

The industry's current skills concerns have rendered the attraction and retention of skilled construction workers a top priority that the industry needs to address (Yankov and Kleiner, 2001). One of the ways in which the industry is trying to tackle the problem of skills shortage is by attempting to diversify its workforce (Dainty *et al.*, 2000). The industry is the most white male dominated of all major industrial sectors (EOC, 2000). During the 1990s, the ethnic composition of the workforce saw little change, with non-white employment in the industry barely rising from 1.5% in 1992 to 1.7% over the next eight years (CITB, 2001). The proportion of women in the workforce has declined over the same period. In 1992, women accounted for 11.7% of total construction employment whereas by 2000, this had decreased to 9.6% (CITB, 2001). In recent years the construction industry has sought to break down old stereotypes by seeking to attract more women and ethnic minorities who have hitherto been under-represented within the sector (Whittock, 2002). This has in turn resulted in a series of *labour* market initiatives aimed at attracting and retaining underrepresented groups to the sector, although it remains to be seen if they are having a tangible impact in the diversification of the industry's *labour* market.

This paper explores a case study of an initiative being used to attract females and ethnic minorities to the industry. More specifically, it examines how Geographic Information System (GIS) technology is being used to overcome traditional problems in *labour* market planning (LMP) and to facilitate its implementation. The use of GIS offers the potential to better understand and address the spatial dimension of the *labour* market. It achieves this by allowing the strategic combination, of different and varied datasets from different sectors of the industry and to produce new visual information through highly detailed maps that can be analyzed together rather than singularly. This paper therefore explores the potential of GIS in facilitating *labour* market initiatives. It begins with a brief introduction to GIS and its current use in the construction industry before presenting how it is being used to facilitate the diversity planning initiative. The potential of GIS for facilitating other *labour* market initiatives are then reviewed.

2. Geographic Information Systems

Geographic Information Systems are essentially digital maps linked to database management systems which can be used for the purposes of displaying and querying information, carrying out spatial analysis and

assisting in the *decision-making* process (McMahon, 1997). Figure 1 illustrates the main concepts. Although various GIS packages will have different features and levels of sophistication, all systems must offer a basic level of functionality; a database management system, tools for the input and manipulation of geographic information, tools that support geographic query, analysis and visualisation and a graphical user interface (GUI) for easy access.

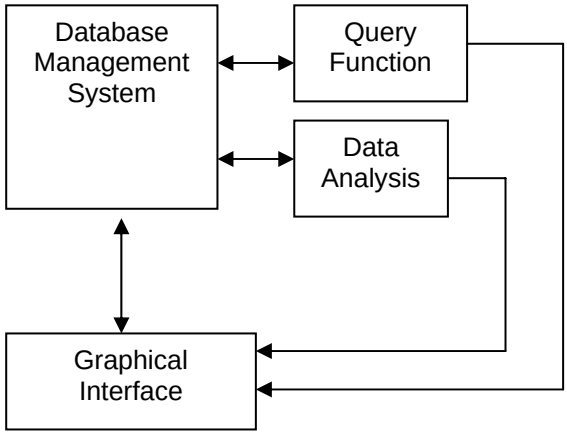

FIGURE 1: MAIN CONCEPTS OF A GIS

These tools assist the user in the retrieval and display of data for complex queries and thus, help to convey a diverse range of complex (and hitherto disparate) datasets in a readily understood medium. With the data stored and retrieved in a structured format, this allows the strategic combination of information to answer particular queries, which would have been impossible without the ability to analyze them within the same user environment. Geographical Information Systems have several important benefits over other database packages. Firstly, the database management system makes access and distribution to the data faster and easier, particularly as is it linked to a graphical output. This enables the rapid analysis of disparate datasets within a single analytical environment. Secondly, they create detailed maps that enhance presentation of the information and can aid in *decision-making* and planning. By facilitating the graphical representation of geographic data, this allows for more rapid assimilation of complex datasets. Finally, they can reveal patterns and trends in the data that cannot readily be discerned from textual material. Thus, GIS is a powerful tool for the analysis of multiple, spatially oriented datasets.

3. The Use of GIS in Construction

GIS has been used over the years in the construction industry to provide a spatial dimension to planning. Some of the best known applications are

summarised below and are categorised according to their functionality or application area:

3.1 Thematic Mapping Applications

Thematic mapping is the use of colours or styles to systematically represent different forms of data. The ability of a GIS to overlay thematic layers has been used to produce positive results in construction. (King and Kiremidjian, 1996) have developed a GIS-based seismic risk estimation tool for assessing, mitigating and managing seismic risk to the built environment in order to reduce losses in future earthquakes. A number of different and disparate thematic layers were overlayed on a map and the graphical representation of the datasets analyzed to provide answers to the complex relationships between the numerous thematic layers. In a related study Etzion *et al.* (2000) developed a GIS-based methodology for recording and analysing modifications in residential buildings using this capability of the technology. Data such as the number of rooms in a house, landscaping features, walls etc. were overlayed so that in order to analyze and understand post–occupancy changes in residential buildings. Other construction applications based on the concept of thematic mapping include site suitability analysis, extracting dominant trends, and investigating different solution scenarios to complex spatial problems (Herzog, 2000). There is considerable scope for the use of thematic mapping in *labour* market planning as data on various demographic or *labour* market variables can be displayed on different thematic layers and overlaid to reveal patterns or relationships that exist within the datasets.

3.2 Topological GIS Applications

A GIS contains tools for determining distance, proximity, direction, adjacency and connective relationships between mapped features, these are called topological tools or buffers. They are useful in determining all the objects of one class within a specific distance of another type of object (Esa and Chan, 2000). This capability of the software has been utilised to assess the archaeological potential of a development site in Hertfordshire, England (Needham and Macklin, 1992). The GIS was used to reconstruct the pre historic landscape and search for indirect indicators of ground conditions that accompany archaeological remains. While there is no similar topological dimension to *labour* market planning, it may be possible to use this feature to plot *labour* market data.

3.3 GIS Query Applications

Geographic Information Systems have the ability to answer spatial questions through their query tools. The query mechanism allows users to ask different questions of the data and create different ‘what if’ scenarios. This ability has been utilised in construction in relation to design *decision-making* (Griffin, 1999; Hellawell *et al.*, 2000; Hellawell *et al.*, 2000). This could be useful in *labour* market planning as it would provide various options for planners to consider

when planning for the future and make decisions based on what is more likely to happen in the future.

3.4 GIS Integrated with other Applications

This is where a GIS function can be isolated and embedded in almost any other program. An example of how this has been used in construction can be found in the work of Lie *et al.* (1996), who developed a GIS-based system for tracking pavement compaction. The system maps the movement of a compaction machine and transforms the result into a geometrical representation. The GIS technology is integrated with a real-time positioning system to analyze this geometrical representation by tracking the number of coverages made by the machine. In another application, Cheng and Chen (2000) have developed an automated schedule monitoring system for the erection of prefabricated structural components in precast building construction. A GIS was integrated with a database management system (DBMS) to form the expert system ArcSched. The GIS was useful in storing descriptive information as attributes of graphical features and its query function used in analysing the data. Rylatt *et al.* (2003) also developed a GIS-based prototype for general domestic energy modelling. The GIS was integrated with an expert system (BREDEM-8) to enable the prototype to estimate the baseline energy consumption for houses in a given geographical area. Integrating expert systems within the GIS takes advantage of its capacity for storing data in an organised way. The expert system provides a set of rules for the GIS to follow in order to analyze the data in much the same way as an expert would dissect a complex problem (Esa and Chan, 2000). This results in a powerful system, which can be effective in *labour* market planning situations where the problem being tackled by the expert system has a spatial dimension.

4. A GIS - Based Diversity Planning Initiative

In this section the use of GIS to facilitate a specific diversity planning initiative is presented to illustrate its potential as a *labour* market planning tool. The planning initiative to which the GIS is applied is called *STEP into Construction*. STEP is being used by the industry's Sector Skills Council in the UK (CITB-ConstructionSkills), to attract females and ethnic minorities to the construction industry. It has been suggested that the reluctance of women and ethnic minorities to enter the industry severely limits the *labour* pool from which the industry can recruit (Druker and White, 1996; Wall, 1998). With the STEP initiative, if an employer guarantees an interview for a job vacancy, CITB-ConstructionSkills provides support for a trial period of six weeks for adult ethnic minority and female candidates. Recruitment at the end of the trial is based on merit alone and is at the discretion of the employer. CITB-ConstructionSkills supports associated costs such as short-term childcare, diversity training for staff and site supervisors, or an equal opportunities recruitment campaign aimed at finding suitable candidates.

4.1 The Current STEP Process

CITB-ConstructionSkills currently uses an Intermediate *Labour* Market (ILM – employers who get sponsored and are committed to employing and training new recruits to the industry) approach to achieve its STEP outcomes. With this approach, the ILM organization recruits the candidates and offers them the six weeks trial for which they are paid by CITB-ConstructionSkills regardless of outcome. Figure 2 illustrates the STEP Process before the integration of the GIS application. At the end of the six weeks the ILM employer and the candidate fill in an 'outcome form' as proof that a STEP trial has taken place. This is then sent to CITB-ConstructionSkills, who then pay the employer for the outcome. CITB-ConstructionSkills files the form away in paper format and scans it for storage in Livelink (a web-based knowledge management system). This is done for audit purposes and for the Board to use as a guide at the end of the year when setting the organizations targets on STEP.

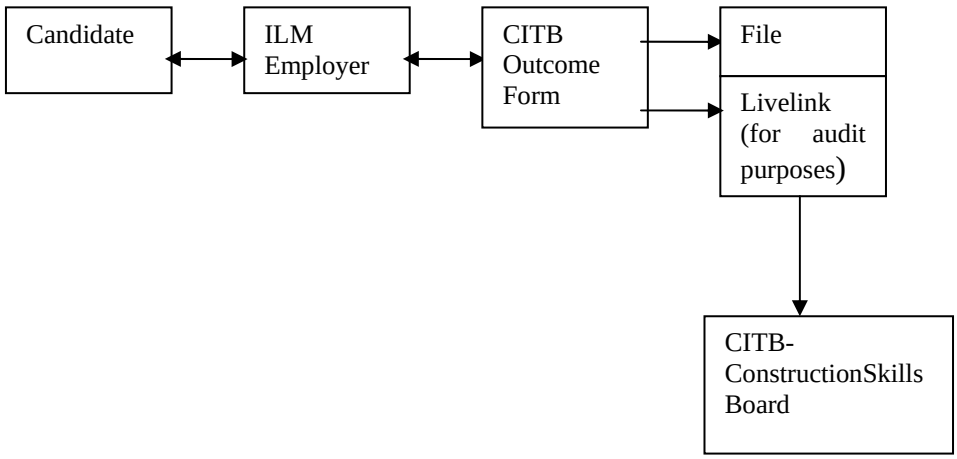

Figure 2: Flowchart of STEP process before GIS Application

4.2 Limitations of the Current Process

An analysis of the scheme and its administration revealed the following limitations in its operation:

- There is no centrally held data for the initiative which means that pieces of information stay with the different organizations for which the other has no access to. This can cause problems when it comes to analysing the forms/data. For example, the form that is completed by the employer and the candidate has no provision for recording the ethnicity of candidates. This makes it difficult to keep track of the different ethnic backgrounds of the candidates and to verify whether the candidates met the required standard of the initiative.
- There is no contact between CITB-ConstructionSkills and the candidate in order to gain important feedback on which the initiative can be improved. CITB-ConstructionSkills has no way of knowing if the candidates procure jobs at the end of the trial or not. Similarly, there is no feedback from the ILMs to CITB ConstructionSkills on the progress of the candidates while they are on the six weeks trial.

- CITB-ConstructionSkills has no control over the profile of candidates being secured for the trial process. Thus, there is more emphasis on candidates going through the trial period rather than them securing a job at the end.
- The process involves many manual steps such as form filling and filing.
- The ILMs tend to secure candidates from the areas where they are based, which means that only certain geographical areas tend to benefit from the STEP initiative.

These deficiencies mean that there is no way of knowing if the initiative is achieving its aim, which is to increase recruitment in the industry and help to make the *labour* market more diverse. The emphasis is more on the number of candidates who go through the six weeks trial rather than them securing a proper job and staying on in the industry.

4.3 Scope for GIS in STEP

The rationale for applying GIS to the STEP initiative was based primarily on a review of the initiative, which recommends that the focus of STEP should be on 'job outcomes' (i.e. the candidate securing a proper job at the end of the trial). In order to achieve this CITB-ConstructionSkills has to recruit suitable candidates and employers to participate in the initiative, which therefore requires information on the geographical distribution of both eligible candidates and employers. However, the current process does not readily have access to this information, so there is scope for the use of GIS to model this and explore a variety of scenarios. It is this shift that gives the impetus to look at GIS in the context of STEP.

5. Development of GIS-Based STEP Application

This section outlines the objectives of the application, the development procedure and the implementation of the system. The operation of the system is also described and illustrated using a number of some screen shots of the system in use.

5.1 Objectives of GIS Application

The objectives of the proposed GIS-based process were:

- To automate the STEP process in order to facilitate better data integration, accessibility and enhanced utility;
- To create a central resource that holds all the necessary information required for the STEP initiative, which will help in the tracking and monitoring of successful job outcomes and the recording of retention rates;
- To introduce better integration of operations and col*labour*ations with other entities (i.e. other departments in CITB-ConstructionSkills);
- To create a better customer service to candidates and employers, as it will have an available and up-to-date database with all the necessary information;
- To enable CITB-ConstructionSkills to match appropriate candidates and employers geographically;

- To facilitate cross-departmental working between the different departments within the CITB-ConstructionSkills;
- To generate representations of datasets that show which geographical areas are benefiting from STEP and which are not.

5.2 Development Procedure

The first stage in implementing the proposed GIS-based STEP system was the use of Process Mapping to understand the information flows within the process and understand how GIS can enhance the process. This was done through interviews with the personnel involved in the initiative both within and outside CITB-ConstructionSkills. The responses from the interviews were then used to map out the old and new processes of STEP. This was presented to the key managers within the organization and their feedback and comments used to refine the process. Individual interviews were then held to brief them on what data is required from their departments, find out how their data is stored and how best this could be integrated into the GIS.

5.3 Development of GIS-Based STEP Application

The GIS platform used was the Map Info Professional 7.0 operating on a Pentium-based PC in a Windows NT environment. The primary map layers of the system include a UK postal code overlaid by UK counties. Both sets of data were obtained from the Ordinance Survey and converted into the MapInfo format. Both map layers (postcodes and counties) have an attribute data file with information on each postcode area and county linked to them. Five databases were then created.

- An eligible employer database
- An eligible candidate database
- A database of candidates currently on the STEP trial and their progress
- A database of candidates who have finished the trial period and the outcome of the trial.
- A database of universities and colleges as CITB ConstructionSkills works closely with them to enable the right candidates to be attracted to the STEP initiative.

Figure 3 shows the system architecture for the GIS-Based STEP application. It is organised in five databases, each with input and output facilities. The information in the databases can be manipulated and analyzed via the user interface with Microsoft commands and tools. The output of the application can be in the form of a map, graphs, reports, and integrated datasets due to overlay information.

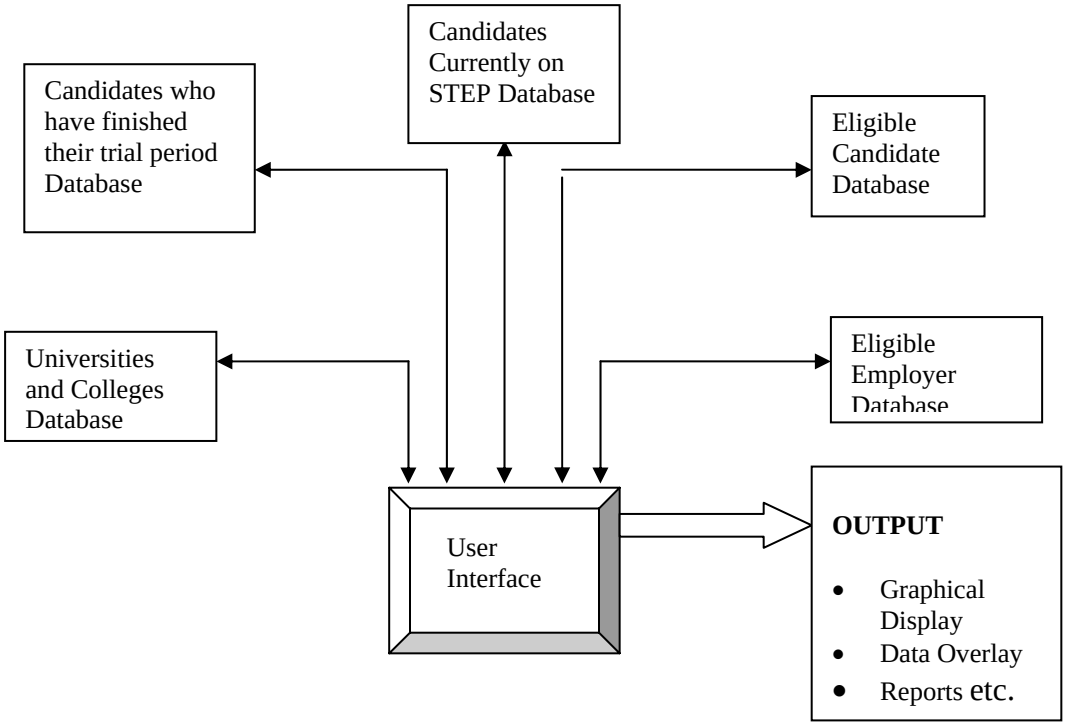

Figure 3: System Architecture of STEP GIS Database

The appropriate information was collected from the different departments and entered into the databases. The databases were then used to create map layers showing the geographical locations of employers, candidates and colleges/universities by a point (these are shaped differently so they can be easily differentiated). The system is open and expandable, and allows for additions of fields and descriptors to each of the different databases if necessary. It also allows for updating of the information.

6. System Operation

The GIS-based STEP application is conceptualised as a stack of floating map layers. Each map layer (i.e. database) is registered to a common map base (i.e. postcode and counties) and tied to a co-ordinate system (latitude and longitude) such that the information from the individual layers can be spatially referenced to one another. Each map layer is also linked to a data file or files through a relational database management system (DBMS). Information in the data files is associated with features on the map layer such that by querying the data files, map features can be accessed for analysis (for example, a query such as how many available candidates live in Leicestershire can be analyzed through the map features). Conversely, querying the map features can likewise provide access to the information in the data files.

Figure 4 shows a map layer of two databases (eligible employers and eligible candidates), with their data files. The information on the screen can help in the *decision-making* about which candidate is most geographically suited to which employer. The screen shows a close proximity of both eligible employers and candidates, which should help in the matchmaking. It should be noted that there

are other issues outside the GIS application that need to be considered when matching the candidate to the employer such as choice of profession, and the expectations of both parties (i.e. the employer and candidate). The names of the employers and candidates have been deleted in accordance with data protection legislation.

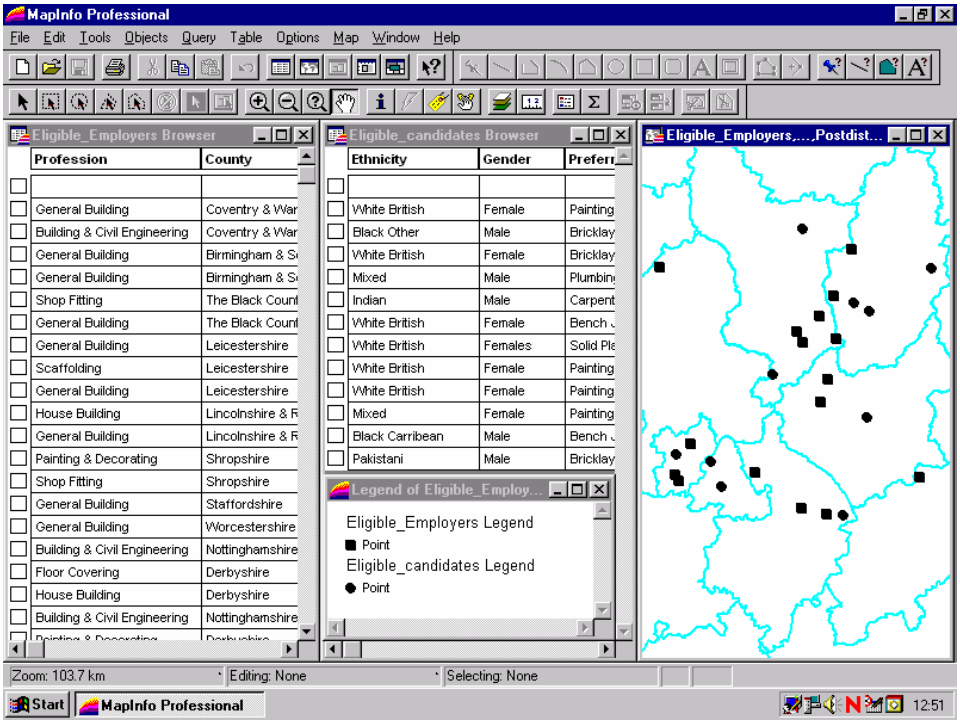

Figure 4: Example of a map layer showing its related data files, it also shows the integration of the eligible employer and eligible candidate databases

Figure 5 shows an integration of the databases eligible of employers and the universities and colleges that offer construction courses. This is necessary in order that CITB-ConstructionSkills can geographically link female and ethnic minority students on construction courses who are interested in the STEP initiative to interested employers for the purposes of gaining some practical experience. The screen shot demonstrates that there is close proximity between interested employers and colleges, which means students from the colleges can easily be placed with employers. There is only one employer on the left of the screen that seems to be at a considerable distance from any university or college. The attribute data files of the database map layers hold information on details such as names and addresses of the universities/colleges and the employers. In the case of the universities, there are also details of the construction courses that they offer. The geographical location of the universities can be integrated with other information such as the density of the population of ethnic minorities. This will give an indication of universities and colleges situated in areas with high ethnic minority population that should be targeted for candidates of ethnic minority background.

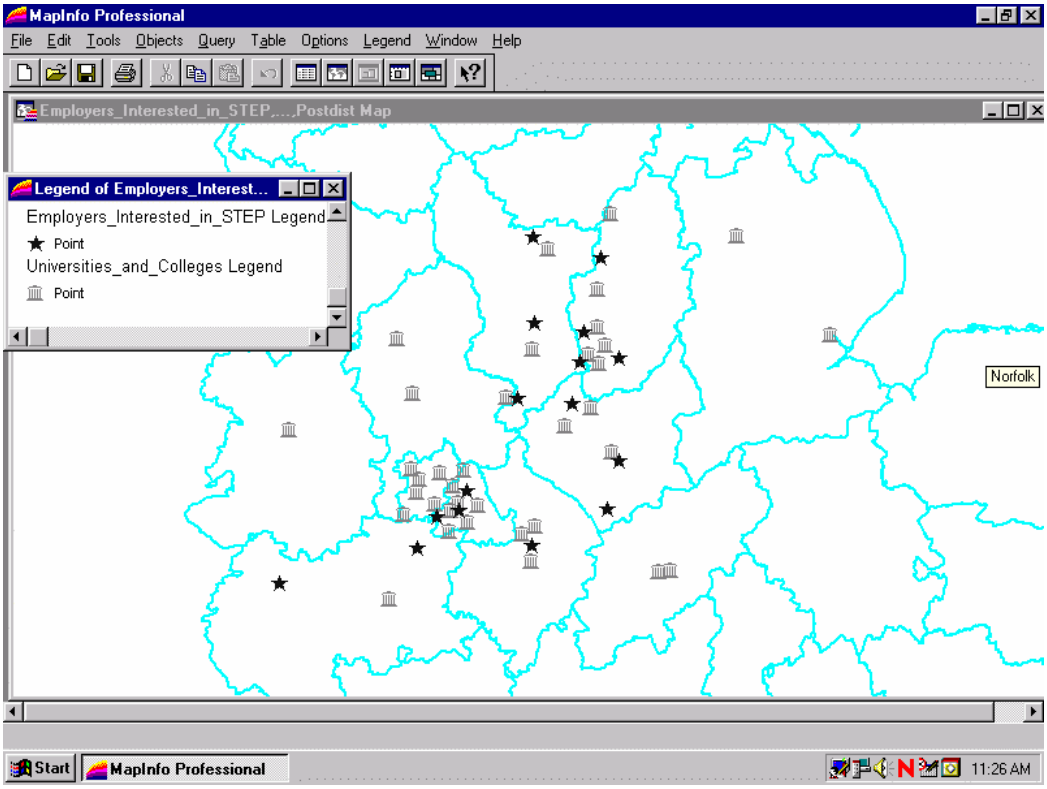

Figure 5: The relationship between 'Eligible Employers' and 'Universities and Colleges'.

Figures 6 and 7 show a query being performed on the database of candidates who have finished the STEP trial. The question asked of the data is "*How many candidates who have gone through the trial live in a geographical area called Leicestershire?*" The query has been analyzed based on both the map features and the data file. Figure 9 shows the symbols in the geographical area in question being highlighted; the candidates and their details in the data file are listed. The data can be queried in this way as a mean of retrieving information faster than going through the same information in a paper format. The information on the different databases in the application can be manipulated individually or integrated together to suit the objectives of the user.

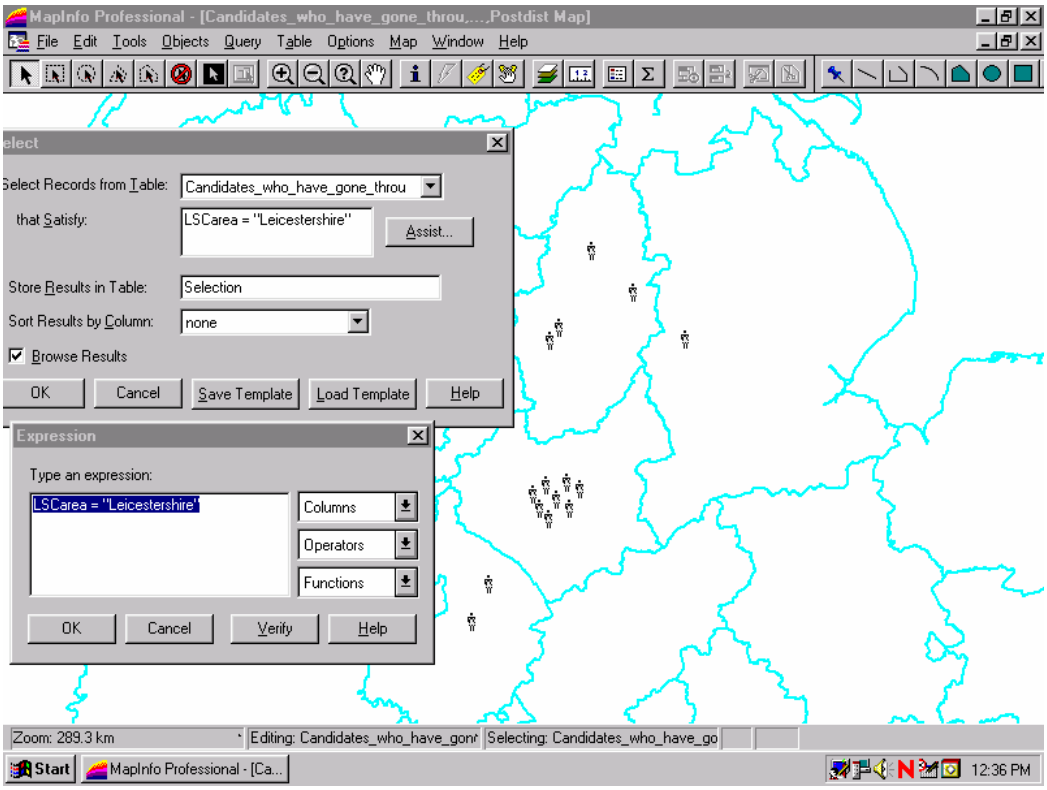

Figure 6: A query being performed on both the map feature and the data file of the database 'Candidates who have gone through the STEP trial'

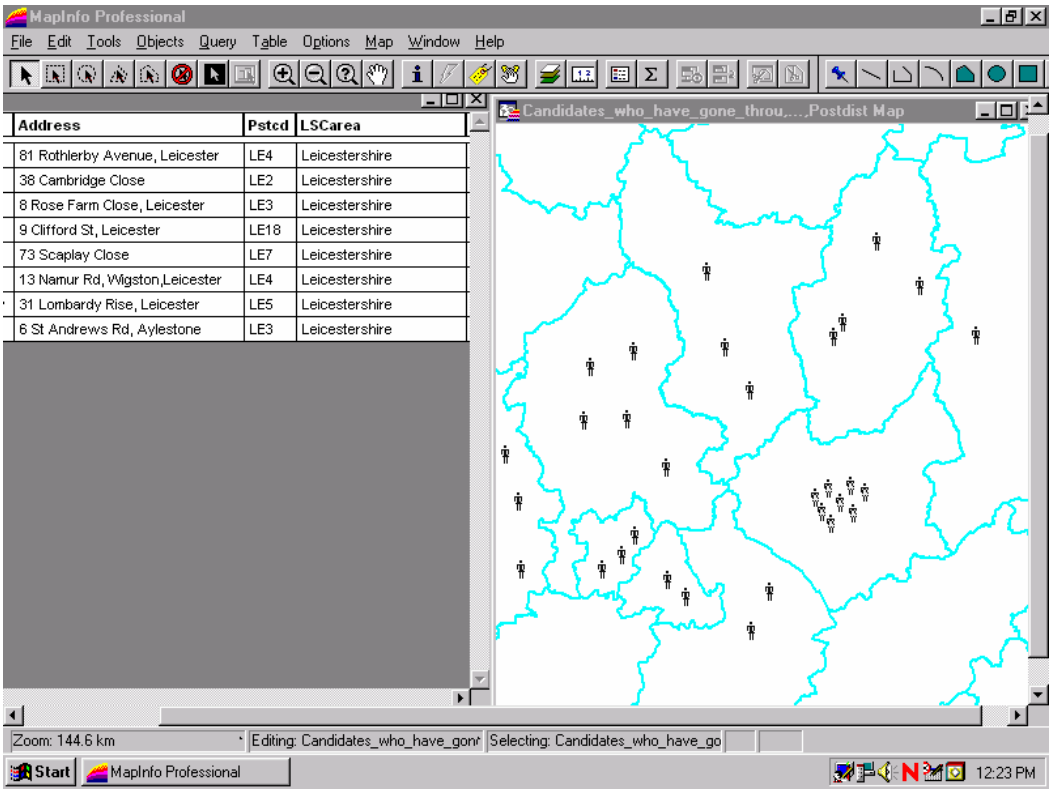

FIGURE 7: RESULT OF THE QUERY

7. Discussion

The application of GIS to this diversity planning initiative has automated the administration of the STEP process by providing quick and easy access to information for CITB-ConstructionSkills staff. Whereas in the past each department held and stored their information separately, the GIS has allowed for the integration and concurrent analysis of all data relevant to the effective administration of the scheme. This has helped in the tracking and monitoring of successful job outcomes and the recording of retention rates as the outcomes are recorded centrally where they can be easily accessed and updated. The application also assists in the monitoring of the retention rates. The GIS enabled STEP programme can therefore help the construction industry to access a wider pool of the *labour* market by assisting candidates in obtaining real jobs in the industry, rather that just going through a six- weeks trial with very little benefits for themselves and for Construction.

One of the most important outcomes of the application is the way it has enhanced the work practices and integration of the different departments at CITB-ConstructionSkills. Before the GIS application was introduced, there had been no mechanisms to share STEP information. The GIS has been used to formalise the information flows, as well as in assisting the organization to achieve its new focus of 'job outcomes'. Thus, the GIS has presented an opportunity for the organization to enhance its cross-departmental working to ensure that their job outcomes and targets are successfully achieved. CITB-ConstructionSkills consists of four separate departments with an involvement in the STEP process as follows:

e) *Advisory Department*, which has responsibility for advising employers in the construction industry on CITB-ConstructionSkills products' and services that support and encourage the business case for training. It also advises on and administers the organizations' grant application process for training. The Advisory Department provided details of employers who are interested in participating in STEP.

f) *Education Department*, which is responsible for facilitating partnerships between local authorities, schools, employers and construction colleges to deliver the concept of construction into the school curriculum. Data provided by the Education Department includes contact details of colleges, universities, and training providers with female and ethnic minority students who have expressed an interest in the industry.

g) *New Entrant Training Department*, which has responsibility for assisting employers in the industry who decide to enter into a contract with CITB-ConstructionSkills Managing Agency to make a commitment to train new entrants to industry standard. They were responsible for providing leads on interested employers and their details; details on female and ethnic minority trainees who have applied for new entrant training but have not been placed with employers and universities and colleges in the region who offer construction courses with a view to finding out if they have females or ethnic

minority students on their courses who are willing to participate in the STEP initiative and to secure a permanent job.

h) *Strategy Department*, which is responsible for actively engaging in regional debates that concern or have implications for the industry. This department does not provide information *per se*, but is responsible for overseeing the initiative and its processes.

Thus, by integrating the data and activities from all of the departments in relation to the STEP scheme, the GIS allows the whole organization to have an involvement and a responsibility for the initiative (i.e. providing the necessary information) as well as pooling together their data resources. At a wider level, the GIS has the potential to facilitate many other *labour* market planning issues. Most problem solving tasks in *labour* market planning require reference to both tabular and mapped data, which GIS integrates effectively. The ability to integrate different types of information and highlight patterns in the data means that it can indicate potential problems that might occur in the future. The ability of GIS to integrate with almost any other software provides many opportunities to improve the richness of the industry's *labour* planning information.

8. Conclusions

This paper has presented a case study of how GIS can be applied in order to facilitate the planning and administration of a *labour* market imitative more effectively. Until the GIS application was introduced, there was no mechanism to manage and share STEP information in such a way that the scheme could be managed efficiently. By designing and utilising the GIS application to formalise the information flows associated with its new focus of 'job outcomes' it has yielded a practicable methodology for integrating different information and work activities which have culminated in female/ethnic minority potential recruits finding jobs within the industry. Notably, the GIS application assists in the matching of the appropriate candidates to the appropriate employers in terms of the geographical spread of the available vacancies and candidates. It shows pictorially where the vacancies are and where the available candidates are. This ensures a more rapid and effective matching of employers and candidates.

On the basis of this case study, there is considerable potential for using GIS to facilitate *decision-making* in relation to *labour* force issues in construction. Notably, the ability of GIS for spatial analysis is such that it can create a platform on which strategic planning and *decision-making* for the industry's *labour* market can be built, thereby helping with the analysis and development of policies which are linked to geographically determined phenomena and trends. Future work will apply the tool to skills and *labour* market trends in order to support policy-planning measures to overcome other challenges in addressing the industry's skills crisis.

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APPENDIX 4: PAPER 4

Anumba, C., Dainty A.R.J., Ison, S.G. and Sergeant, A. (2006): Understanding Structural and Cultural Impediments To ICT System Integration: A GIS-Based Case Study – submitted to *Engineering, Construction and Architectural Management Journal* (Accepted for Publication)

UNDERSTANDING STRUCTURAL AND CULTURAL IMPEDIMENTS TO ICT SYSTEM INTEGRATION: A GIS-BASED CASE STUDY

Claire E H Anumba# Andrew Dainty#, Stephen Ison# and Amanda Sergeant ∗

#Centre for Innovative Construction Engineering Loughborough University, Loughborough, LE11 3TU

∗Construction Industry Training Board ConstructionSkills, 20 Prince William Road, Loughborough, LE11 5TB

Abstract

Purpose of the paper

Despite a substantial investment in construction information and communications technology (ICT) in recent years, the structure, culture and ingrained working practices of the sector are such that the industry's organisations represent problematic arenas for their successful implementation. In order to better understand the factors affecting the integration of a new ICT within the industry, this paper examines the implementation of a Geographic Information System (GIS) aimed at facilitating an aspect of the labour market planning process within the construction sector. It explores the interplay of structural, social and technical factors which, when combined, can complicate the implementation of ICT systems.

Approach

In the case study presented, the considerable potential of the system to facilitate the implementation of a labour market initiative was affected by a range of internal and external factors. An analysis of the implementation process and the socio-technical systems which surround it shows how these factors combined to delimit the abilities of the system to meet the needs of the organisation.

Findings

The findings of this work have clear resonances for an industry renowned for its conservative culture and slow uptake of new technologies. They also underscore the importance of developing flexible implementation approaches which are able to cope with an organisation's external environment and changing requirements.

Value of the paper

The lessons learned are used as the basis for a set of recommendations for enabling construction organisations to better prepare themselves for ICT implementation in the future through proactive planning and end-user engagement.

Keywords: ICT implementation, socio-technical systems, organisational structure, culture, GIS, system integration.

Introduction

No matter how well conceived an information and communication technology (ICT) tool is, the implementation process can undermine its ability to enhance the process for which it was designed (Wilmott et al 1990). There is a substantial body of research which has identified the factors associated with the success and/or failure of ICT management systems (Gardner, 2000). These can relate to the nature of the user community, the processes or practices for which they are designed, or structural factors which impact on its implementation. The most significant impediments to system implementation however, usually relate to the people using them rather than the technology itself (Roepke et al 1998). Implementation is usually seen as simply the final stage of development – during which the technology is tested out and the hardware and software are delivered to the users. However it is more beneficial to consider implementation in a wider sense, to include consideration of all the human and organisational issues which can help make an information system successful (Grimshaw 1994). Indeed, Hellman (1992) suggested that the persistent failure of end-user computing to achieve its objectives is because of the impact of human issues, such as end users not being involved in the design of IT systems and the impact of organisational culture on the implementation of ICT.

With regards to the uptake of ICT systems in the construction industry, Anumba (1998) attributed the problems to several factors most notably: poor user-interface design, mismatch between system functionality and end-user expectations, and poor planning amongst. Due to its conservative nature the industry has historically been resistant to change particularly in the adoption of technological and process innovations (Watson and Anumba 1991). There are several reasons why these issues need to be examined, such as increased competition; the demand by enlightened clients for greater efficiency and value for money; the need to improve quality and ensure client satisfaction and the increasing requirement for projects to be delivered within tighter time-scales.

Organisational issues and computing infrastructures are often viewed in isolation, and are usually taken for granted as being ready to meet the end user's needs (Mandefrot 2002). Such systems can, however, affect the way in which people work and it is essential to understand how change should be managed in relation to the introduction of ICT within an organisation (Regan and O'Connor 2000). A clear vision of what the ICT is for and how it resonates with the core values and culture of the organisation is vital, although this can prove problematic. This is because any vision for the future that involves ICT has to wrestle with the ICT paradox: that ICT has to be part of wider policy thinking, but that ICT in itself offers new policy opportunities (Jones and Williams 2005).

This paper examines how implementation issues surrounding well-intentioned ICT systems are manifested within the context of the construction industry. It examines the implementation of a new ICT system aimed at facilitating the labour market planning process. It shows the approach adopted in the implementation of a Geographic Information System (GIS) which was designed

to integrate disparate datasets and overcome barriers in information flow. It explores the interplay of structural and cultural factors which determine the success of ICT implementation and in doing so, reveals the necessary flexibility which must represent a core feature of the ICT system. The lessons learned through this implementation process are used as the basis of guidelines for improving ICT implementation in construction in the future.

Implementing new ICT

ICT implementation research has evolved as successive generations of researchers and practitioners have observed and commented on the issues surrounding the process. In his seminal work, Likert (1966) showed that interdependencies between structure, task, technology and people are involved in major interventions within organisations. A change to any component necessarily implies a change to the others. Thus, the outcome of an implementation process is not just the change of technology, but also the change in tasks, structures and, in some cases, personnel. Thus, in defining what is meant by implementation it is essential that the implications of the ICT are viewed holistically. Lucas (1981) defined implementation as the whole process of introducing a system into an organisation, from conception of an idea, through the analysis, design, installation and operation of the developed system. Such a perspective underlines the importance of involving end users throughout the ICT development process. In this respect, implementation can be seen as preparing an organisation to receive an information system for its effective use (Davis and Olson, 1985). Other conceptions of implementation have viewed it as a process of influence (Gibson and Smilor 1991), as an interaction between designer and user (Gintzberg 1981; Lucas 1981), and as a problem solving exercise (Mitroff, 1983). All of these definitions, however, acknowledge the interaction between the system designer, the system itself and the end user.

In breaking down the implementation process into discreet steps, Walton and McKersie (1991) see three broad sub-tasks involved in the implementation of an ICT system. These are designing the IT system for the organisation that will operate it, developing enabling human resource policies to support the end user and managing the implementation process itself. This represents a socio-technical approach, in that both the requirements of the technology and the requirements of the organisation are taken into account simultaneously.

Grimshaw and Kemp (1989) reported on the factors significant in achieving a successful implementation of office automation. Table 1 shows the factors and how they were rated by IT managers. The table shows commitment from top management being the most important factor for a successful implementation process. However, it is clear that user-defined, as opposed to technical issues, represent the most significant factors in the success of ICT implementation. Stewart et al (2000) take this concept a stage further in suggesting that implementation should be seen as technology diffusion through a social system. Such a view suggests that preparedness for ICT implementation must include

appropriate communication, culture, leadership, championship and environmental/organisational conditions to succeed. These are discussed below:

Table I: Factors leading to a successful implementation

Priority	Factor
1	Commitment from top management
2	Continuing support for users
2	Highly reliable systems
4	Involvement of users
5	Easy to use systems
6	Effective project management
7	Clear cost justification
7	Well proven systems
7	Full training
10	Precisely defined objectives
11	Facilities to meet specific needs
11	Use of pilots or prototypes
13	Organisational change

(Source: Grimshaw and Kemp 1989)Take in Table I

Effective Communication

Effective communication is key to the successful implementation of an ICT system (Hammer and Stanton 1995, Carr and Johansson 1995, Dawe 1996). Communication is needed throughout the change process at all levels and for all audiences (Davenport 1993). It should take place frequently and in both directions between those in charge of change initiatives and those affected by them (Grugle 1994), and should be open, honest and clear (Janson 1992). Whole system change in particular requires dialogue, engagement and interaction within and outside the organisation (Jones and Williams 2005). This is also necessary to ensure patience and understanding of the changes needed (Berrington and Oblich 1995). The literature emphasises the importance of effective communication as it brings a common understanding among all those involved in the process of the aim and objectives of the technology and how it will achieve these. It also gives an opportunity for the designers and users to share their knowledge for the good of the process.

Organisational Culture

Organisational culture refers to the commonly held and relatively stable beliefs, attitudes and values that exist within the organisation (Williams *et al* 1993). It is a determining factor in a successful implementation process (Hammer and Champy 1993, Zairi and Sinclair 1995). Significant functions of a shared culture in an organisation include conflict reduction, co-ordination and control, the reduction of uncertainty, motivation and competitive advantage (Brown 1998). A shared organisational culture also influences the organisation's ability to adapt

to change. A strong organisational culture facilitates goal alignment, as all the employees share the same basic assumptions and so are able to agree on what goals to pursue and how to pursue them.

There is a need to harness information technology directly to the achievement of important organisational objectives in order to bring about dramatic changes in organisational functioning. Eason (1996), states that the real success of implementing new technology occurs when the users begin to perceive how the system can be used to perform organisational tasks in different and more effective ways. The technical system therefore needs to be complemented by a *social system* dedicated to its use and development. The concept of a 'socio-technical' system is derived from the notion that any production system requires both a technology and a work structure (Clancey, 1993); as the work structure ties people to the technology, its design has a major impact on both aspects of the work.

It is always beneficial for organisations to strive to attempt to design work structures that can obtain a match between the employees and the technology (Cummings 1977). This may involve changes in the technology and the work structure or both. The primary aim is to design a work structure that is responsive to the task requirements of the technology and the social and psychological needs of the employees, a structure that can be both productive and humanly satisfying.

Socio-technical systems have to relate to the task environment. These involve external elements such as the economy that are relevant to the achievement of a set of goals or objectives. Given this interdependence, socio-technical demands have to be structured so that they can meet environmental demands while remaining relatively resilient to external disruptions (Cummings 1977). This may involve changes in the system or the task environment. Another important aspect of socio-technical systems is the behaviour of the users in the organisation. If they feel the system is de-skilling them or causing them to change the way they work, they may actively resist the introduction of the system into the organisation as they might have a feeling that their status is being reduced by the system. This can be avoided if employees are given the freedom to have an input in the design of the technology and adjust work activities to match task and environmental demands (Brown 1998).

An organisation must understand and conform to the new values, management processes and the communication styles that are created by the implementation process so that a culture which upholds the change is established effectively. Such change occurs gradually over a period of time. According to Brown (1995), change can happen at three different levels. Firstly, it can be at employee's cognitions (i.e. their beliefs and values) with no complementary change in their behaviour. This can occur when the individuals intellectually agree that, for example, new working practices are a good idea, but find it difficult to adopt them because of ingrained habits or because they lack the relevant knowledge and skills to put them into effect. Secondly, change occurs at the behavioural level, but not necessarily matched at a cognitive level. This

occurs when compliance with new organisational rules and procedures are brought in with the threat of reprimand if they are not adhered to, rather than the rules being enforced through the employees enthusiasm. A third stage is where there can be change at both the behavioural and cognitive levels. This is the most ideal and permanent form of organisational change as employees will have belief, confidence and value in the new changes making them self-sustaining and mutually reinforcing.

Gardner (2000) states that an effective management system that emphasises involvement, consultation and participation at all levels in an organisation can represent a major change in organisational culture. It is the change in culture and behaviours that drives real improvement (Margetts and Dunleavy 2002). This requires an understanding of an organisation's current culture, particularly in relation to technology, and consideration of how this will affect ICT implementation. A specific challenge presented by new ICT systems is that they can often only achieve change when a sufficient number of people use them. A failure to engage the user community inevitably leads to system failure. Although some researchers suggest that the only way to encourage people to use new systems is through compulsion (see Curthoys and Crabtree 2003), it is unlikely that such an approach will yield the most effective use of the system. Thus, the culture of the organisation has an important role to play in the implementation process as this will determine the extent to which it is accepted and effectively utilised by the end users. It is important to recognise, therefore, that technology and culture are inter-twined, as technology affects and is affected by the prevailing cultural environment (Davies *et al*, 2003).

Leadership
Senior management leadership is often cited as crucial to a successful implementation process (Stanton et al 1993; Bashien et al 1994; Gardner 2000). The most frequently cited leadership issue undermining the implementation process concerns a lack of commitment amongst senior management (Juran and Gryna 1993). Leadership has to be effective in thinking and understanding in order to provide a clear vision of the future. This vision must be clearly communicated to a wide range of employees who then become involved and motivated rather than directly guided (Carr and Johansson 1995). Commitment and change must constantly be secured from senior management throughout the process. Birchard (2005) comments that IT should be at the top of any leader's list of priorities as an organisation's utilisation of technology and information represents a key differentiator in the competitiveness of modern businesses.

Championship and sponsorship
Organisational 'champions' play a major role in overcoming barriers to ICT implementation and increasing the chance of a successful implementation of the technology (Worsley 1994). The champions must be able to persuade top management of the need to change and to continually push the change efforts throughout the organisation. They need not be senior level management, but must have influence over such managers and their subordinates.

Environmental/Organisational issues
Environmental changes in an organisation can also affect the implementation process. Change initiatives, such as restructuring, can cause upheaval which has a tendency to impact negatively on the process. Such change can create uncertainty among employees and can cause them to view new technology as a threat to their security. As such, there is a need to build support for the vision and for change in the context of sensitivity to the other demands of staff and stakeholders. Regardless of how the vision is generated, it has to be engaging, well communicated and flexible. Breakthroughs in performance come from setting broad, aspirational goals and then giving people space and support to use their ingenuity to innovate and learn (Cave 2005).

Methodology

The ways in which the organisational and cultural climate affects ICT implementation was explored through an in-depth longitudinal case study carried out within an action research framework. The ICT innovation explored was the development and implementation of a new Geographic Information System (GIS) for facilitating a new labour market initiative designed to encourage the entrance of women and ethnic minorities in the industry. GIS offered an ideal tool for facilitating the combination and graphical representation of complex datasets, the analysis of which is essential for making informed labour market planning decisions around the selection and placement of trainees taking part in the scheme. Accordingly, a GIS tool was designed as a decision support system (DSS) to facilitate the process of finding suitable candidates and matching them to employers and training providers within the East and West Midlands regions of the United Kingdom. To achieve this it had to draw on datasets extracted from a range of different departments within the organisation and engage a diverse range of stakeholders.

A predominantly inductive methodology was employed for the study. Initially, those with responsibility for administering the labour market scheme were interviewed and the current implementation processes mapped. Following this, a GIS-enabled process was developed, refined through discussions with staff, and then developed using MapInfo™ software. This comprised an iterative development process during which regular meetings with key departmental managers informed the development of the database, graphical display and user interface (which was programmed in MapBasic™). Following its development, the system was evaluated within the organisation and trialled in order to establish its effectiveness in informing decisions and automating the processes of the departments involved. The evaluation took place over a 12-month period during which time managers and users were interviewed and the system's functionality regularly evaluated. This enabled the effectiveness of the GIS to reshape practices around this labour market initiative to be evaluated. This was facilitated by one member of the research team working within the organisation throughout the trial period.

The STEP Initiative

The labour market initiative to be facilitated by the GIS was entitled STEP, a scheme designed to attract and place females and ethnic minorities to the construction industry. The STEP initiative operates by rewarding employers for providing work placements to non-traditional entrants to the sector. If an employer guarantees an interview for a job vacancy to an ethnic minority or female candidate, CITB ConstructionSkills provides support for a trial period of six weeks. Recruitment at the end of the trial is based on merit alone and is at the discretion of the employer. The scheme operator, CITB ConstructionSkills, supports associated costs such as short-term childcare, diversity training for staff and site supervisors, or an equal opportunities recruitment campaign aimed at finding suitable candidates. The GIS was being developed to facilitate the operation of the scheme by providing a tool for the identification and placement of candidates with employers. In order to administer the scheme, four separate departments within CITB ConstructionSkills have to share information to enable the process:

i) *Company Development Team*, which has responsibility for administering the grant application process for training. This Department provided details of employers who are interested in participating in STEP.

j) *Education Department*, which is responsible for facilitating partnerships between local authorities, schools, employers and construction colleges to deliver the concept of construction into the school curriculum. Data provided by this Department includes contact details of colleges, universities, and training providers with female and ethnic minority students who have expressed an interest in the STEP initiative.

k) *New Entrant Training Department (NET)*, which has responsibility for assisting employers who decide to enter into a contract with CITB ConstructionSkills Managing Agency to make a commitment to train new entrants to an industry standard. They were responsible for providing leads on interested employers, details on female and ethnic minority trainees who have applied for new entrant training and colleges in the region who offer construction courses.

l) *Strategy Department*, which is responsible for overseeing the scheme as part of the organisations strategic remit. This department does not provide information per se, but is responsible for ensuring that the scheme achieves its overall objectives.

Prior to the development of the GIS, these departments held their information separately and in different formats. An analysis of the scheme and its administration revealed several limitations in its operation:

- There was no centrally held data for the initiative which meant that some information resided within different organisations for which others had no access. This had caused problems with the administration of the scheme.

For example, the form that is completed by the employer and the candidate has no provision for recording the ethnicity of candidates. This made it difficult to keep track of the different ethnic backgrounds of the candidates and to verify whether the candidates met the requirements of the initiative.

- There is no contact between CITB ConstructionSkills and the candidate in order to gain important feedback on which the initiative can be improved. There is no feedback from the participating employers to CITB ConstructionSkills on the progress of the candidates while on the six week trial.

- CITB ConstructionSkills had no control over the profile of candidates being secured for the trial process. Before the new process where candidates have to have a job outcome rather than going through the trial process there was more emphasis on candidates going through the trial period rather than them securing a job at the end.

- The process involved many manual steps such as form filling and filing which slowed down the process of assessing and placing of candidates.

- The employers tended to secure candidates from the areas where they are based, which meant that only certain geographical areas tended to benefit from the initiative. Candidates who lived within easy commuting distance of an employer could therefore miss out on a placement opportunity.

The rationale for applying GIS to the STEP initiative was based primarily on an internal review of the initiative, which recommended that the focus of STEP should be on 'job outcomes' (i.e. the candidate securing a proper job at the end of the trial). In order to achieve this, CITB ConstructionSkills has to recruit suitable candidates and employers to participate in the initiative, which therefore required information on the geographical distribution of both eligible candidates and employers. There was also a need to determine whether training providers are geographically proximate to both the candidates and the employers in order that they can be trained and qualified in the future. Thus, the objectives of the proposed GIS-based approach were:

- To automate the STEP process in order to facilitate better data integration, accessibility and enhanced utility;
- To create a central resource that holds all the necessary information required for the STEP initiative, which will help in the tracking and monitoring of successful job outcomes and the recording of retention rates;
- To introduce better integration of operations and collaborations with other entities (i.e. other departments in CITB ConstructionSkills);
- To create a better customer service to candidates and employers, as it will have an available and up-to-date database with all the necessary information;
- To enable CITB ConstructionSkills to match appropriate candidates and employers geographically;

- To facilitate cross-departmental working between the different departments within CITB ConstructionSkills;
- To generate representations of datasets that show which geographical areas are benefiting from STEP and which are not.

Evaluation and Findings of GIS-Enabled STEP Process

An evaluation process was undertaken to establish the impact and efficacy of the system in enhancing the operation of the STEP scheme. This process was managed in three phases: Firstly, the system was demonstrated and the users trained in its operation; secondly the departmental managers with overall operation of the system were interviewed along with the area manager and the Equal Opportunities officer who is responsible for overseeing the STEP programme; and finally a workshop was held at which all of the managers were invited to discuss the system and its operation. The cumulative results of this evaluation process are presented below.

Functionality of the System
A simple questionnaire was used to evaluate the relative performance and utility of the system. The respondents included the managers and staff from each of the departments involved in the STEP implementation process described above. With regard to its functionality, the respondents rated the system as being effective at facilitating the STEP process. It was thought that the system is useful to the STEP process and to the organisation as a whole. It was agreed that the system represents an improvement on the existing process, particularly in facilitating better integration between the departments with responsibility for the scheme's operation. It was also seen as facilitating a common understanding of the requirements of the STEP process amongst the different user groups. A common line was that there was a great potential in the system being integrated into other information processes within and across the participating departments.

User Interface
The second part of the questionnaire related to the usability of the interface that was designed to make access to the information easier. The system was seen as being relatively easy to use, particularly in terms of the user interface which made it easier to perform tasks which met their individual needs. The respondents also thought that the system enhanced their ability to access STEP data, and helped to facilitate integration of data from the different databases. All of the respondents would recommend adoption of the interface within their departments.

Interviews
A series of semi-structured interviews were carried out with the departmental managers to gain further insight into their department's perspective of the prototype. These interviews revealed the contextual issues surrounding the implementation of the system and enabled the researchers to explore the socio-technical environment into which the system was to be embedded. These are

discussed under headings extracted from the analysis of the transcribed interview data below.

Scheme targets and departmental targets
Although all of the departments had a responsibility for the delivery of the STEP process, not all of them had individual STEP targets. The initiative was therefore prioritised differently in different departments. For example, the Training Advisors in the Company Development Team were not given targets for placing females and ethnic minorities. They had a limited time when they meet with employers and they have to make sure they dealt with the key issues that affect their core requirements. This rendered it difficult to promote the scheme in some departments and hence, meant that there was a reluctance to supply data.

Reliance on external agencies
In some cases where the organisation depended on external partners for the data required for the system, some of the information needed was not adequately recorded. There were also problems with the level of granularity of the data provided. For example, if careers events were carried out there was no breakdown in the data with regards to how many females or ethnic minorities attended. It is fair to say however that this level of data is not usually required. Legislation also played a role in the way information was provided for the GIS. For example, if the Education team planned to carry out career events in schools for just female and ethnic minority students to promote STEP, schools often rejected this as their policies do not allow promotional events to be targeted at just a section of the pupils. As such, there was a paucity of potential candidates to be placed as part of the scheme. Although these issues had nothing to do with the efficacy of the system to facilitate the placement process, this did undermine the commitment to the scheme amongst the user group as it was not possible to place a large number of students. Moreover, given the limited number of potential candidates in the scheme, this also rendered the need for an automated system somewhat questionable in the opinion of some users.

Organisational change
During the development and implementation process, the organisation underwent a great deal of change internally and externally. It also had to adapt to external circumstances most notably being endorsed to become part of the Sector Skills Council for the industry. This had marked implications for the process of information management within the organisation. According to the Strategy Manager "*The organisation responding rapidly to a reinvigorated set of targets made it difficult, because the GIS mechanisms found it difficult to accommodate the quick responses to requests for information*". This was confirmed by the New Entrant Training Manager who commented: "*At the beginning of the project we thought: yes, this is a good idea but we did not realise how fast things would be moving in the organisation and trying to utilise GIS for a business that is changing daily is very difficult. We can have a set of data at the beginning of the week inputted into the GIS, by the end of the week that data would have changed completely*".

Resource requirements
The system's need for regular updating was a major issue for the users. In order for the system to provide accurate information, this meant there had to be someone responsible for updating it. The organisation had not budgeted for that at the outset of the project and so the database was not regularly updated. Several users perceived the system as generating added responsibility which increased their workload. Indeed, several informants suggested that the system would have been better suited to the Head Office environment as they had more control and access to data that would be needed for the GIS. From the Education Manager's perspective *"It obviously has a huge potential. For me it sits neatly as a Head Office tool as opposed to a local area; that is where I think it would have the biggest effect"*. Another problem was the system was only installed on a single desktop PC and was not installed on to the office network. The reason for this was that only a single user licence had been purchased for the system. The interviews revealed that if it was widely available to other members of staff there would have been more of an uptake and initial interest would have generated much more interest. This also adversely affected the users' understanding of its capability and this probably created some aversion to it.

Timeliness of implementation
Most of the interviewees felt that the GIS system has great potential as a labour market planning decision support tool, but that the implementation period may not have been the most appropriate for it to have been trialled. They also expressed the view that there were other systems within the organisation that met their requirements and that they did not feel that the GIS enhanced the process enough to warrant the considerable time and effort required to learn to use it effectively. It became evident, therefore, that the technology was misaligned with the organisational priorities at the time of its implementation.

Discussion

The literature review suggested that the ICT implementation process should not be looked at in isolation, but must incorporate aspects such as appropriate communication, culture, effective leadership, championship and environmental/organisational conditions for it to be a success. Thus, embedding a new system within an organisation demands that ways are found to take account of the socio-cultural landscape into which it is embedded. This case study has demonstrated that without such issues being taken into account, the implementation process and eventual take-up of the system is likely to end in failure.

The potential of the GIS system for enhancing the STEP process was clear; it could integrate the data provided by the different departments involved and hence, facilitate the inter-departmental working necessary for the successful delivery of the scheme. Before the GIS application was introduced there had been no mechanisms to share STEP information. By integrating the data and activities from all of the departments in relation to the STEP scheme, the GIS

enabled the whole organisation to have more involvement and control over the initiative as well as pooling together its disparate data resources. In understanding the reasons for the apparent lack of use of the system, the issues emerging from the questionnaires and interviews are discussed below under the headings derived from Grimshaw and Kemp's (1989) analysis presented in Table 1.

Commitment from top management
As was discussed above, leadership support through the ICT implementation process is vital (Earl 1989; Hirschheim and Klein 1994). Indeed, a lack of leadership amongst senior managers has been found to be a crucial factor in the implementation process across many sectors (Stanton et al 1993; Bashien et al 1994; Gardner 2000). The management team in this case study saw the potential of the system at the beginning of the development process. However, the senior manager who initiated the development of the GIS moved on to another job six months into the research. Without the buy-in and commitment from this manager it was difficult to deploy the system across the organisation in innovative ways. Moreover, as the internal structures of the organisation evolved during the implementation process this invariably changed some of the senior managers' roles and agendas to the extent that the commitment and engagement in the GIS dissipated. The importance of the integration of the GIS was effectively lost in the day–to-day activities of the organisation.

Continuing support for users
There was continuing support for the users, primarily via the embedded researcher. She was responsible for developing pilots of the system to help different departments get a better understanding of the geographical aspects of some of their responsibilities. However, the nature of the research programme was such that the researcher was not available every day and some users were not fully aware of the support available. There were also manuals available in the office which were fairly easy to understand, and an online support provided by the software developers when the researcher was not available to support the users.

Highly reliable systems
After the GIS STEP application was developed, tests on it proved that it had the potential to be a highly reliable system. However the accuracy of the application depends to a great extent on the data that is input. Acquiring the data necessary for the efficient operation of the system was problematic as acquiring STEP data was of less priority to some departments than to others. This had an impact on its credibility amongst the user group. As there was also a problem of gaps in the data this meant that there were some isolated units missing making it difficult to carry out some of the functions built in to the GIS system. The apparent inability to conduct the analyses required quickly undermined confidence in the tool and in the data upon which it was predicated. There was a problem with the reliability of other systems being used in the organisation and this created a reluctance among the users towards another system being introduced.

Involvement of users
In terms of the user perspective on the ICT implementation, an important issue was that the system was perceived as more labour intensive than the manual systems which had existed prior to its implementation. There were also some negative feelings towards new technology as they had problems with their present systems which had not been addressed. Many in the organisation failed to recognise that the tool would make their jobs easier by integrating the information and providing graphical outputs that enable a greater understanding of what was happening geographically. With the benefit of hindsight, it is clear that the system did not suit the office environment into which it was implemented. As was alluded to above, several users commented that they felt that the system would be suited to a Head Office environment which may have enabled better communication of changes and maintenance of the top management commitment.

Ease of use
The GIS STEP database was designed using the Mapinfo^{TM} GIS software which has Microsoft features, which are universal and it is easy for the user to understand their function. To increase its usability and make it easy to operate a user friendly interface was designed which enabled users to directly access the different databases and integrate them accordingly. The effectiveness of this interface was confirmed by the participants in the evaluation, most of whom considered the system easy to use. Thus, this issue can not be said to have undermined the system. The fact that the software was on a stand alone pc may have contributed to the problem as it was not easily accessible to other users for them to familiarise themselves with it.

Effective project management
The research project was well defined at the outset, with training and seminars arranged to demonstrate the operation and features of the system. The implementation process however, which comprised the last year of the research programme coincided with changes in personnel resulting in a different user group, one which had not fully benefited from the initial training inputs. Furthermore, as the organisation responded to internal and external changes, strategies were not put in place that would allow the project to fit into these changes. The inherent inflexibility of the GIS (which is grounded in its requirement for appropriately structured datasets), rendered it unresponsive to changes in the administration of the scheme. The result was that the capabilities of the system objectives became misaligned with those of the wider organisation. Project management contingencies to take account of this had not been put into place.

Clear Cost Justification
Cost was never an issue throughout the life time of the project. At each stage resources were made available in order to ensure that the system was given every chance of success. However, the follow up interviews revealed that updating the system with new data is added responsibility that the organisation had not bargained for. If it is used in the future they might have to employ

somebody to update the system, which would be an added cost to the organisation.

Well proven systems
The GIS software (Mapinfo^{TM}) on which the prototype was based is a proven system as it is popular and well known world wide. However, from the user group perspective, the system's potential and ability to support labour market planning decisions had not been proven. Hence, there was no opportunity to instil confidence in the system amongst the end users. As such, any apparent inability to facilitate the processing of the data was viewed as a weakness of the system and its capabilities were questioned.

Full training
As was alluded to above, provision for training was made available at the outset of the implementation process. However, this inevitably tailed off as the impediments discussed earlier became apparent. It was also planned at the outset of the research for a manual on how to use the system to be produced at the end as a guide for users. However, this did not happen because of the result of the implementation process. As people left the organisation or took up different roles, further training could not be provided due to time constraints and the fact that the operation of the STEP scheme had been modified which had rendered some of the capabilities of the system superfluous.

Precisely defined objectives
Precisely defined objectives were developed at the outset of the software development project, namely to:

- Evaluate and map the current internal and external STEP processes in order to identify potential knowledge gaps and discontinuities;
- Identify the potential role for GIS in integrating/facilitating current activities and processes in a way which ensures the effective achievement of STEP targets by adapting an appropriate information process model;
- Develop and implement a GIS database and train user group in its operation and effective utilisation;
- Evaluate the performance of the GIS enabled process of STEP and refine accordingly.

Facilities to meet specific needs
As was stated earlier, a user friendly interface was designed to make the system easier to use since GIS places considerable demands on the user. For example, when combined, the wide variety of data types recorded, the complex data structures used to organise them and the range of operations available, amount to a formidable obstacle for most users with standard requirements (Raper and Bundock 1991). As such, the quality of interfaces to GIS has taken on a considerable importance in terms of awareness, training and usage, both to the providers of GIS software and users of the systems (Rhind, et al. 1989). The quality of a GIS user interface is therefore an important factor in the acceptance, uptake and efficiency of the system. The ease of use factor is key to how quickly the GIS can be implemented and can influence the quality of work done and the effectiveness of a GIS as a decision support system.

Use of pilots and prototypes
Several pilots and prototypes were used for interim demonstration and evaluation purposes. One such pilot demonstrated the integration of demographic and educational establishment data to support the education department in carrying out their promotional activities. Although this demonstrated the potential of the system, they were developed and used for certain self contained activities and as such presented difficulties in being developed further as useable tools for the staff team. This may have contributed to the scheme being viewed sceptically when the STEP system application was developed and implemented.

Organisational change
Grimshaw and Kemp's (1989) survey ranked organisational change as the least important of the priorities, but this case study has revealed that it can be the most important factor in an implementation process. At the outset of the project, the objectives were clear and the potential of the system acknowledged by both managers and the wider user group. As time progressed however, the changes in the organisation became a major factor and played a huge role in the outcome of the system implementation. At the beginning of the research it was agreed by the management team that STEP was an ideal platform to trial GIS in the organisation and if it was successful, it would be rolled out to other regions and also used in other processes within the organisation. Due to the changing environment in which the organisation found itself (i.e. internal structural changes due to restructuring and having to respond to its externally assigned role as a Sector Skills Council), the objectives of the organisation changed and it was difficult for the system implementation to achieve its original targets. Other factors also provided a changing implementation context amongst the user group. The manager who had originally commissioned the development of the system left the organisation. As well as losing the senior manager leading the initiative, this individual was also acting as the GIS champion. Without such an individual overcoming barriers to the implementation of the system were made even more difficult (see Worsley 1994.) Further changes were brought about through restructuring which effectively changed staff roles and priorities. In particular, the new role of the organisation as a Sector Skills Council meant the roles and targets of the organisation and departments changed.

The change that the organisation experienced throughout the implementation process also had an impact on the prevailing climate and culture. As the literature suggests, the culture of the organisation is a determining factor in a successful implementation process (Hammer and Champy 1993, Zairi and Sinclair 1995). The changes meant that new work practices being introduced such as the way data was being collected and stored. There was also greater pressure to achieve targets such as the number of female and ethnic minority trainees to the industry.

Conclusions and Recommendations

This paper has shown the inherent problems involved in the implementation of a GIS-based system for labour market planning. Although well intentioned and conceived as a technological tool, the implementation process was not responsive enough to the dynamic environment into which it was to be embedded. It can be seen that ICT system implementation requires careful management as, whilst many positive conditions existed within the case study organisation, rapid internal and external changes can quickly have a deleterious impact on the system's implementation. In hindsight the research team could have been more proactive in adapting the system implementation process to take account of these changes. To be deployed effectively in the organizational arena and its full potential realised, the GIS system implementation must involve a concurrent structural and cultural realignment to take account of the integrated working which it promotes.

As the interviews revealed, in many respects a GIS was probably inappropriate given its inherent inflexibility and the dynamic organisational context into which it was to be integrated. However, the case study has also revealed the crucial importance of there being a clear vision and purpose of the ICT tool which takes account of the needs of end users and other stakeholders. In this respect it is crucial to involve end-users at all stages of the process so as to improve the design and increase uptake. The objectives of the implementation project and details of the process need to be regularly reviewed and updated so they can keep pace with changes taking place in the organisation and its external environment. Where the system is to span different departments and operating environments, structural systems and procedures must be put in place which facilitates this intra-organisational working in a way which aligns with the ICT system. This is not to say that ICT should drive policy, but that job design, ICT systems and procedures must be seen as mutually reinforcing if the change that they induce is to be accepted by the organisation. In this regard, probably the most crucial aspect of the implementation process is to communicate the implementation and operation effectively. This can both allay the concerns of the users and ensure that those affected by the ICT maintain a dialogue and overcome implementation difficulties.

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APPENDIX 5: EVALUATION PROFORMA

Questionnaire for Evaluating GIS STEP Database

Evaluation of STEP GIS Database

The aim of this exercise is to evaluate the STEP GIS Database which was developed to aid in the matchmaking of appropriate candidates with appropriate employers as well as acting as a central resource for the STEP process.

How well does the GIS STEP Database facilitate the precise definition of requirements?

1	2	3	4	5

How useful is the system to the overall STEP process?

1	2	3	4	5

How useful is the system to the organisation?

1	2	3	4	5

To what extent does it represent an improvement to the existing process?

1	2	3	4	5

How well does GIS STEP facilitate communication among the different departments?

1	2	3	4	5

How well does it facilitate a common understanding of the requirements of the process among the different departments/teams?

1	2	3	4	5

Can you see GIS being used in other information processes in your department or in the organisation?

If so, which one(s)?

Interface

How user friendly is the GIS STEP Interface?

1	2	3	4	5

How easy it is to perform tasks?

1	2	3	4	5

Can the user tailor the system to suit their needs?

1	2	3	4	5

Is the user able to achieve their objectives?

1	2	3	4	5

How effective is the interface for accessing STEP data?

1	2	3	4	5

General Comments

In what way(s) can the GIS STEP Database or the Interface be improved?

Any other comments

CITB-ConstructionSkills
Midlands Area
Belton Road Industrial Estate
20 Prince William Road
Loughborough
Leics, LE11 5TB]

Centre for Innovative and Collaboartive Engineering (CICE)
Loughborough University
Loughborough
Leics, LE11 3TU