An expert advisor system for college management.

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An Expert Advisor System for College Management

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ABSTRACT

An Expert Advisor System for College Management

This thesis has explored the economic, political, legal and technological changes that have an impact on decision support requirements in many organisations. It has looked particularly at the Public Sector and the FE Sector and has established the need for an intelligent decision support system. Critical Success Factors have been identified that have influenced the design of a specific Expert Advisor System experimental prototype, the development of which has been central to the research. A range of system development methodologies have been reviewed, and justification has been provided for the selection of the CommonKADS methodology. Technologies and techniques to be used in the development of the Expert Advisor System have also been reviewed and justification has been provided for incorporating Case-Based Reasoning and Data Warehousing. The analysis, design and development of the system has been strongly influenced by the Critical Success Factors that were identified to ensure the system met the decision support needs.

The experimental prototype has been developed specifically to assist Senior Managers at an FE college with the decision making that is used to complete ISR Funding Returns. The system gives access to historic data, provides auditable data trails to substantiate decisions and facilitates 'what-if' projections. Case-based knowledge discovery, data-based knowledge discovery, graph-based knowledge discovery and projection-based knowledge discovery have been achieved through the use of the prototype. An important part of the development process was the adaptation of cases and the adaptation of queries that extracted and aggregated data to provide system adaptation.

The research has focused around addressing two research hypotheses. Evidence has been provided to show that the two research hypotheses have been addressed. This demonstrates that (hypothesis 1) CommonKADS Models are well suited to providing a template for the design and documentation of Decision Support Systems that need to operate in rapidly changing domains. Justification has also been given to show that (hypothesis 2) CBR principles can be used together with other knowledge discovery techniques to provide useful adaptive systems. The research concludes by looking at how new technologies could be incorporated in later versions of the Expert Advisor System.

CHAPTER 1 - THE AIMS AND OBJECTIVES OF THE THESIS

1.1 INTRODUCTION

The research undertaken to support this PhD thesis has investigated and evaluated changing decision support requirements and has identified the need for an Intelligent Decision Support System. The research considers how economic, political, legal and technological change is having an impact on the need for informed decision making in many organisations. It recognizes that today's world provides only small windows of opportunity during which managers must make decisions. It also recognizes that many internal and external constraints are imposed on the decision maker, and that organisations operate in rapidly changing competitive and demanding environments.

Technologies are investigated and evaluated in this research. The capabilities of Case-Based Reasoning (CBR), Rule-Based Systems, Artificial Neural Networks (ANNs) and the application of the principles of Data Warehousing and Data Mining are examined. As a result of this, a selection of technologies and principles are identified that are suitable for integration to provide an experimental Intelligent Decision Support System prototype. The research then continues to investigate the adequacy of a Soft Systems Methodology, a Hard Structured Systems Methodology and a methodology suitable for the analysis and design of Knowledge-Based Systems (KBS). Justification is provided for the selection of one of these methodologies. The research then proceeds with the analysis, design, development, implementation, testing and evaluation of an experimental Intelligent Decision Support System prototype for one particular organisation which is operating in a difficult, volatile environment where many internal and external constraints are imposed. This is an organisation that, like many others, needs to provide auditable data trails to authenticate the validity of its decisions. The organisation is a Further Education college.

This work has provided an understanding of the complex changes that are happening in many organisations and has drawn attention to the way in which their decision support needs are altering. The development of the experimental Intelligent Decision Support System prototype has resulted in knowledge, learning and understanding that could be useful to many organisations that operate in unpredictable environments with a requirement for informed decision making.

1.2 RESEARCH AIMS AND HYPOTHESIS

The research aims that have been identified for this work recognize the impact that rapid change is having on today's decision-making requirements. Succinctly, the research aims are to investigate and evaluate new approaches for use in meeting the present-day decision support needs in many organisations. As mentioned above, one outcome of the research is the construction and evaluation of an experimental Intelligent Decision Support System prototype. The contributions to knowledge that have been achieved will be made explicit in the thesis and substantiation of the contributions will be provided throughout the thesis.

In carrying out the research needed to develop the Intelligent Decision Support System, two specific research hypotheses have been addressed.

The first hypothesis focuses on the CommonKADS methodology when it is used for the analysis and design of Intelligent Decision Support Systems operating in rapid change situations. The CommonKADS methodology is one that is used for the analysis and design of KBS. The first research hypothesis is as follows:

> ***CommonKADS Models are well suited to providing a template for the design and documentation of Decision Support Systems that need to operate in rapidly changing domains.***

The second hypothesis recognizes the need for auditable data trails to support decision making. It addresses how Intelligent Decision Support Systems using CBR together with the principles of Data Warehousing can provide system adaptation.

When CBR is used, case adaptation is applied when an enquiry is received for information to support decision making and a case search fails to find a match with other cases. If the search solution is not adequate, or there are some variations in the parameters since the most appropriate case was last used, the case that is the nearest match to the requirements is adapted to form a new case.

When the principles of Data Warehousing are used snapshots of data relating to different time periods are held in a Data Warehouse. Data from the Data Warehouse are used to enable informed decisions to be made.

When case adaptation occurs, data retrieval routines also need to be adapted to ensure the decision support data that are extracted correspond, to the adapted case. Case adaptation, together with data adaptation, is described as system adaptation in this thesis. System adaptation enables an audit trail of detailed data, totals derived from aggregations of the data, and charts such as bar charts or pie charts, to be produced for adapted cases. These can be provided for different periods in time.

The second research hypothesis is the following:

> ***CBR principles can be used together with other knowledge discovery techniques to provide useful adaptive systems***

System adaptation, as described above, makes accurate, auditable data trails available when rapid change occurs.

1.3 RESEARCH OBJECTIVES

In order to address the research aims and hypotheses five research objectives have been identified as follows:

i) Changing Decision Support Requirements

The first objective is to explore the changing needs in many organisations for informed decision making. It is also to identify and evaluate the adequacies and inadequacies of existing decision support systems operating in volatile environments where auditable data are required to authenticate decisions.

ii) Decision Support Systems

The second objective is to investigate new and rapidly changing decision support requirements. A case study will be used to explore these changes in Further Education. This is a domain where new legislation has been introduced. As a result of this legislation financial, technological and cultural change has occurred and a situation has been created where informed decision making is essential. Although the case study is focused on Further Education, it will portray the changes that are happening in many organisations and reflect a widespread need for informed decision making. The knowledge and understanding gained from the case study will have wide applicability elsewhere in similar organisations.

iii) Methodologies for the Design of Intelligent Decision Support Systems

The third objective is to explore and evaluate a Soft Systems Methodology, a Hard Systems Methodology, and a methodology used for the analysis and design of knowledge-based systems. The appropriateness of these methodologies for use in the design of an Intelligent Decision Support System that will operate in a complex, unpredictable domain is assessed. The knowledge gained from this research will contribute to learning in the systems methodology area of research.

iv) Technology Evaluation

The fourth objective is to examine, evaluate and assess the use of technologies from other domains and select those that could be integrated to provide an Intelligent Decision Support System. The technologies need to be capable of operating in a domain where the rules rapidly change. The technologies are not only required to provide adaptation relating to decision support requirements, but also to provide adaptation relating to the data extraction which provides the auditable data trail that is required. Together these provide system adaptation.

In the case study a Further Education college is required to provide an auditable data trail to substantiate its funding bids. Case adaptation relating to decision support requirements and adaptation relating to data extraction will both be required. This is a situation that is common to many organisations.

v) The Expert Advisor System

The fifth objective is to use the selected methodology and the selected technologies for the analysis, design, implementation, testing and evaluation of an experimental Intelligent Decision Support System prototype which has to operate in an environment where internal and external constraints are being imposed. This system is known as the Expert Advisor System.

1.4 RESEARCH HYPOTHESES

The research I have undertaken spans ten years. During this period of time many changes that affect organisations have happened. New legislation has been introduced, technology has advanced and management styles have often altered. Many organisations that in the past were managed to meet their own requirements now have to adopt different management styles to meet external impositions. Where a substantial amount of funding comes from an external source organisations are frequently driven by the demands of the funding body and the controls they impose. This often brings with it new responsibilities, more accountability and rapidly changing rules. It has also introduced radical changes to what is acceptable as a decision making process.

Many decision makers now have only a small window of opportunity in which to make their decisions. These decisions have far reaching effects on the organisation and the consequences of wrong decisions can have serious repercussions. Decisions need to be informed decisions. In addition to this, legislation often dictates that auditable data trails are provided to substantiate the decisions that are made.

My own work, as a Head of School in a Further Education college made me aware of this situation and placed me in a position where informed decision making was essential. Although I recognized the need to make informed decisions and the need for data trails to substantiate the decisions it proved impossible to find any system that could help me in the decision making process. The complexity of the data sets and the rules that frequently changed added to the difficulty. The need for a solution to this situation provided strong motivation for my research.

Other motivation for my research came from many sources. Literature searches were important and stimulated my interest in Intelligent Decision Support Systems, and appropriate methodologies for the analysis and design of KBS operating in rapidly changing environments. In the early years of this research web technology was still evolving, but in the later years web access was available and web searches also provided a significant contribution to my research and were another motivating factor.

An exchange of ideas, knowledge and understanding of my research area arose through participation in user group discussions, meetings, seminars, courses and collaborative ventures. In my role as Head of School I was frequently involved in discussions with the Further Education Funding Council (FEFC) and received requests for information from them. I also received requests for information and appropriate software from other members of management, staff, FEFC auditors and FEFC inspectors. All of these provided the motivation that encouraged me to continue with my research work.

The lack of an Intelligent Decision Support System that could operate in a domain that was frequently changing helped to convince me that this was an important and essential area of research. In addition to this my research relating to the needs of the Public Sector confirmed that there is still a need today for this type of system in many organisations. It also showed that the learning from my research could be valuable to other organisations. Consequently the motivation to complete this work and make a positive contribution to the research area of Intelligent Decision Support Systems increased.

My research also confirmed the rapid rate of change that was happening in many organisations and the difficulties that were occurring in system development and acceptance. It proved difficult to find a methodology that was suitable for the analysis and design of a system that had to take account of organisational issues, handle knowledge and operate in a rapidly changing environment. Awareness of the CommonKADS methodology came through attendance at a conference. In the early stages of this research information on the CommonKADS methodology was difficult to find. Marie Gustafsson who participated in the ESPIRIT project responded to a letter I sent requesting information. Her help and encouragement provided additional motivation for this research.

Although my research has continued for ten years I have still not been able to identify an Intelligent Decision Support System that can operate on complex data sets and with rapidly changing rules. I am still continuing to do literature searches and web searches and I am frequently involved in discussions with academic and commercial contacts. My exploration of this interesting area of research is continuing.

1.5 THE STRUCTURE OF THE THESIS

An overview of the chapters making up this thesis is as follows:

Chapter 2 - Decision Support Requirements to Meet Changing Needs

This chapter explores the impact which change is having on many organisations. It describes how it is altering the way in which they operate and how it is transforming their decision making processes and the way in which they use technology. Consideration is then given to smart, learning organisations and their thirst for knowledge. The chapter goes on to provide an understanding of the data management and data quality problems that often exist in decision support environments. It then proceeds to provide an understanding of complex domains, the intricate framework that systems need to operate within and the many demands that are imposed. E-government and government IT system failures are used to provide an insight into how change is affecting the way in which the Public Sector is operating, how its decision making processes are expected to alter and the way in which technology is expected to be used to enable change.

An explanation of the Further Education (FE) Sector, its management information systems, the Further Education Funding Council (FEFC) funding methodology and the Individualised Student Record (ISR) funding returns that colleges have to complete is then provided. This is included to set the scene for the case study, but it should be noted that the complexity present in FE is typical of other sectors. The chapter concludes by providing evidence of problems with funding returns and software.

Chapter 3 - The Problem Domain

This chapter describes how organisational expectations of decision support systems are changing. It then gives details of a transformation that is taking place in the Education Sector as a result of new legislation. It continues to explain the roles of different people who are involved in work relating to funding bids and the associated decision support needs in a Further Education college. An explanation is also given of how contact with internal and external sources raised my awareness of technological change and the need for an Intelligent Decision Support System to assist in the decision making process. The chapter concludes by providing details of Critical Success Factors that have been identified for such an Intelligent Decision Support System, the Expert Advisor System for short.

Chapter 4 - Evaluation of Technologies for Use in the Expert Advisor System

The main purpose of this chapter is to research the strengths and weaknesses of different technologies and gain an understanding of the way in which they have been used in different organisations. The findings from this research are then evaluated and appropriate technologies are selected for use in the development of the Expert Advisor System experimental prototype.

Chapter 5 - Using the Commonkads Methodology to Design the Expert Advisor System

This chapter evaluates a Soft Systems Methodology (Multiview), a Hard Systems Methodology (SSADM) and a methodology for knowledge based systems (CommonKADS). It then justifies the selection of CommonKADS as the chosen methodology for the analysis and design of the Expert Advisor System experimental prototype. It proceeds by discussing the design of each of the CommonKADS models. The chapter concludes by summarizing the findings that have been identified through the practical application of the CommonKADS methodology and by identifying a constraint that exists when CommonKADS is used in rapidly changing situations.

Chapter 6 -Preparation for the Development of the Expert Advisor System

This chapter discusses the issues which need to be considered when the Expert Advisor System prototype is developed and implemented. It also defines and explains the architecture and the case structure that will be used to support the development of the Expert Advisor System experimental prototype.

Chapter 7 - Developing and Implementing the Experimental Prototype

The development of the Expert Advisor System prototype and its use of the CommonKADS models are discussed in this chapter. Socio-organisational issues that could have an impact on the development and acceptance of the Expert Advisor System are explored. In addition to this, examples of techniques that have been used by other organisations are provided and used to justify their inclusion in the development of the prototype. The chapter also provides an understanding of the Expert Advisor System experimental prototypes contribution to informed decision making for the Further Education Funding Council ISR Funding Returns. It concludes with an explanation of the achievement of knowledge discovery.

Chapter 8 - Testing and evaluating the Expert Advisor System

This chapter explains how users tested the experimental prototype and evaluated the decision support capabilities that it offers. Users completed exercises to gain an understanding of the system then allocated scores and gave comments on individual facilities. An analysis of the scores is provided and conclusions are drawn about the capabilities of the Expert Advisor System experimental prototype.

Chapter 9 - The Achievement of Critical Success Factors

Evidence is provided in this chapter, to demonstrate that the Critical Success Factors for the Expert Advisor System experimental prototype that were identified in Chapter 3, have been achieved.

Chapter 10 - Evaluation of the Thesis Aims and Objectives

This chapter demonstrates that both the research hypotheses have been achieved.

Chapter 11 - Conclusions

Chapter 11 reviews the entire thesis, particularly the achievement of the research aims and objectives and outlines future work that could be undertaken to enhance the experimental prototype that has been developed.

CHAPTER 2 - DECISION SUPPORT REQUIREMENTS TO MEET CHANGING NEEDS

Many organisations are feeling the impact of change. It is altering the way they operate, their decision making processes and the way in which they use technology. This chapter considers these issues in detail and documents the evidence which justifies the need for an Intelligent Decision Support System. Initially the chapter focuses on the need for intelligence, data quality and data management and the changes and use of technology in the Public Sector. Finally it explains the changes that are happening in the Further Education Sector and how they are affecting colleges.

2.1 SMART COMPANIES THIRST FOR INTELLIGENCE

Veryard (2000) describes how some organisations are alert to changing circumstances, react creatively to new threats and opportunities, and are constantly learning from their own experiences. These are intelligent organisations. He states that an intelligent organisation is likely to be more successful in the short term, and have greater prospects for survival and growth in the longer term. He explains how intelligence is related to creativity and says that intelligence may require the ability to innovate. He adds that this will not be innovation for its own sake, but will be appropriate innovation that is connected to environmental demands.

Veryard (2001) also states that technology management generates demands on people and organisations, whilst change management generates demands on technology solutions and technical staff. He highlights the difficulty which many organisations face when he says that without adequate technology change management, an unending set of impossible demands appears. Organisations face this problem when they address the issue mentioned by Rakow (1999). Rakow says that everyone, this being companies, colleagues, suppliers and competitors, are looking for competitive advantage. He then explains how the competitive edge is achieved by smart companies when they make the changes that are needed to accommodate new solutions.

One motivation for the research carried out in this thesis is the need to enable intelligence to be available to companies that recognize the necessity for intelligent, informed decision making, and are making changes that will enable them to become smarter companies and gain a competitive edge. These are companies that are prepared to learn from their own experiences. The Expert Advisor System experimental prototype which is the focus of the case study in this thesis is an Intelligent Decision Support System designed to enable companies to become smarter companies and learn from their own experience.

Burstein and Linger (2003) explain the purpose of an Intelligent Decision Support System that operates in an environment where tasks are not only performed but are also reviewed and evaluated to provide understanding. They say that this process enables learning from experience. They also comment on how some aspects of the process represent knowledge work. In addition to this they describe the process as one that requires the collection of, and re-use of, organisational knowledge. An explanation is provided of how the user is engaged with the system in a joint cognitive process of problem exploration. The system provides the necessary intelligent assistance in areas of uncertainty or complexity through extended functionality such as reasoning, memory aids, explanation facilities and learning capability. The Expert Advisor System is a system like this.

2.2 DATA MANAGEMENT AND DATA QUALITY

Most organisations are operating in an environment where many system and data problems have to be recognized and managed. English (1999) explains some of these problems. He describes how organisations often have many files that contain the same information. The data and the field definitions in these files are frequently inconsistent and it becomes difficult to know which version of the data to use. This also results in additional work and extra costs when many copies of the same data are being updated. It also becomes hard to identify which field definition in one file relates to another field definition in a different file. In addition to this English (ibid) also states that other problems occur when formal definitions and business rules have been specified for legacy data, but the meanings of the data and the business rules have changed and the documentation has not been updated. He also says business rules sometimes only exist in the application code, but informal rules also exist as anomalies within the files.

English continues by pointing out that historic data may have different definitions over a period of time. This occurs when a database design has to change to meet new information requirements. He also draws attention to the problem of data that have been defined and designed to meet high-performance transaction processing needs. Such data are often highly cryptic and have meaning embedded within them. Only the programs and a few subject specialists understand the data. English proceeds by explaining how legacy data architectures generally do not meet knowledge workers' information requirements. This results in them using data fields to store data in a different way from what was intended or it forces them to create their own private databases which hold data that meet their own particular needs.

English continues to discuss data content problems. He identifies the problem of domain value redundancy, where non-standardized data values are used, or synonyms in which two or more code values which mean the same thing are used. He also mentions the additional problems of missing data values, incorrect data values, multiple facts being entered in the same field, and fields being used for different purposes depending on the specific requirement. In addition to this English explains the danger that exists of combining accurate data with inaccurate data. The derived data are inaccurate and this contaminates the quality of information.

Blumberg and Atre (2003) comment on data issues when they say that the management of unstructured data is recognized as one of the major unsolved problems in the information technology industry. They add that the main reason for this is that the tools and techniques that have proved so successful in transforming structured data into business intelligence and actionable information simply do not work when it comes to unstructured data. New approaches are necessary.

Unstructured data in relational database terms means data that cannot be stored in rows and columns. These data are stored as Binary Large OBjects (BLOBs). Unstructured data can also be e-mail files, word-processing text documents, PowerPoint presentations, Joint Pictures Expert Group (JPEG) files, Graphic Interchange Format (GIF) image files and Motion Pictures Expert Group (MPEG) video files. These are all data issues that cause concern for organisations. Clements' (2001) comments enlighten us still more about the changes that are happening. He emphasizes the scale of the data management problems that not only exist, but are growing, when he says:

> 'Much like nature's 'perfect storm,' several forces in the IT world are converging to form a magnitude of data management problems that transcend previous levels of experience. Both the supply and demand sides of the business equation are escalating together at a whirlwind pace. New-generation e-applications are producing torrents of data at a predicted hundredfold, five-year growth rate. At the same time, enterprise managers continue to thirst for more insights that can only be gained from analysing these massive amounts of accurate and timely detail data. Add to this turbulence an overwhelming projection in the associated cost to contain and manage these torrents of data, and it becomes apparent that new alternatives need to be considered.'

Data Warehousing addresses issues such as those raised by Clements. It recognizes the need for data management and quality data. A statement by English (1999) points out the significance of information quality problems that have been exposed by Data Warehousing. He says:

'Data warehousing has exposed horrific information quality problems that become apparent when an organisation attempts to integrate disparate data. Its quality may satisfy operational knowledge workers and functional processes but fails miserably to satisfy the down stream knowledge workers and enterprise processes.'

These discussions on data and data management provide an indication of the serious and complex technical problems that exist in the environments where decision support systems have to function, and where they acquire the data they use. They also show that the technology that is used to enable informed decisions to be made will need to change to cope with issues such as unstructured data. The case study in this thesis will concentrate on the need for an Intelligent Decision Support System experimental prototype that will work with structured data. Although technologies are integrated to provide the experimental prototype used in the case study, I also recognize the necessity for technology change management. New learning will come from the work that is documented in this thesis, but it is appreciated that the learning will be used in future decision support systems that are developed from new or different technologies with more advanced capabilities. The Expert Advisor System is a step in technology change management in the field of decision support systems. It will provide additional knowledge in an area that is advancing rapidly as it strives to meet the demands of rapid change. Decision Support Systems of the future will need to cope with unstructured data.

2.3 ORGANISATIONAL CHANGE IN THE PUBLIC SECTOR

This section focuses on the Public Sector in England. It is a sector where rapid change is occurring. The learning gained from my work should help to provide an understanding of complex domains, the intricate framework that systems will need to operate within and the many demands that will be imposed.

I will concentrate on change that has been imposed through legislation. Changes that have occurred in the Health Service, the Department of Transport and the Police will be considered. Government actions and the organisational requirements that are imposed as a result of new legislation will be discussed. This investigative work will provide an insight into how change is affecting the way in which the Public Sector is operating, how its decision making processes are expected to alter and the way in which technology is expected to be used to enable change.

In 1998 the Office of the Deputy Prime Minister (1998) issued a white paper, 'Modern Local Government in Touch with the People', that spelt out the Government's vision for modernizing Local Government. It also stressed that local financial accountability would be improved and that this would have an impact on council spending and taxation decisions. It said decisions would need to be open and understandable. In addition to this it stated that the financial system for Local Government would need to reflect the importance of local accountability and also the strong interests of Central Government. It pointed out that the current system would need to be improved.

The Office of the Deputy Prime Minister (ibid) also added that the lack of stability in Government funding in past years had meant that people did not understand who was responsible for changes in council tax levels. It also said that council decision making too often lacked openness and transparency and this resulted in a weakening of the councils' legitimacy. It then identified the need for the Government to have reserve powers. These would enable it to limit unwarranted council tax increases. They would also allow it to act when excessive increases in council budgets occurred. This could be because the increase was particularly large or because the council was not performing to the standards of efficiency and economy that people rightly expected of public services. This demonstrates the power of the Government and shows how they have the right to intervene in the way in which organisations operate. It also shows the importance of decisions and how they can have an impact on an organisation's authenticity.

In the years following the white paper, Parliament (1999, 2000) passed two Local Government Acts. These acts encompassed a wide range of changes based on the Government's vision for change. Another white paper was issued by the Office of the Deputy Prime Minister (2001), 'Strong Local Leadership Quality Public Services', which confirmed the Government actions that were required to comply with the acts. This paper described legislative changes that would alter the way in which the public departments dealing with health, transport and crime operated, made their decisions and acquired their funding. The paper states that the Government will take tough action where councils and services are failing, will stretch targets and rewards to achieve improvements in service, will promote sound financial management, will design new grant formulae and will introduce priorities for public services. Details of the priorities are given in Table 2.1.

Public Sector Priorities
Health i. to improve health care for older people ii. to improve children's services iii. to narrow the health gap
Transport i. to introduce bus and light rail usage ii. to reduce accident rates iii. to reduce congestion iv. to contribute to the improvement of the quality of local air
Crime i. to reduce crime and fear of crime ii. to tackle drug abuse
Source: Office of the Deputy Prime Minister (2001), Strong Local Leadership, Quality Public Services, Section 3.9.

Table 2.1
Public Service Priorities

Many organisations are having changes such as these imposed by the Government and are having to alter their management styles and their decision making processes to comply with external requirements. They are also having to alter the way in which they use technology to meet the new external demands that come with these changes.

The 'Strong Local Leadership Quality Public Services' paper also identifies new requirements that the public departments dealing with health, transport and crime have to meet. These are to respond to local needs and circumstances, to improve the efficiency, transparency and accountability of local leadership and decision making and to work clearly to defined priorities and exacting performance standards. It also states that they have to undertake comprehensive performance assessments and inspections and have to increase the emphasis on delivery, responsibility and accountability. In addition to this it says they must exploit the potential that new technologies offer to restructure services and speed up transactions, and that they must provide performance indicators.

Imposed changes of this nature lead to changes in the way in which organisations operate and the way in which they use technology. The demand for improved efficiency, transparency and the accountability of local leadership will also alter decision making requirements and increase the need for informed decision making, as will the performance assessments and inspections. The external powers of Government that have been identified in relation to tax provide an indication of the importance of decisions, and demonstrate how the Government has the right to intervene in the way in which organisations operate.

2.4 TECHNOLOGICAL CHANGE IN THE PUBLIC SECTOR

Earlier in this chapter I wrote about problems that occur in many organisations that are connected with change, technology, data and decision making. I now want to revisit the issue of technological change and explore the Government findings that relate to the implementation of technological change in the Public Sector.

The Government recognizes that significant technological change has to be undertaken if new legislation is to be effective. McCartney (2000) states in a Cabinet Office document that reviews major Government IT projects, that the Public Sector is undergoing radical change. He says that the first ever e-Government strategy sets out how IT will change the way the sector works. Others have also established the need for technological change. Nick Raynsford (Minister for Local Government and the Regions in 2002) together with Sir Jeremy Beecham (2002) wrote in their foreword to the Local Government Association consultation paper that Local Government could not succeed alone. They indicated that technology was a necessity. In addition to this they stated that e-Government was already helping to make services more accessible, convenient, responsive and cost effective. They also added that it would make councils more open, more accountable and inclusive, and that it was enhancing the councils' ability to lead their communities into the information age.

2.4.1 E-GOVERNMENT

The Local Government Association et al (2002) state that Local e-Government can make a reality of joined up government. They say it enables services to be built around customers and community needs. In addition to this they reveal that public services can be more heavily influenced by, and accountable to, the individuals and the communities they serve. They add that e-Government can offer opportunities to exploit the benefits of modern technology.

The Local Government Association explain how e-Government means exploiting the power of information and communications technology. They justify e-Government when they explain how it will incorporate national standards and have clear accountability. They describe how it will engage in devolution, be flexible and offer choice. They also emphasize that organisations that provide services will be made more open, more accountable, more inclusive, and better able to lead the communities. They state that e-Government will be shaped by a partnership between Central Government and local service providers. It will consist of local service delivery priorities, forward looking policies to deliver outcomes that matter and a strategic e-planning and delivery framework. It will provide a common model of e-Government, technical standards and information sharing protocols, a national infrastructure for electronic service delivery, a framework to support partnership working and will make provision for resource allocation.

The Local Government Association continue their description of e-Government. They say it is complex and that it touches the political, cultural, organisational and technical aspects of everything that local authorities and other public services do. They continue by explaining that it is driven by pressure for change both from bottom up - as the expectations of citizens and businesses increase - and from the top down - as the Government and councils seek to modernize their organisations. This results in a complicated set of overlapping priorities and programmes.

These statements by the Local Government Association justify the use of technology in complex domains that are in the midst of political, cultural, organisational and technical change. They verify that national standards have to be implemented, clear accountability can be demanded, and more openness and flexibility can be expected as a result of legislative change. They say that technical standards and information sharing protocols need to be adopted to modernize organisations, and to enable them to meet the expectations of citizens, businesses and the government. These findings focus on health, transport and crime, but are true of many organisations. They provide an indication of the rapid rate of organisational change that is occurring. They also identify the role of technology as an enabler and describe the changing expectations that systems need to meet. Decision Support Systems have to operate in these environments and meet the need for informed decision making that arises from new legislation and the related changes. Technology change management and informed decision making have to enable organisations to move forward and not only meet existing demands but also meet new demands such as these.

All this lends weight to my belief that the introduction of organisational change and technology change on this scale will result in a requirement for a methodology to design decision support systems for complex environments. The methodology will need to be one that makes provision for organisational issues and enables the problems and opportunities that are encountered to be considered.

2.4.2 IT SYSTEMS

A year after the second Local Government Act the Cabinet (2000) published a paper that reviewed major IT government projects. The paper gives an important message:

> 'A change of approach is needed. Rather than think of IT projects, the Public Sector needs to think in terms of projects to change the way the Government works, of which new IT is an important part.'

The paper also describes the Government aim to provide the skills needed to deliver improvements in the handling of IT related change. It explains how the introduction of IT systems used to be seen as an end in itself and how this often led to system failure. It then explains how it now needs to be seen as part of a wider process to meet the overall business objectives of departments and agencies. It says that business skills need to be strengthened to support the management of business change projects and to enable informed business decisions to be made. The paper provides evidence of the following system failures.

System Integration Failure

The Cabinet (ibid) explains how a Government agency used leading edge technology to develop a new system. The agency failed to implement it within the context of its existing IT provision. Many changes were made to the existing system during the development of the new system and it proved difficult to integrate these into the system.

Failure due to Legislation Deadlines

The Cabinet also says it is vital that Ministers and senior officials are aware of the affect that their leadership and decision making can have on a system project environment. An example of an organisation that received late delivery of a large, updated business system is provided. It says that the delay was partly due to a high-level decision to implement the system on an extremely tight timescale in an attempt to meet a deadline in a legislation proposal.

Inexperienced Project Manager Causes Failure

The characteristics of good managers are discussed by the Cabinet. They explain how managers who are competent in their existing management roles, but inexperienced in managing projects are often put into project manager posts. They say the results of this are mixed, but they add that it is very clear that ineffective management has frequently been a major contributing factor to the failure of projects. An example is provided where someone with no experience of project work was given a very challenging project and a team of over 200 people to manage. The manager was not familiar with project issues and valuable time was lost when decisions were being made.

Inadequate Risk Management Leads To Failure

Another issue which the Cabinet explains is how the quality of risk management varies. They then provide an example where risk management has been inadequate. They describe how a major Government project failed when it experienced an adverse reaction from end users. They continue by saying that the development phase of the project had taken longer than planned. They then explain that it had still been rushed through without considering the needs of the users. The project risks had been documented but effective mitigating action was not taken quickly enough to resolve the problems with the users.

An additional problem which I met was that of not being able to find an existing, or a planned Intelligent Decision Support System that could meet the needs of the decision maker in the complex and rapidly changing environments of the public Departments of Health, Transport and Crime. Extensive web searches and literature searches were performed. References to 'decision making' occurred many times in the documents I found. These searches, however, did not provide references to Intelligent Decision Support Systems that could operate in complex domains with rapidly changing rules. On 5th February 2003 an email was sent to 'pathfinders@vantagemc.co.uk', the Local Government online service that explores and develops new ways of implementing e-Government. It requested help in finding this type of software, but I received no response. A copy of the email is provided in Appendix A.1. My lack of success in finding any suitable software helped to convince me of the importance and value of my work and demonstrated the need for new learning and knowledge to be added to the area of Intelligent Decision Support Systems.

The examples that have just been provided give evidence of problems that can occur during system integration, whilst meeting legislative deadlines, when inexperienced project managers are used and when inadequate risk management procedures are employed. They also illustrate how difficult it is to find systems that meet new or changing requirements. McCartney (2000), the Minister of State in the year 2000, whilst writing in the Cabinet Office paper, 'Successful IT: Modernising Government in Action' offers advice based on the learning that has been gained from examples such as these when he says:

> 'The power of IT is not always easy. The tasks involved are very complex and fraught with risk. Government has already successfully implemented a range of complex projects. However, we still need to improve performance and avoid the mistakes of the past'

This statement aligns with that made earlier by Jones (1998) when he describes the construction of large software systems as one of the most hazardous activities in the business world. His research findings show that over 20 per cent of software systems fail or are cancelled. He has also found that about two thirds of large completed systems experience schedule delays and costs can almost double. About the same number of systems are plagued by low reliability and quality problems in their first year of use. Jones' research, however, did not focus on the Public Sector.

These discussions on IT systems provide evidence that many problems arise when new legislation is introduced and technology is used to implement the resulting changes. These problems, together with the data and data management problems covered in Section 2.2 add to the complexity of developing new systems in rapidly changing domains. In addition to this the investigation into the organisational changes that are taking place in the Public Sector has revealed the importance of considering organisational factors and risk management issues, during the analysis and design of new systems that need to operate within tight time constraints, arising from the introduction of new legislation.

2.5 CHANGING DECISION SUPPORT REQUIREMENTS

As organisations are now operating in a period of rapid change, information requirements are changing and so are the methods that are needed to achieve informed decision making.

Arsham (2003) says that today's business operations are complex and competition is aggressive. He says that this and Government controls have made a manager's job increasingly difficult. He adds that it is no longer possible for one individual to be aware of the details of every characteristic of an organisation, or to make all the decisions regarding its operation. Arsham (ibid) explains that the factors affecting manager's decisions are often so numerous and their effects so pervasive that 'seat of the pants' (sic) decisions are no longer acceptable. As a result, effective decision making often requires analysed and summarized information to be available on time. Arsham also draws attention to today's businesses being driven by data. He says that business managers and decision makers are increasingly encouraged to use data to justify their decisions.

In addition to this Arbor Software (1995) have confirmed how organisations need to access complex, interrelated data sets and provide meaningful, shared information. They say:

> 'Information is a strategic weapon in today's fast paced global business environment. Companies are realizing that the key to successful competition and growth lies in their abilities to quickly obtain the right information for spotting trends, forecasting market changes, and analyzing performance. In an effort to better manage the sheer volume of data available, they have invested heavily in information systems and technologies at both the corporate information systems level and on individuals' desktops.
>
> Through this proliferation of computers, knowledge workers have become technology literate. Yet, many are not able to penetrate the tangled maze of data sources that exist, let alone extract meaningful information from them. Workgroups also lack effective means to share information and fully utilize each individual's strengths. What is needed today is an analysis system that speeds and simplifies access to the data contained in corporate information systems. It must allow users to analyse complex, interrelated data sets and share this information with each other. Finally, it must convert raw data to useful information while maintaining a shareable, updated copy of core enterprise data'.

The thinking of Arsham (ibid) and Arbor Software (ibid) justifies the need to use technology to inform decision making. The alternative that faces organisations is highlighted by Handy (1985). He discusses how motivation and morale can be depressed when decisions appear to be inconsistent. He adds that decision making may be delayed and lacking in quality when there are no adequate procedures for evaluating the results of similar decisions in the past.

The comments from Arsham, together with those of Arbor Software and Handy (ibid) reinforce the need for a tool to help organisations access complex, interrelated data sets and provide meaningful, shared information if informed decision making is to be achieved. They also add weight to the necessity for auditable data sets to be available and highlight the need to gain knowledge and understanding of past decisions.

2.6 MY EXPERIENCE IN THE FURTHER EDUCATION SECTOR

Many changes that are happening in Further Education are similar to those that are happening in the public Departments of Health, Transport and Crime. For a period of seven years I was employed as Head of Information Systems at a Further Education college and was involved in researching and acting upon Government expectations and impositions arising from Parliament (1992) passing the Further and Higher Education Act. My role as a senior academic with responsibility for management information, data collection, publication of student information and the provision of funding and strategic planning returns for the Further Education Funding Council (FEFC) provided me with a detailed understanding of the difficulties that were caused by the Act. The demands which the new legislation made resulted in my working closely with the College Principal, College governors, other heads of school, college auditors and the FEFC auditors and inspectors. It also led to my leading a substantial part of governance and management during inspections and providing performance indicator information.

During this work I became very aware of the importance of informed decision making and the obstacles that could prevent this from happening. I was also extremely aware of the impact many decisions had on the Colleges' ability to survive. Decisions relating to funding returns were of prime importance as were the data trails that were required to authenticate the decisions made to complete these returns.

Through my own work, that of other members of the senior management team and staff, it quickly became apparent that a software system was needed to assist in the decision making process. It was also obvious that the system would need to provide knowledge of past funding bids and be able to adapt to changing rules. In addition to this it would have to provide an auditable data trail to support the decision making process. Despite extensive searching and consultation with other colleges, software developers and suppliers, I could not find at that time a product that could handle the complex data sets, rapidly changing rules, use knowledge of past funding bids, and provide the information needed to meet internal and external demands. I was also conscious that a software supplier could not develop a decision support system that would meet these needs without considerable understanding of the FE environment, the FEFC funding mechanism and the Individualised Student Record (ISR) Funding Return.

2.7 ISR FUNDING BIDS IN FE COLLEGES

The difficulty I experienced in finding suitable software to assist in the decision making process, together with my knowledge of the cultural, political, financial and technological changes that were happening as a result of new legislation, made the FE college where I worked a suitable domain for the case study used in this thesis. Many aspects of the transformation that is happening in Further Education colleges are very similar to aspects of the Public Sector transformation that has been discussed in Sections 2.3 and 2.4. The main difference is that FE was not e-enabled when this work began.

My experience of the FE environment and my knowledge of the complex Individualised Student Record funding bids, difficult FEFC funding methodology and rapidly changing FEFC funding rules played a vital part in the development of the Expert Advisor System experimental prototype. I was constantly aware of the crucial role these funding bids played in enabling the College to survive. I was also very conscious of the need for an Intelligent Decision Support System, but also appreciated that financial, technical, human resourcing and political difficulties had to be overcome if such a system was to be introduced.

Resolution of many of the problems resulting from new legislation was an integral part of my work. The new legislation often led to situations where the College was managed to meet external funding requirements rather than to meet College needs. The ISR funding bids were a central and controversial issue in this. Software was another contentious issue. I was responsible for the use of the software that was proving inadequate and I had an income target to achieve from the funding bids that used the software. In other words, I had to manage conflicting demands for decision support information whilst working with software that was unable to provide information about past funding decisions, or provide access to detailed data, aggregation of the data and graphics, or provide projections for use in uncertain situations.

2.7.1 COLLEGE MANAGEMENT INFORMATION SYSTEMS

Prior to incorporation Birch, the Deputy Director of the Further Education Staff College (1988) stated that within five years colleges would have to have in place computer based systems that would enable them to satisfy the requirements of a 'Joint Efficiency Study, Managing Colleges Efficiently'. This was published by the Department for Education and Science (1987). He said the systems would need to be capable of producing a record of academic achievement and progression for each student; aggregations and analyses to produce indicators of effectiveness; a record of student taught hours and lecturer class contact hours; aggregations and analyses to produce Staff Student Ratios (SSR); and be capable of feeding into a costing facility and into space utilization records. He added that to implement all these facilities within five years was a significant challenge. He also stressed that priority must be given to implementing student records.

The Further Education Staff College (ibid) defined this in more detail when they said that all colleges should be operating comprehensive, integrated, computerized management information systems. They pointed out that the student record would be of concern to administrators responsible for admissions, fee collection and examination entries: to managers responsible for planning and controlling institutional performance and to teachers responsible for guiding the progress of individual students. They also indicated that there would be external interest. This would come from the Local Education Authority, the Education Department, and the numerous examining and validating bodies who required returns and analyses of enrolments, projected enrolments, completion rates, examination / assessment results, first destinations and so on. They mentioned that in addition to this, information from the system would be required by students, parents, sponsors and employers who required regular updates on individual progress.

They also said that college libraries, student unions, careers offices, student welfare, counselling and accommodation services would require information.

These statements from the Further Education Staff College are important in that they describe the many demands that are made of management information systems that are used in colleges. The expectations of the wide variety of stakeholders who want figures from the system can result in design and development complications. A system of this type serves many purposes and the system frequently needs to be integrated with other software. Examples of this are software from examining bodies and software from the FEFC. There may also be a need to interface different modules of the management information system. In addition to these issues colleges have to cope with data and data management problems like those that were identified in Section 2.2.

These deliberations help to provide an understanding of the complexity of the college environment and to identify some of the factors that have led to a strong need for informed decision making. Another very important factor that needs consideration is that the computerised management information system that has been defined here is a system that meets operational needs. The remit for this system did not include the ability to support informed decision making. KPMG Management Consulting (1993) started to identify this need for information to support decision making when they wrote about 'Measuring your College's Success'. They stated:

> 'Fast information is becoming more important as decisions often need to be taken quickly. If data has to be re-keyed into spreadsheets or new reports have to be written by computer programmers then the required information will often be too late to be useful'.

KPMG Management Consultants (ibid) also commented on challenges and change in the FE Sector. They said:

> 'The crystal ball is full of challenges and potential threats for us. Whilst the FE Sector is high on the agenda politically it will be vital for colleges to come up with the goods and flourish in a period over the next few years, when change will be the most radical we have ever known'.

It is statements such as these that determined the need for an intelligent advisor system to assist colleges in the decision making process. In view of the complexity of the environment, the technology, the systems, the data and the overlapping demands for information I decided the Intelligent Decision Support System would focus on helping colleges with their Individualised

Student Record (ISR) funding bids. I also realized that the system would be used to provide informed decision making for many of the other stakeholders that have been identified and to validate data to meet operational and strategic management needs, but these activities would be outside the scope of this research.

2.8 THE INDIVIDUALISED STUDENT RECORD (ISR)

A more detailed explanation of the background to the ISR, the way in which the funding methodology works, the importance of strategic planning returns, the range and complexity of the demands which colleges have to meet, the adequacy of the funding methodology, details of the schedule for the ISR Funding Return submissions and details of the associated software will be provided in this section.

Background

The FEFC (2001a) explained in their press release relating to student numbers that on 1 November 2000, the Further Education Sector comprised 405 Further Education and sixth form colleges. They also explained that 2.33 million students were enrolled on 1 November 2000 at colleges in England. 1.88 million of these students were enrolled on provision funded by the FEFC and 450,000 were enrolled on provision that was funded in other ways. In addition to this they provided figures that showed how the student numbers that they funded had grown by 9.8% since 1994. The Skills Task Force (1999) described how the FEFC also inspects colleges. It said that 70 full time and 600 part time inspectors were employed and explained that inspections take place every four years. The inspectors report on all aspects of a college's activity and give the college a grade. The Skills Task Force (ibid) say that a college's grade determines how many funding units the FEFC will agree to fund.

These statistics provide an indication of the volume of student records that colleges have to handle and show how this volume is growing. They also show the importance of the inspections that colleges have to undertake. These inspections result in many requests for information relating to student records. The quality of this information often is reflected in the grade that is awarded to the college by FEFC inspectors - hence the need for a tool that can assist in providing quality information. Such a tool could well contribute to the achievement of increased funding.

The Funding Methodology

The Skills Task Force describes how the FEFC funding methodology is based on funding units, known as tariff units, and that funding should follow a student's programme of study or support.

Colleges are awarded funding units for the entry element, the teaching and learning element and the completion or outcome element of a students learning programme. The FEFC's Tariff Advisory Committee (TAC) consult the sector each year and advice the FEFC on the value that will be assigned to the qualifications they fund. TAC uses the ISR to gain an overview of the courses and qualifications being followed. They also use the ISR to calculate the annual guided learning hours for each course. If a qualification is to be funded it must have a minimum threshold of 9 guided learning hours. Qualifications are then divided into 7 load bands according to how many guided learning hours they require. Each load band is allocated a number of Basic On-Programme Units. Basic On-Programme Units are tariff units. Qualifications in each load band are also assessed against five cost weighting factors (CWF) (A-E). Details are provided in Table 2.2.

Load Bands and Cost Weighting Factors							
Load Bands	Hours	Basic On-Programme Units	CWF A	CWF B	CWF C	CWF D	CWF E
0	9-20	2.0	2.0	2.4	3.0	4.0	4.4
1	21-59	3.8	3.8	4.6	5.7	7.6	8.4
2	60-119	10.0	10.0	12.0	15.0	20.0	22.0
3	120-209	18.4	18.4	22.1	27.6	36.8	40.5
4	210-329	30.2	30.2	36.2	45.3	60.4	66.4
5	330-449	43.6	43.6	52.3	65.4	87.2	95.9
6	450+	84.0	84.0	100.8	126.0	168.0	184.8
Source: FEFC (1999j), Circular 99/01, Annex A: 40 - 41 Guidance on the Tariff for 1999-2000							

Table 2.2
The FEFC Funding Methodology

An example ISR funding Return is provided in Appendix B.1.

Strategic Planning Returns

The Skills Task Force explain how the FEFC give colleges an annual funding allocation that is based on their strategic plans. Each college sets out a target number of funding units it will deliver and if the FEFC agrees to fund against the college plan, the college receives an agreed Average Level of Funding (ALF) per unit. An example which summarizes the information required in a strategic plan, and an example of the strategic planning cover sheet are provided in Appendices B.2 and B.3. Another example is given below which shows the calculation for a college's block grant. This calculation is based on figures in the college's strategic plan. Thus a college that has planned to achieve 600,000 units and was funded on the minimum ALF of £16.60 would receive a block grant for 1999-00 of £9,960,000.

FEFC inspectors and auditors request information from the MIS to validate the figures in the ISR Funding Returns, to correlate these returns with the strategic planning returns and to validate any differences between the two sets of figures. A system that can provide a data trail for the figures in past returns and could assist with projected figures for the strategic planning return would be invaluable to colleges.

The Range and Complexity of Demands

The Skills Task Force unveils how the funding methodology aims to get colleges to maximize student retention and achievement. They also disclose that it drives colleges to amass as many funding units as possible. In addition to these funding demands colleges need to manage a wide range of other demands. Many of these arise from the complex array of curricula provision that they cater for. The Skills Task Force explains how the demands reflect the requirements that colleges have responded to for many years. They then proceed to reveal how colleges respond to the shifting nature of their local labour markets; the needs of local, regional and sometimes national employers; the introduction of new qualifications; the demands of national initiatives such as the Youth Training Scheme and the Modern Apprenticeship; and the demands of the local population. These demands all add to the complexity of managing the funding and making informed decisions. Potential changes in demand can also lead to a need for projected figures if adequate funding is to be achieved. In addition to this, meeting these requirements can also lead to additional demands being made on the technology and staff.

The Adequacy of the Funding Methodology

The Skills Task Force state that if the nation requires the FE Sector to continue being the provider of a broad-based, responsive curriculum to everyone from 16 years old to senior citizens, then the funding system itself must be capable of helping colleges to meet the challenges which face them. Unfortunately, they also declare that it would appear that the funding system has not yet proved itself to be sufficient to ensure colleges can respond appropriately and with consistency to the needs of their diverse range of clients and their local labour markets, let alone to the national skills agenda.

The Skills Task Force divulge that there is a need for a single coherent funding strategy, that avoids duplication, provides clarity and builds a solid foundation on which to address skills needs. However, they draw attention to a key policy question that still remains unanswered. They ask how a funding system might enable and compel the suppliers of post-16 education and training provision to work together to address local, regional and national skills needs without encountering the problems which beset the current funding system. They state that this is a question which requires further thought if Government funded education and training is to be fit to meet the skills challenge which lies ahead.

This assessment of the adequacy of the funding methodology highlights the need for change. With these changes will come a need for technology change management and a change in the provision for intelligent informed decision making. The Expert Advisor System prototype in the case study used in this thesis will bring new learning and understanding to the area of Intelligent Decision Support Systems and contribute to development in this new and rapidly advancing area.

ISR Funding Returns

The Learning Skills Council (LSC) (2001b) describe the ISR as the auditable basis for calculating funding units. The LSC (1994 -1998) explain that colleges are required to submit three ISR Funding Returns each year. Detail of these returns is provided in Table 2.3. Auditable data trails that support the figures in these returns need to be available to FEFC inspectors and auditors during their visits to colleges.

The Schedule for the Submission of ISR Funding Returns		
Type of Return	Content of the Return	Submission Date
The Early Return	Student, qualification aim and Higher Education data sets.	1 November
The Full-Year Return	Student, qualification aim, Higher Education and qualification on entry data sets	31 July
The Full-Year-Plus Return	A copy of all the Full-Year return records plus student destinations, qualification outcomes and grades	31st December
Source: FEFC (2001b) Executive Summary to Circular 01/05, Individualized Student Record (ISR) 2001/02, 3.		

Table 2.3
The Schedule for the Submission of the ISR Funding Returns

Software

Section 2.7.1 of this thesis has already described college management information systems (MIS), but this section will consider MIS in more detail and explain their role in the ISR funding process. CIVICA (2002), a company belonging to the Sanderson Group, is one of the providers of MIS that have been designed specifically to meet the needs of the FE Sector and the FEFC funding methodology. CIVICA explain that their system provides modules for enrolment, attendance, student administration, examinations, personnel, finance, applications, enquiries, and management information.

Colleges vary in their MIS provision. A college may have an MIS such as the CIVICA one, a mixture of modules from more than one of the educational MIS that are available, or an MIS they have built in-house. Owing to internal and external demands for information colleges need to use data from one or many of the modules, or their equivalent, to meet their operational and strategic information requirements and to substantiate their funding bids. Complex SQL queries with many table joins often need to be used to extract the required information. If Synchrony (1997) confirm that this type of query, particularly when it provides aggregated figures, can seriously impair the performance of an MIS. The MIS that stored the data that was used for the case study in this thesis was a FECAS MIS. The FECAS MIS was produced by the Sanderson Group and preceded the CIVICA MIS.

The set of data that is collected to support the ISR Funding Return is stored in the college's MIS. In addition to using their MIS each college uses ISR software. This software validates the data set that supports the ISR Funding Return and determines the funding units that are generated from the data. The ISR software was originally issued by the FEFC and was known as the 'ISR Validation Software'. It is now issued by the Learning Skills Council (LSC) and is known as the 'Learner Information Suite' (LIS) software. Although it is ten years since incorporation colleges still frequently experience problems with the software.

The LSC (2002) Frequently Asked Questions (FAQ) web page relating to 2001/02 student data provides an indication of software inadequacies:

> 'a number of updates to 9.01 have been issued to cure issues with funding calculations, reconciliation, and issues with validation rule S30.'
>
> 'a patch that was issued for version 9.02 includes a correction to the funding calculation, an expanded institution list and enhanced error reporting capabilities.'

The LSC also provide answers to questions from colleges on their web page. Sixteen questions were posed by the colleges on the web page I viewed. Two example questions and answers from this page are provided below:

Q. When I validated my return using LIS version 9.01 with both patches, I received no errors. However, when I received my validation report from the LSC, I had quite a few Q01f errors. Why is this happening?

A. This issue has been resolved by the integrated Version 9.01 patch. Q01f errors arose from missing HE data sets. In version 9.01, the export diskette function is not working properly, and as a result diskette exports did not contain HE data sets.

Q. When installing LIS version 9.02, I get an error saying " Cannot find the source file d:\LIS V902\\@CalculateWrap.dll.

A. This is a known problem with the installation software which appears mainly to affect machines running Windows 98. A similar problem affected version 9.01 of LIS.

These questions and answers help to provide an understanding of the difficulties that colleges still have to deal with. The first question shows that colleges need to be able to look at past data that has been used to support ISR Funding Returns, to help them identify shortfalls in data relating to current funding bids. The second question shows that LSC software does not appear to work for all operating systems. This creates problems for the colleges. There are no common standards relating to the platforms, operating systems or MIS that FE colleges are allowed to use. Question two identifies a need for colleges to ensure that no anomalies relating to the data or calculation have occurred as a result of the platform that they are using.

These statements from the LSC (ibid) identify errors that have a significant impact on a college's ability to submit valid funding bids and obtain the right level of funding. An Intelligent Decision Support System that made provision for looking at past data trails and aggregated results could assist in the process of obtaining the right level of funding.

The discussions in this section provide an understanding of the number of colleges who submit ISR returns in order to claim their funding. The number of students, the number of inspectors, the difficult funding methodology, the range and complexity of the demands that are made, and the inadequacy of the funding methodology and software are considered. These all contribute to the difficulties that face colleges as they try to acquire the funding that enables them to survive. Although these factors make intelligent, informed decision making essential they also make the decision making process extremely difficult. An Intelligent Decision Support System to help colleges with their ISR Funding Returns is an important part of a college's survival strategy.

2.9 THE COLLEGES' EXPERIENCE OF THE ISR

The following section provides an overview of the ISR and its role since incorporation. The experiences and views of the colleges are documented.

2.9.1 THE METHODOLOGY, TECHNOLOGY, OPERATORS, RESULTS AND TARIFF UNITS THAT CANNOT BE COUNTED

Austin (1995), the Principal of Accrington and Rossendale College, whilst commenting on the ISR validation software and the underpinning MIS technology, describes how completing the 1994 - 95 ISR Funding Return and meeting its requirements has been a 'daily horror-story' in many colleges. He explains how difficulties occur because the funding methodology is 'awesomely complex'. Austin then points out that the ideal of good, reliable and useful management information has been overshadowed by the use of deficient technology. He says that this has led to 'demoralizing confusion'. He then adds that flaws in the software, together with 'staggeringly complex' demands for data capture, and the use of inexperienced operators to enter data have produced wildly fluctuating results. He states that although the technology is clearly not up to the job, colleges are required to use the ISR. He also alleges that colleges cannot count their tariff units with certainty. College income from the FEFC is calculated from the tariff units which colleges generate. The calculation is based on student enrolment, retention and achievement and the income from this usually represents around 70% of a college's total income. He then states that no ISR means no final audited accounts.

2.9.2 THE FLAWED SOFTWARE AND LATE OR UNUSABLE RETURNS

In January of the following year Ward (1996a) says that a third of colleges have been excluded from new calculations of student numbers because their figures are either late or unusable. She also comments that many principals complain that it is difficult to get the highly complex ISR funding mechanism running in a short time. In February she (1996b) talks about colleges having missed the deadline for submitting their funding claims for 1994 - 95 amid renewed concern that computerised student records are proving unworkable. In addition to this only 50 colleges have returned final ISR funding claims to the FEFC on time. She then adds that hundreds of other colleges are still grappling with flawed ISR computer software. She states that the FEFC is still trying to iron out problems which have left some colleges thousands of pounds adrift after calculating the amount of cash they can claim. She also says many managers and auditors are concerned about the continuing problems with the ISR and major audit firms, including KPMG and Coopers & Lybrand, are warning colleges that their ISRs do not stand scrutiny.

2.9.3 THE ISR PROCESS, POOR USE OF RESOURCES AND SOFTWARE THAT MISCALCULATES

Later in February, Ward (1996c) reporting on the annual FEFC conference states that Sir William Stubbs (the Chief Executive) and Sir Robert Gunn, (the Chairman) publicly acknowledged the suffering caused to colleges by the controversial new ISR system and accepted the process was time-consuming and expensive. College Principals who were still struggling to amass detailed data using flawed ISR software were delighted to hear this statement. Ward adds that Sir Robert Gunn confessed that introducing the ISR had been 'very taxing indeed for colleges'. He added ' It has consumed scarce resources at institutions and has required a considerable amount of management attention'. Ward reports that Gunn says the FEFC admits the ISR validation software it commissioned to allow colleges to process data miscalculates the total amount of cash they can claim. She says that one college chief executive said:

> 'The energy, enthusiasm and drive which permeated FE just after incorporation has gone now and the hatches are battened down. We are older, wiser and sadder.'

2.9.4 A REQUEST FOR ADDITIONAL INFORMATION, STAFF STRESS AND THE USE OF MANAGEMENT TIME

Later the same year, Merrick (1996), reports on a new requirement for student destination information. He says there are already problems with the ISR and explains that it requires colleges to record 60 different facts for each student in their systems. Merrick (ibid) states that Mr. Ricketts, Management Information Systems Director at City College, Manchester, said this demand had caused staff great stress. Merrick also reports that Sue Ransom, President of the Association for College Managers, said it was understood that colleges must have good systems in place to track a student's pathway through college, but it should not become so onerous that middle managers spend all their time satisfying demands for information.

2.9.5 PERFORMANCE INDICATORS AND INACCURATE FIGURES

Four months later, Ward (1996d) discusses the preparation of performance indicators. These were based on the 1994 - 95 ISR figures. She says some colleges recalculated their figures and resubmitted their raw data after discovering their showing was worse than expected. She adds that around 20 colleges found they had inaccurately recorded the number of students achieving qualifications and so appeared to be less successful than they really were. She explains how the indicators reveal each college's record on achieving its funding target, student numbers, retention rates, qualifications achieved, contribution to National Education and Training Targets (NTETs), and on value for money. In addition to this she states that the FEFC were playing down the changes and attributing errors to historical weaknesses in college enrolment systems which had not been ironed out to meet post-incorporation demand.

2.9.6 A REMIT TO REDEVELOP SLOW, UNSTABLE SOFTWARE

The following year Russell (1997) reports that the architects of the troubled high-tech ISR system had been told to go "back to the drawing board". He says that experts called in to investigate the problems with computers recording student returns from colleges said the ISR validation software should be redeveloped. The software sometimes was unbelievably slow and different systems gave different results, causing great difficulties for staff. The experts said that although the software had improved considerably, they believed that the council should redesign and implement new improved systems using recognized good practice in the software industry. Russell also reported that John Rockett, the Principal of Rotherham College of Arts and Technology, and a member of the FEFC Statistics Steering Group, said the basic information system worked without major problem, but few colleges had fully exploited the opportunities it presented. Rockett said there was 'tons' (sic) of marketing information, cost benefit information and value-added information but there was no integrated software which allowed colleges to get at it in detail.

2.9.7 A FUNDING BID THAT COULD NOT BE MET

A month later, the Principal of North Lincolnshire College, Allan Crease (1997) announced that the FEFC had failed the sector. He said the recent fiasco of the Demand Led Element (DLE) funding bids, (the provision of cash for growth in student numbers), highlighted how far out of touch the FEFC were. Half way through the academic year the FEFC found that it had no commitment from the Department for Education and Employment (DFEE) to pay monies owed to colleges. Crease questioned why the DFEE was unaware of the impending demand-led element claim. He also questioned why it had taken so long to make a claim. He continued by asking if it was because the individual student record funding system was so complex that the Council had no confidence in its own ability to present a properly audited claim.

2.9.8 COLLEGES MUST IMPROVE OR GO

Two years later Nash and McGavin (1999) reported on the FEFC annual conference. They revealed that ministers and funding chiefs had warned that failing colleges would be given a year to turn themselves round or face closure. They said that Mudie, the Lifelong Learning Minister, instigated a new red card system of final warnings and sendings off to under-achieving colleges and told Principals and Governors that he and the FEFC would be uncompromising in their efforts to raise college standards. He declared that colleges who were the worst offenders were guilty of gross negligence with public money. While refusing to name names, he said 30 colleges had exam success rates below 50% and he cited unacceptable retention rates and poor standards of governance and management. He announced that options other than closure for failing colleges would include the sacking of governors and the intervention by neighbouring colleges with proven records of excellence. Nash and McGavin reported that Melville, the Chief Executive of the FEFC, said colleges would be given a year after the issue of a yellow card to improve. If after that period of time they had not improved the college could be closed. He stated that the FEFC were going to be quite ruthless.

2.9.9 THE LEARNING SKILLS COUNCIL (LSC)

Shortly after this other governmental changes to the Further Education Sector were publicized. Education Secretary, Blunkett (1999), announced plans to set up a national Learning Skills Council (LSC) to take responsibility for the funding of Further Education and training. The LSC (2001a) confirmed that they replaced the FEFC on 2nd April 2001.

2.9.10 TIME CONSUMING INSPECTIONS MAKING HEAVY DEMANDS

Whilst operating under LSC control, Jones (2001), the Principal of Sutton Coldfield College, wrote about the inspection process. He commented that almost all inspectors were professional, courteous and helpful but the process of inspection was exhausting, distracting, damaging and counter-productive. He added that the data validation team wanted documentary evidence of 2,500 enrolments, two years worth of registers, enrolment forms, learning agreements and proof of success from examination bodies when they visited his college. The team was submerged in the colleges ISR for a whole week before they finally surfaced to pronounce the data clean.

2.9.11 STAFF TIME AND AUDITS

A month later Nash (2001) reported that Brian Styles, the Principal of the City of Bristol College had stated that the college had to set aside at least 480 senior staff days a year to help external auditors scrutinize student recruitment figures. The principal then said that external auditors took the equivalent of 80 days trawling through paperwork checking for accuracy. He added that it took at least five times that number of days in his manager's time to service their needs. He had already recruited two extra full-time staff to spread the load. He then announced that the major burden falls on staff whose time would be better spent supporting students. He commented that they were 'losing all sense of proportion and had reached a state of utter silliness' (sic) and that the ISR demands summed it up. He explained that 35,000 full time and part time students at his college had ISRs, each with at least 90 fields of information. They also had learning agreements, enrolment forms and complex attendance registers. He said that instead of demanding quality of learning, he found himself 'harping on' (sic) about quality of data. He says he realizes that there must be checks and controls but his college was spending more and more time 'chasing their tails' (sic) rather than doing what they ought to be doing. He adds that in the mid 1990s, the audit was a low key affair, involving only the finance staff, but all colleagues now were saying it had grown inexorably, with a huge leap in time and costs this year since the Learning and Skills Council had taken control.

2.9.12 A LACK OF CONFIDENCE IN DATA AND SYSTEM OUTPUTS

The current situation in the F.E. Sector is still problematic. Hook (2003) states that confusion over the Further Education funding methodology has been made worse by the computer technology used to process college funding claims. He says that the tide of queries from baffled financial directors has been met with bewilderment by local Learning and Skills Councils. In addition to this, Hook reports that Gravatt, the Finance Director of the City Lit, London says neither the LSC nor colleges can be confident in the data or with what the systems are telling them. Gravatt adds that this generates a fog around whether targets are being met and creates either panic or anger. Hook proceeds by reporting that an LSC spokeswoman says the implementation of changes in the funding formula has proved too much for the software to cope with. Hook then adds that individual learner records were found to be amongst college principals' biggest pet-hates. 76% said ISRs were a top priority in terms of reducing bureaucracy. According to one Principal, management time was increasingly being taken up by the 'infernal triangle' (sic) caused by the funding methodology, individual learner records and the Individualised Student Record (ILR) audit.

2.9.13 THE COLLEGES' VIEWS AND DECISION SUPPORT NEEDS

This collection of evidence confirms that although ten years have past since colleges became incorporated the FE environment is still turbulent and experiencing problems with software and a complex and confusing funding methodology. Despite the funding body having changed from the FEFC to the LSC as a result of new legislation, Hook (ibid) reported that Gravatt, the

Finance Director of City Lit stated this year that colleges still do not have confidence in their data. In addition to this the reports that have been discussed also provide evidence of growth in data collection. Merrick (ibid) found that 60 different facts were being collected for each student in 1996. Five years later Nash (ibid) reported that the Principal of the City of Bristol College found that his college was collecting data for 90 fields in each student record. Although more data is being collected Russell (ibid) reported that Rockett, the Principal of Rotherham College of Arts and Technology, and a member of the FEFC Statistics Steering Group said there was no integrated software that allowed colleges to get at detailed data.

The need for an Intelligent Decision Support System becomes apparent through these reports. Such a system could enable an audit trail to be provided to support the decision making relating to the timely completion of ISR Funding Returns and could enable colleges to access detailed data. It could reduce the staff and management time spent resolving problems relating to the unreliable, expensive ISR process. It could count tariff units, and assist in the production of accurate, consistent results. This could help to reduce auditor and inspector demands and could result in less documentation being required to support funding claims. In addition to this it could also reduce the pressure on staff, the amount of time that has to be dedicated to meet audit and inspection needs and help to avoid the situation where red cards are issued and college survival is put at risk.

2.10 CONCLUSION

This chapter identifies the need for smart organisations. It establishes that organisations not only need to look for competitive advantage but also need to be learning organisations that learn from their past experiences. It also shows that these organisations are working with large volumes of complex data and are operating in turbulent, difficult, rapidly changing environments where many stakeholders make different demands. These demands result in a need for informed decision making.

It also describes system failures that have occurred and highlights issues arising from new legislation, a new funding methodology and new software that have led to customer dissatisfaction. It establishes that today's organisations need to manage technological change, address data management issues and need to achieve customer satisfaction whilst operating within the context of organisational change.

The factors of organisational change that are identified are the need to respond to local needs and circumstances; to improve the efficiency, transparency, and accountability of local leadership and decision making; to work to clearly defined priorities and exacting performance standards; to undertake comprehensive performance assessments; to undertake inspections; to exploit the potential that new technologies offer to restructure services and speed up transactions, and to provide performance indicators. In addition to this these organisations have to meet customer, business and government expectations. These factors are common to many organisations.

This chapter shows how new decision support needs are emerging and how the provision of an intelligent decision support system to assist decision makers has to embrace these needs and be capable of operation in a complex, demanding, rapidly changing environment. The Intelligent Decision Support System will be a tool for the smart, learning organisation endeavoring to attain competitive advantage. The experimental prototype that will be developed in the case study in this thesis will add to the learning in the area of Intelligent Decision Support Systems. It will enable organisations to learn from past experience and will assist them in making projections about the future. It will provide access to data in such a way that the data will be available to substantiate decisions.

The Intelligent Decision Support System experimental prototype, known as the Expert Advisor System will be developed to assist in the decision making process associated with the completion of ISR funding bids in a college of Further Education.

CHAPTER 3 - THE PROBLEM DOMAIN

Chapter 2 discussed the changes that are taking place in the Public Sector and the Further Education Sector and identified some of the problems that can arise. This chapter builds on the understanding gained from the work in Chapter 2 and focuses on one Further Education college. It explores the importance of knowledge in the decision making process and identifies the need for an Intelligent Decision Support System to assist in the knowledge acquisition process, to support informed decision making and to provide an understanding of how past decisions have been made. The roles of different people whose work relates to college funding bids and who would benefit from the provision of an Intelligent Decision Support System are discussed, and typical requests for management information are identified. The chapter concludes by identifying Critical Success Factors for an Intelligent Decision Support System experimental prototype

3.1 KNOWLEDGE BASED DECISION MAKING

The research undertaken by Bhatt and Zaveri (2002) into the enabling role of decision support systems in organisational learning identifies the problem facing many organisations today. They explain how although organisations have been considered to have a predefined and static set of goals in the past, this is no longer the case. They now must be able to respond quickly and able to adapt to changes in their business settings if they are to stay competitive and survive in today's dynamic environment. They add that organisations whose structures, processes, and technologies are not well suited to deal with the increasing environmental complexity and knowledge are unlikely to survive. In addition to this Carlson and Turban (2002), whose research explored the directions decision support systems will take in the next decade say that the data, information and knowledge that should be mastered by the senior people, who staff the responsible positions in leaner organisations, will continue to grow and become more complex.

Morgan (1991) describes the transformation that is happening in organisations when he says we live in times of change. He reveals that the complexity of the change is as likely to increase as to decrease in the years ahead. He explains how numerous technological, social, and information revolutions are combining to create a degree of flux that often challenges the fundamental assumptions on which organisations and their managers learn to operate. He tells how traditional competencies or market niches can be challenged by new technologies, generating new skills and new products. He explains how slumbering giants can be shaken to life and left staring at new competitors, who have new ideas and new approaches and will carry developments into new realms. He says that few, if any, organisations can be sure of a secure future, as scientific and technological developments can transform the very ground on which they have learned to function. Morgan (ibid) also comments on complexity. He says that many managers may want simplicity, but the reality is that they have to deal with complexity. The complexity of organisational life is increasing rather than decreasing. This is manifested in the conflicting demands posed by multiple stakeholders, the need for managers to deal with many things at once, and the almost continuous state of transition in which their organisations exist.

An additional problem that managers face is highlighted by Price (1989) when he explains the need for knowledge to inform the decision making process. He describes how a production manager achieves a 40 per cent increase in productivity. His decision to do so is right in the narrow context of his knowledge and his managerial objectives. However, the decision is proved to be wrong because it is founded on inadequate knowledge. Holsapple and Whinston (1996) explain the need for knowledge still further. They talk about a knowledge-rich world in which managers make a multitude of decisions everyday and explain how these decisions range from being simple to being extremely complex. They say that every one of the decisions involves the use of knowledge of varying kinds and amounts and many of the decisions can benefit from, or even require the use of, technology in the form of decision support systems. Rainsinghani and Schkade (1999) add to this. They say that we don't know how to measure knowledge or display it on the balance sheet but we are beginning to realize that its application is a distinguishing factor amongst companies. They state that knowledge is what core competency and competition is all about and that business is based upon it. They continue to put this demand for knowledge into context when they say that companies seeking knowledge management solutions are usually driven by the need for innovation. Continuous learning becomes an absolute necessity and up-to-date knowledge becomes essential. They explain how firms need to exploit their knowledge if they wish to transform their intellectual assets into business value.

Princeton (2001) considers decision making and knowledge from another perspective. He states that as a result of increased time pressure many organisations find themselves in 'decision overdrive' - going too fast to be effective and losing focus and precision in the process. He continues by drawing attention to comments by Peter Tobia, the Director of Kepner-Tregoe Management Consultants' Business Issues Research Group. Tobia whose organisation undertook a survey involving 339 hourly paid workers and 479 supervisors, asks how well do today's business organisations preserve their decision making experiences? He adds that over 90 per cent of respondents to the survey told us their organisation does not keep and share information on how past decisions, good or bad, were made.

As we have seen, FE colleges are experiencing change and handling many complex situations that require informed decisions, need up-to-date knowledge and are operating within tight time constraints. Colleges also need an understanding of past decisions. In addition to this college decision makers frequently work with inadequate knowledge. This occurs through people leaving or moving into new jobs within the college and taking their knowledge with them, people being reluctant to share knowledge or the data that could support decisions simply not being available or accessible. As Price (ibid) explained decisions taken in this context may not be correct.

The case study used in this thesis will focus on an Intelligent Decision Support System experimental prototype known as the Expert Advisor System. Its role will be to assist in informed decision making relating to the ISR Funding Return. The need for adequate knowledge, informed decision making and an understanding of past decisions are all factors that will be considered in this case study. The Expert Advisor System experimental prototype will assist the college used in the case study in transforming their intellectual assets into business value.

3.2 THE ORGANISATIONAL SITUATION

Coopers and Lybrand Deloitte (1992) identified how the workings of the Further and Higher Education Act of Incorporation which Parliament (1992) passed, would lead to fundamental changes for the colleges of Further Education when it became operational on 1 April 1993. One of the most significant changes as a result of the Act was the requirement for colleges to submit the ISR Funding Return and supporting data to the Further Education Funding Council (FEFC). A sample of the ISR Funding Return is provided in Appendix B.1.The FEFC (1993a, 1993b, 1993c, 1993d, 1993e, 1993f, 1994a, 1994b, 1994c, 1994d) issued many circulars giving details of the complex and rapidly changing funding methodology that colleges had to use for completion of their funding returns. Basic details of this funding methodology were discussed in Section 2.8. The changes which this methodology invoked gave rise to the need for the Expert Advisor System to assist in the decision making and knowledge acquisition process that was necessary to complete ISR Funding Returns in an effective way, and to provide access to the auditable data trails that were required. The Expert Advisor System also needed to allow managers to predict student numbers for the strategic plans that the FEFC correlated with the ISR Funding Returns, as described in Section 2.8.

3.3 STAKEHOLDERS IN THE PROBLEM DOMAIN

The main stakeholders who worked with the ISR Funding Returns in colleges were the FEFC, the College Senior Management Team, the college Database Administrator (DBA) and her team, the FEFC auditors and the FEFC inspectors. The problem environment of Further Education is now described from the differing perspectives of each of these stakeholders.

3.3.1 THE FURTHER EDUCATION FUNDING COUNCIL

As a result of the Further and Higher Education Act, the FEFC was established in the UK in 1992. It had responsibility for allocating Government funding to colleges in the Further Education (FE) Sector. The FEFC introduced the ISR Funding Return as a mechanism that enabled colleges to bid for funding allocations appropriate to their performance. They also specified the format for the supporting data sets that form the audit trail for the ISR Funding Return bids. The FEFC (1994b) state that the supporting data are needed to enable them to formulate policy, publish information about the sector, calculate performance indicators, analyze trends, account for the distribution of funds, inform responsible Government ministers about the sector and monitor the performance of colleges against their strategic plans.

Colleges complete the ISR Funding Return for all students who are enrolled with them and submit the return and supporting data to the FEFC. The Higher Education Funding Council for England (HEFCE) (1999) fund the FE students who are included in the ISR Funding Return but are enrolled on Higher Education (HE) programmes. They also fund HE students enrolled at the universities. Although the HEFCE system is analogous to the FEFC system university student funding bids will be outside the scope of this work. The focus here will be on the FEFC ISR Funding Returns made by one particular FE College. This is the College were I worked as Head of School.

The ISR Funding Returns that will be considered are for student enrolment, retention and achievement. The FEFC (1998c) confirm the dates for submitting these funding returns are November and July for student enrolment and retention and December for student achievement.

3.3.2 COLLEGE MANAGEMENT

During discussions with college Principals and senior managers from many FE colleges, confirmation was given that information from college operational MIS databases was needed to monitor and evaluate short and long term planning, to analyse patterns of student demand, to predict income and to gain information and knowledge to support decision making. They verified that they also needed to use the data stored in their college MIS database to substantiate the ISR Funding Returns. The FEFC (1999f), (1999g) state that colleges are responsible for ensuring the database used for the ISR Funding Return provides a complete and accurate record of student enrolments, retention and achievement and has full data audit trails.

3.3.3 DATABASE ADMINISTRATOR

The Database Administrator (DBA), at the college where I worked, agreed that the DBA's role is to develop and maintain the MIS where the ISR data are stored, to take responsibility for the accuracy of the data and to ensure the data set complies with FEFC funding rules. The data are used to prepare the ISR Funding Return and substantiate funding bids. The DBA develops database SQL queries to provide information for auditors and inspectors, and to respond to demands for information from college managers.

During interviews, other senior college managers and the DBA stressed that the MIS and the Database Administration team have an extremely important role to play if the college is to meet FEFC requirements. Tasks are becoming harder to accomplish through lack of time or lack of knowledge. Finding ways to prevent duplication of effort or to use technology to capture knowledge are important if colleges are to provide meaningful ISR Funding Returns for the FEFC. Knowledge and information must be captured by the Database Administration Team to reduce costs, free management time and encourage informed decision making.

3.3.4 FEFC AUDITORS

During the time I worked at the College, auditors undertook thorough inspections of the MIS database and the supporting documents for the ISR Funding Returns and requested bespoke reports from the MIS. Their work often established the validity of data trails. The FEFC (1998c) require colleges to supply these data trails to substantiate the figures the colleges submit in their ISR Funding Returns. In addition to this the auditors frequently requested walkthroughs to substantiate how student data had been captured for student guidance and counselling, for student retention during the learning programme and for student achievement. They required any additional support needs to be authenticated, MIS reports to be date stamped, and queries to be developed by the DBA to cross check any information supplied during the course of their audit.

The National Information and Learning Technologies Association (NILTA) (2001a) have produced a report looking at the optimization of funding which gives advice to colleges about coping with FEFC auditors. It makes the following nine recommendations:

- read the funding methodology in detail, in advance of audit
- 'tick off' current paperwork against the requirements
- ensure staff are aware of the importance of
    - learning agreements
    - registers or equivalent
    - timely recording of withdrawals
- involve auditors early, there is no such thing as too early
- perform internal audits (make systems matter, so everyone becomes an auditor)
- read FEFC Audit guidelines with care both on and between the lines
- file evidence carefully, an extra hour spent can save ten searching for misplaced records
- ask auditors to set out exactly what they want to see and have it ready
- engage auditors as allies, they see other colleges, other cockups (sic) and other ideas.

These guidelines help to illustrate the intricacy of the funding methodology, the importance of the audit guidelines and the power of the auditors. In addition to this NILTA (ibid) talk about the need to maximize funding with integrity, within the rules and without distorting the curriculum. These are considerations that affect all colleges and need to be contemplated when the Expert Advisor System experimental prototype is produced.

In addition to this, NILTA, whilst talking about the soundness of data, state that the FEFC is very keen to see auditable college data. They add that colleges must strive for 100% supporting evidence, or risk a 'qualified' audit report and loss of funding. They mention that particular attention must be paid to the course file and how the guided learning hours (GLH) for each course is justified, and must retain evidence to support claims based on the GLHs. Statements such as these show how much emphasis the auditors put on the data and show the need for accurate, correctly coded data. This highlights the need for effective data management to be considered when the Expert Advisor System is developed if assistance is to be provided for informed decision making that can be substantiated by an accurate data trail.

3.3.5 FEFC INSPECTORS

During visits to the College where I worked the FEFC Inspectors looked at student records and requested bespoke reports. This was often to evaluate the quality of governance and management prior to allocating a grade to the College and producing their inspection report. NILTA (2001b) have produced a summary of the FEFC Inspectors' reports received up to 16th June 1995. This provides an indication of the role of inspectors. One of their statements about a college that received a bad grade was:

> 'The college does not effectively manage the collection or use of information... No steps have been taken to analyse the information needs of the college or to develop a prioritized information and data management strategy. The college does not have an agreed plan to improve management information... The central function, serving both the college management and external reporting requirements, is wholly ineffective ... it is unable to produce consistent and reliable information ... there is little confidence in its ability to be able to produce meaningful information on the past or present'

Key points that inspectors are aware of in this statement, and that colleges need to address, are the need for 'data management' and the need 'to be able to produce meaningful information on the past or present'. Both these issues are important and need consideration when the Expert Advisor System experimental prototype is developed to assist in decision making. In addition to this NILTA (ibid) provide another example relating to College Management Information Systems (CMIS) that gives cause for concern. They say:

> 'While the CMIS produces a variety of statistical information, it is seen to be inflexible and unreliable... There is little confidence in its accuracy... the majority of staff rely on manual records.. Particular concerns include the lack of accurate registers and uncertainties in the recording of accurate information about students'

This draws attention to other key issues that inspectors think about. It highlights the need for accuracy and flexibility and illustrates the uncertainties about the student information. All these points reinforce the need for data management to be considered when the Expert Advisor System experimental prototype is produced.

NILTA also state that CMIS figure significantly in inspection reports. They are usually mentioned under Governance and Management, with a comment in the Conclusion and Issues Section of the inspection report if significant strengths and weaknesses have been identified. CMIS is not graded as such but affects the grade that is given to the college for governance and management. They add that they repeatedly imply, and occasionally spell out, how colleges lack a management culture that exercises judgment informed by facts. They also say the FEFC Inspectorate clearly intend and require this to change.

My experience of working with inspectors was that the substantiation of figures produced for the ISR Funding Return, projections of figures made for the strategic planning returns, and bespoke reports produced at their request, had a significant impact on the inspectors judgment and the grade they awarded to the college. It is apparent that the Expert Advisor System needs to allow data to be accessed and projections to be made, to assist not only college managers but FEFC auditors and inspectors.

3.4 THE FEFC DATABASE STRUCTURE

The FEFC (1993c, 1993f) explain how the ISR specification comprises four interrelated data sets, a student data set, a qualification aim data set, a module delivery data set, and a qualification on entry data set. All attributes for these data sets are well defined in terms of their descriptive names, type, format, validation rules and position within the relevant data set, although, clearly, the actual database names differ according to the college MIS implementation.

The standard structures and format that are used mean that data can be transferred between a college and the FEFC. Although this structure is used in the production of the ISR Funding Return many colleges use large, complex, integrated management information systems developed in accordance with other specifications or in accordance with advice provided by Touche Ross Management Consultants (1992) prior to incorporation. College student records are frequently only a subset of a complete MIS covering finance, staff contracts, timetabling, examinations and other functions.

Details of the Individualised Student Record Structure are provided in Figure 3.1.

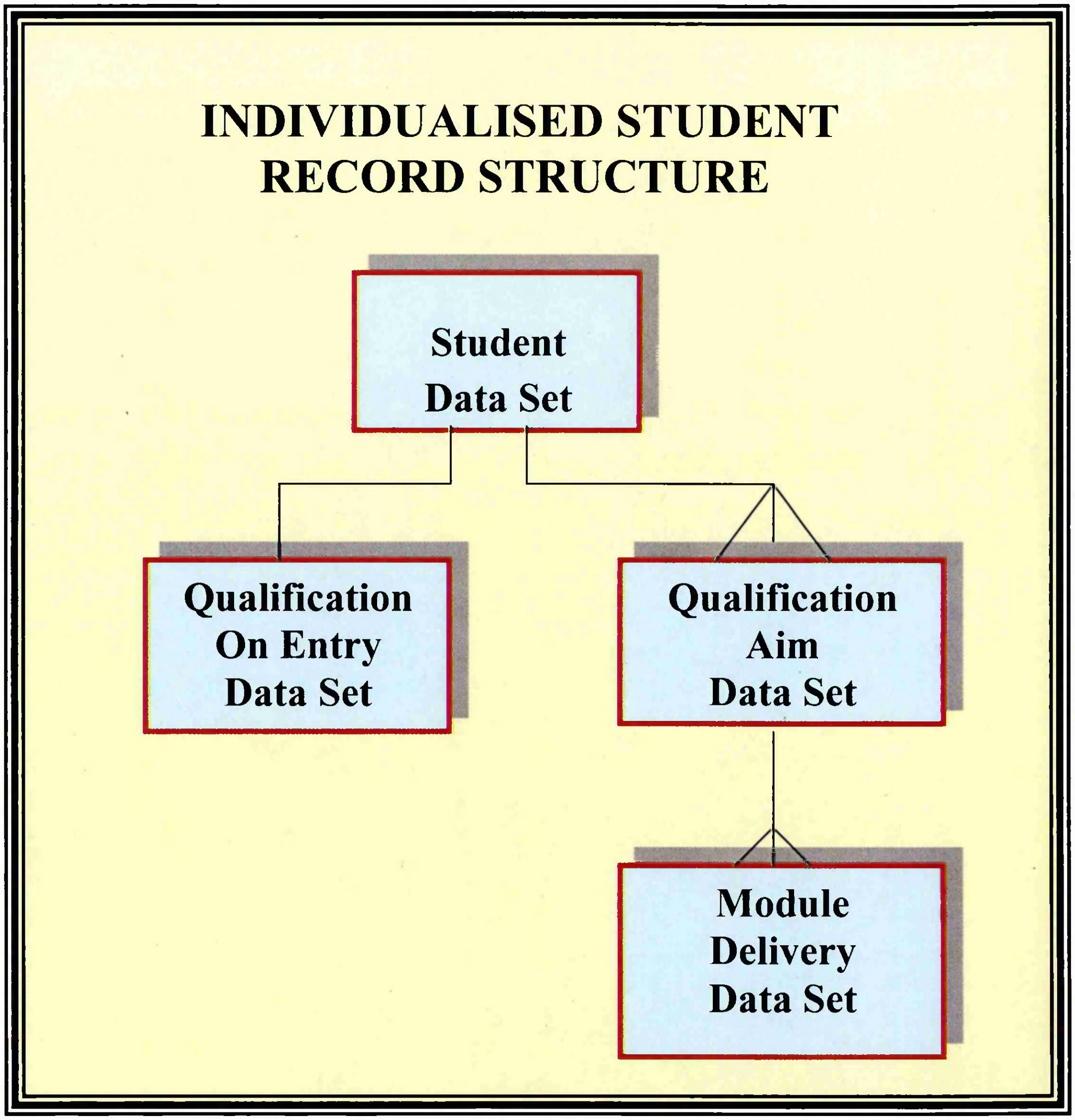


Figure 3.1
Individualised Student Record Structure

3.5 DECISION SUPPORT REQUIREMENTS

Interviews with senior college managers from many different colleges confirmed that educational institutions are operating in a competitive, continuously changing and complex environment. There are tight time constraints, growing levels of accountability and many problematic human and physical resourcing issues. Colleges are aiming to provide a quality education for students, to achieve growth and expansion and to manage finance successfully to meet their operational and strategic targets. They are trying to survive in an environment governed by cash flow and investment. Managers stated that the introduction of the ISR Funding Return is adding to the complexity of the environment and is highlighting the need for knowledge, information and new skills. They need to be able to make informed decisions. The Senior College Managers added that they are coping with many tasks, strict financial constraints, changing staffing provisions and heavy workloads. They stated that they need to use technology to assist in informed decision making if additional tasks like completing ISR Funding Returns and providing the supporting data are to be carried out and if change is to be managed effectively and efficiently. Price Waterhouse (1994) drew attention to the expectation of having to manage these changing needs in an information technology review undertaken to inform colleges of the expected consequences of incorporation.

3.6 CHANGING TECHNOLOGIES AND CHANGING DEMANDS

In addition to the many discussions that took place within my college many other discussions took place with external people and organisations. As a result of these discussions additional knowledge and understanding was acquired, new ideas were stimulated and facts were verified. These meetings had a significant impact on the task of developing an Intelligent Decision Support System.

Numerous discussions with FE managers, commercial managers, developers and researchers took place when I attended meetings, seminars and courses that were essential to the progression of my work at the college. Some of these events were hosted by the Further Education Funding Council in 1994 and 1995; the Department for Education and Science in 1993; the Colleges Management Information Systems group (CMIS) in 1993 and 1994, the National Association for Information Technology in Further Education (NAITFE) in 1992 and 1995 and the Association of College Registrars and Administrators (ACRA) in 1994. Other investigative work was with vendors and developers of college software. Some of these were with Nord Ltd. in 1992, 1993 and 1994, Sanderson PSS Ltd. in 1994 and 1995 and Ingres in 1993. This work provided a detailed understanding of the FEFC, its method of operation and its intricate ISR funding methodology. It also enabled me to gain an understanding of the changes that were occurring across the Further Education Sector and the software that was being developed specifically for the sector. Managers from other colleges also spoke about their needs for quality data, knowledge and informed decision making.

My investigation into technologies that could capture past situations was enhanced further by meetings with vendors, developers and researchers using Case-Based Reasoning (CBR) software. Meetings with Inference Ltd. in 1995 enabled me to investigate and evaluate their CBR Express software. Other CBR software was investigated at Salford University Conferences in 1994 and 1995 and at British Computer Society Conferences (BCS) in 1994 and 1995. The software was 'REMIND' software by Intelligent Applications Centre Ltd. and 'Caspian' software by the Centre for Intelligent Systems, the University of Wales.

Vendors of Data Warehousing and Data Mining software hosted other events that I attended and that proved valuable to my work. The vendors were SAS and Cognos. Further discussions with vendors, users and Data Mining and Data Warehousing researchers took place at the Business Intelligence Conference in 1997, 1998 and 1999, the Institute of Electrical Engineers Knowledge Discovery and Data Mining Colloquium in 1998, the Joint Pacific Asian Conference on Expert Systems / Singapore International Conference on Intelligent Systems in 1997 and the SDGUG '99 II European User Conference, Italy in 1999. Through these discussions I became familiar with the data management aspects of Data Warehousing and the analytical and forecasting techniques offered by Data Mining.

These discussions further confirmed that organisational change was taking place in the FE Sector and bringing with it a need for informed decision making and a need for knowledge. They also provided a significant understanding of the role of Case-Based Reasoning, Data Warehousing and Data Mining. The meetings provided a forum for a worldwide exchange of knowledge, experience and views with other researchers and confirmed a growth in interest in Intelligent Decision Support Systems from people operating in many different roles in different organisations. They also established the need for in depth research in the rapidly advancing area of Intelligent Decision Support Systems.

Details of the meetings, seminars, courses, conferences and workshops where the discussions with FE managers, commercial managers, developers and researchers took place and where I evaluated CBR software are provided in Appendix H.

3.7 COLLEGE DIFFICULTIES AND NEEDS

Colleges Managers spoken to at the meetings claimed that they were aware that they needed to access historical data to compare changing patterns and trends over time but this was frequently not possible when the college MIS was used for decision support information. Student data sets relating to funding were often overwritten and could not be extracted at different points in time. If Synchrony (1997) stated that this situation where data are overwritten often occurs. The Managers described how they understood that Data Warehousing and Data Mining could assist in storing historical data sets and acquiring knowledge from them. This understanding was confirmed by Kuijlen et al (1996); SAS (1996a, 1996b, 1997); and If Synchrony (ibid). The managers' concern was that most colleges could not purchase the sophisticated tools and training that would enable them to utilize Data Warehousing and Data Mining techniques due to financial problems. The FEFC (1999d) identified 50% of colleges as falling into financial health group C which they defined as:

> 'Colleges that are financially weak and which are, or may become, dependent on the goodwill of others. This might involve, for example, a loan from their bank for revenue purposes. Colleges in this position are likely to have an accumulated deficit on their general reserve account and / or negative net working capital.'

These colleges would find it difficult to purchase new technologies and acquire the necessary training due to the financial overhead that would be involved.

During discussions College managers identified a need for integrating 'off the shelf' commercial packages to provide a cost effective way of acquiring intelligent decision support information based on historical data. They also indicated that graphical output would enable them to gain knowledge about past ISR Funding Returns quickly and easily. I recognized this as an opportunity to hypothesize and explore a new genre of business tool, an 'Intelligent Decision Support Tool' that used past knowledge and expertise to respond to user enquiries and inform decision making in a rapidly changing environment. Research undertaken by Poole and Axelby (1997) and Axelby and Poole (1998) reinforces the need for a tool of this type in the FE Sector.

Senior college managers and the DBA declared that inadequacies in the source data from the MIS had been revealed during FEFC inspections and that the ISR Funding Returns were inaccurate and could result in under achievement of funding. The managers drew attention to a crucial need for quality MIS data. They also stated that it was often difficult to achieve due to the MIS containing incomplete or ambiguous data, wrongly coded data due to changing rules, lack of common standards, inadequate training or shortage of time, multiple formats for the same data, and keying in errors. The DBA stated that in practice, inconsistent and inaccurate data frequently occurs in college MIS and matching and consolidation is extremely complicated whilst coping with the anomalies arising from this type of data. Vality Technology Inc (1996) confirmed this to be a situation that was true in many MIS.

3.8 TYPICAL MANAGEMENT INFORMATION REQUESTS

The nature of the information required for decision making relating to the ISR Funding Return can be illustrated by considering three typical cases.

(1) Firstly, consider a new source of funding that is offered by an organisation other than the FEFC for certain categories of student. In this case we ought to be able to use the Expert

Advisor System to identify the students who would be eligible for this funding and assess the how much extra income could be accrued. If it is worthwhile changing the students to the new funding source then the 'qualification aim' must be removed from each of the students records so the student is not shown as being enrolled on an FEFC funded course and the 'course type' must be altered from the FEFC code of '99' to the code that is appropriate to the new funding source. The students will then meet the criteria for eligibility for the new source of funding and the new course can be offered. College managers and the DBA would require past auditable information to identify where the students had moved to. These students may have already been included in an ISR Funding Return and in the projected figures for the strategic planning return and would cause the FEFC income to be reduced and additional income to be accrued from the new source.

(2) Consider the problem of student recruitment. If we run the Expert Advisor System to monitor student enrolment, say once a month, then it may be that a lower level of recruitment than expected is indicated in a certain area at a certain time. A marketing campaign might be mounted as a consequence of this information. If this is successful then the Expert Advisor System will reflect the eligibility for additional income when the operational database is updated by the extra student recruitment.

(3) Suppose that a monthly monitoring run of the Expert Advisor System shows disappointing funding predictions in a certain area. This might lead to a reassessment of courses and their qualification aims in that area along with the realization that other relevant qualification aims with higher cost weighting factors could be legally applied to a number of courses. The resulting decision would be to update the qualification aims, rerun the Expert Advisor System and ascertain the extent of the increase in funding.

Other options where the Expert Advisor System could be used to assist in the optimization of funding are suggested by NILTA (2001a). A few of these are:

- making use of listed rather than banded qualifications
- starting programmes just before rather than just after the FEFC census dates
- finding equivalent qualifications at higher Cost Weighting Factors (CWFs)
- exploring whether any students recorded as withdrawn are in fact completers

In addition to these activities that could help to optimize FEFC funding NILTA (ibid) suggest another ninety things for colleges to do that would also help. The Expert Advisor System would provide useful assistance with many of these. Thus, the Expert Advisor System could have a potentially valuable role to play in producing intelligent decision support information for college management.

3.9 CRITICAL SUCCESS FACTORS

As a result of the above consultation Critical Success Factors (CSF) for the Expert Advisor System were defined. These are given in Table 3.1.

Needs	**College Managers**	**FEFC Auditors & Inspectors**	**DBA Team**
To use a development methodology that is flexible enough to cope with rapid change and unclear requirements during the early stages of development	X		
To provide a natural language interface	X		
To facilitate the use of data from different sites, different systems and different platforms	X	X	X
For consistent, accurate data to be available	X	X	X
To view detailed data for different time periods	X	X	
To view aggregated data for different time periods	X	X	
To provide graphical representation of data for quick and easy assimilation	X	X	
To provide easy extraction of comparative information	X	X	
To view existing queries and SQL			X
To provide facilities to enable Senior Managers to make informed operational and strategic decisions and substantiate those decisions	X		
For decision making information to be in the right place at the right time	X	X	X
To achieve improved system performance	X		X

Table 3.1
Critical Success Factors for the Expert Advisor System

The request by the College Managers for 'a natural language interface' to be one of the CSFs introduced a new aspect of development that required consideration. The managers said they would prefer the DBA team to use the Expert Advisor System prototype when it was first introduced, but they made it clear that the prototype should be a desktop system that they could eventually use themselves. They explained how they lacked the necessary technical skills and wanted a simple to use facility where they could use English rather than a programming language when they were searching for information.

3.10 SUMMARY

This chapter has drawn attention to a Further Education college's need to manage and access data, to make predictions, to acquire knowledge, to access information about past decisions and to make new, adequately informed decisions within tight time constraints. It has established that the Expert Advisor System prototype must cater for all these college needs and must be able to operate in a complex environment and assist in maximizing funding. The roles of the people who will work with the Expert Advisor System experimental prototype have been described and CSFs that can be used to evaluate the prototypes fitness for purpose have been defined.

CHAPTER 4 - EVALUATION OF TECHNOLOGIES FOR USE IN THE EXPERT ADVISOR SYSTEM

Section 1.2 introduced the hypothesis:

- ***CBR principles can be used together with other knowledge discovery techniques to provide useful adaptive systems***

CBR and Data Warehousing have been selected as components of an experimental prototype that has been developed to test this hypothesis. This chapter looks briefly at CBR, Rule-Based Systems, Artificial Neural Networks, Data Warehousing and Data Mining. It explores their use in different organisations and justifies the selection of CBR and Data Warehousing as techniques suitable for knowledge discovery. The chapter begins by providing an understanding of the knowledge mediation requirements of the Further Education Colleges and the Further Education Funding Council (FEFC). Further Education is the rapidly changing domain where the experimental prototype enables knowledge to be discovered to inform decision making.

4.1 KNOWLEDGE MEDIATION REQUIREMENTS

Griffiths et al (1999) describe how a representation held in a *case* in their business planning system illustrates a translation between two conceptual worlds belonging to two communities of practice. In the context of the research undertaken in this thesis the FEFC and their auditors and inspectors are a community of practice that have introduced and use a specialised vocabulary for funding bids and strategic planning returns. They have also defined the format for the data that substantiates the bids and returns. Further Education colleges and their staff are the second community of practice who need to learn, understand and use this vocabulary and the data formats. An Expert Advisor System that supports the process of knowledge mediation is needed when knowledge, data and information are moved between these communities, if colleges are to acquire an acceptable level of funding and achieve consistency between funding bids and strategic planning returns.

The motivating concept behind the Expert Advisor System is to increase the value of information sources already available within colleges, decrease the cost of exploiting this information and provide extra knowledge that can inform decision making and reduce some of the uncertainty about the outcomes of future funding bids.

Funding information, rapidly changing funding rules and strategic planning information are accessible through meetings with the FEFC and its published circulars. Decision making relating to new funding bids is currently informed mostly through interaction and negotiation with college personnel. The knowledge, tacit or otherwise, held within the college about previous funding bids, funding rules and the data that formed the audit trail for these bids, is not always available due to staff leaving the organisation, staff operating in different roles through restructuring, or due to changes in technology. The interpretation of data or information is frequently difficult. Knowledge and understanding of funding bids is often not shared by college managers.

4.2 CHANGING ENVIRONMENTS WITH CHANGING NEEDS

Education faces problems analogous to those of the Health Service. Prior to the Further and Higher Education Act of 1992 (Parliament 1992) colleges, like health care providers operating in fee-for-service conditions after the Second World War, functioned in an environment that encouraged the provision of services without regard to ultimate costs. Dutta and Heda (2000) and Carter and Jones (2000) confirm that, whilst a requirements analysis for decision making support in managed care was undertaken, it was discovered that health care providers had little need to develop methods for continuous measurement of the effect of diagnostic and therapeutic interventions on patient outcomes during this period. Colleges were similar in that they had little incentive to develop methods for monitoring student enrolments, retention and achievement. The research of Carter and Jones (ibid) and Dutta and Heda (ibid) also revealed that, due to the apparent existence of a limitless revenue stream, the Health Sector had a proliferation of hospitals, large practice groups, and diagnostic centres, and the sector did not obey the usual laws of supply and demand. The Education Sector was comparable in that it had many colleges, with many outside centres, and this resulted in a surplus of Education providers. Whilst colleges operated under Local Education Authority (LEA) control the student catchment area was primarily the geographic boundary of the LEA, and there was little competition between colleges operating within the same LEA. Carter and Jones, and Dutta and Heda found that in the Health service few large-scale integrated health care organisations existed, so smaller entities carved out fairly well defined geographic influence areas and again there was little competition. Carter and Jones, Dutta and Heda, and Menon and Lee (2000) state that capitation and its attendant effects on revenue flow effectively ended this era for the Health Service, as did the 1992 Further and Higher Education Act and the change to independent charitable trust status for the colleges.

Both the Health and Education Sector moved into a rapidly changing competitive environment with new operational and decision support requirements. A definite economic incentive to increase the volume of services rendered was introduced. Carter and Jones say that this change meant that patients were considered on an individual basis, as well as through aggregation, and the need to control costs became extremely important. The work of Walczak and Scharf (2000), Liu and Olivis (2000), Dutta and Heda, and Menon and Lee (ibid) all confirm this change in direction. Carter and Jones declare that practices such as staff reductions, restructuring, elimination of redundant functions and shutting down unprofitable programmes became common. Both Carter and Jones, and Dutta and Heda report that the Health Sector recognized the need to have electronic systems that stored individual patient records in a form usable by decision support systems to sustain the needs of their changing environment. The focus in the Education Sector also changed to looking at students on an individual basis and, with this change in emphasis, came the need for electronic systems to store individual student records and the necessity for decision support systems to meet their changing needs.

4.3 TECHNOLOGIES, DECISION SUPPORT SYSTEMS AND THE EXPERT ADVISOR SYSTEM

Banks, like colleges, are also being forced to adopt new technologies and make technological changes. Quaddos and Intrapairot (2001) explain how banks are finding that older technologies cannot be extended and cannot keep up with business growth rates or fulfill organisational needs, whilst new technologies can provide more lucrative opportunities. They state that literature suggests that high technology costs, under-utilization, unproductive usage, low acceptance from customers and staff, lack of capable employees, lack of high executive support, unexpected performance from an adopted technology, technological mismatch, and technological difficulty have had an impact on the technology the banks have adopted.

As stated in Section 3.7, senior college managers are also finding technology costs high and have requested that the Expert Advisor System prototype should where possible use 'off the shelf' commercial packages. Their thinking is that this would constrain technology and training costs, increase staff acceptance and encourage competent and skilful use. Colleges like Banks also experience unexpected technology performance difficulties. When college MIS are used to retrieve decision support information, performing complex SQL queries to provide analyses, or to acquire information containing aggregated figures, often results in system performance being impaired. Pass (1996) confirms that system degradation is often experienced when SQL is used in this way. The college managers also state that this, together with the lack of staff with expensive, technical, specialist DBA skills, results in information requests frequently not being processed quickly enough to inform the decision making needed to comply with stringent FEFC deadlines. In addition to this technological mismatch, difficulty occurs when decision support information cannot be provided for comparison at different points in time due to the MIS data continually being overwritten.

The importance and challenge of providing a Decision Support System (DSS) for Education has been elevated because of the increasing financial significance, the rapidly changing complex environment and the demands being made upon the technology. Courtney (2001) states that a new paradigm is needed for decision making in this context. He explains the pragmatist approach to decision support based on the 'Singerian inquiring organisation approach' that is open to multiple perspectives and is innovative and adaptive. This approach offers the openness and flexibility that is required for the development of a system that will need to adapt to rapidly changing requirements. Consequently, it will be adopted during the development of the Expert Advisor System experimental prototype and technologies will be evaluated and a combination selected for use.

Potential Technologies for Evaluation

In 1994, I attended the British Computer Society Expert Systems '94 14th Annual Conference. This provided an opportunity to have discussions with researchers and practitioners, to evaluate presented papers, and to attend a workshop. The main thrust of the conference was the exploration of Expert Systems (ES), Artificial Neural Networks (ANNs) and Case-Based Reasoning (CBR), and the role they were playing in meeting new and evolving requirements. The academic and commercial interest in the capabilities of these technologies and their potential contribution to the provision of Decision Support Systems (DSS) was apparent. This stimulated my interest in exploring and evaluating these technologies further and assessing the contribution they could make to Knowledge-Based Decision Support Systems (KB-DSS).

Klein and Methlie (1995) increased my interest in these technologies and the way they would be used when they confirmed that DSS of the future would integrate new technologies. They said:

> 'Most decision support systems will provide some form of Expert System technology, as a consequence, the DSS development environment will have to supply the ES function in an integrated fashion. The ambition of the new KB-DSS framework is to achieve synergies by integrating the ES technology into the DSS framework.'

Harris et al (1994) also considered the growing need for technology integration. They said:

> 'Neural Network components can be the best solutions for some of the problems that have proven difficult for Expert Systems developers, and allow system developers to address problems not amenable to either approach alone. The integration of these and other intelligent systems components with conventional technologies promise to be an important area for research and development in the 1990's; the communities which are active in each of these areas must look to work together to take advantage of the strengths of the other.'

The thinking of Klein and Methlie (ibid), and Harris et al (ibid) provide a sound basis for exploring rule-based systems and ANNs, and evaluating their appropriateness for use as components of the Expert Advisor System experimental prototype.

My own interest in CBR that was gained from attending the conference was confirmed by Aamodt and Plaza (1994) when they said:

> 'Case-Based Reasoning is a problem solving paradigm that in many respects is fundamentally different from other major AI approaches. Instead of relying solely on general knowledge of a problem domain, or making associations along generalized relationships between problem descriptors and conclusions, CBR is able to utilize the *specific* knowledge of previously experienced concrete problem situations (cases). A new problem is solved in finding a similar past case, and reusing it in the new problem situation. A second important difference is that CBR also is an approach to incremental, sustained learning, since a new experience is retained each time a problem has been solved, making it immediately available for future problems.'

The college used in the case study in this thesis needed to acquire knowledge about decisions that had been made when past ISR Funding Returns were completed. They also needed to learn from this knowledge if future funding bids were to be optimized. CBR is a technology that is worthy of further investigation. Its potential for becoming a component of the Expert Advisor System will be evaluated.

In addition to this White (1994) discussed Data Warehousing. He considered how changes in the business climate had led to corporations examining the effectiveness of their end-user computing systems. He also stated that increased competition was leading to the need to make faster and better business decisions. He said that organisations often had to react on a daily basis to changes in the marketplace, and relying on monthly reports to supply information was no longer acceptable, and the result was that far more management attention was being given to end-user computing and the quality of information available to business users. He pointed out how in many industry sectors providing business users with easy access to quality information could make the difference between remaining profitable and being squeezed out by the competition. He drew attention to the fact that good quality information provides value to the organisation, gives return on investment, and can definitely improve the bottom line.

White (ibid) explains the problem that occurs when end-users are given direct access to operational data and the performance of the operational system is impaired. He also mentions how these data are frequently not in the form the end-user wants. White suggests the solution is to have a Data Warehouse where the data from the operational system are reformatted to meet the user's needs. He says this allows data to be integrated from multiple sources, reduces the impact on operational systems, and makes it much easier for the user to access and interpret data. He explains the benefits achieved by using a Data Warehouse are that it is organized for processing by business users and not for processing by operational applications, and the Data Warehouse contains both historical and summary data, which aids the user when they are analysing data, looking for business trends and so forth.

The college used in the case study in this thesis is having to operate in a changing business climate as a result of incorporation and is experiencing the need for faster and better decisions when it completes the ISR Funding Returns. It is also beginning to understand that it needs to react on a daily basis to the changes that are happening and monthly reports are inadequate for informing decision making. The importance of quality information and its impact on the income accrued from ISR Funding Returns is beginning to be appreciated. The DBA team are very aware that complex decision support queries impair the performance of the MIS, that data are not always in the required format when collected from the databases held at outside centres, that historical and summarized data are not available and that quality data needs to be available for analysis. The principles of Data Warehousing and Data Mining will be evaluated.

As stated in Section 1.3 technologies will be examined, evaluated and assessed and those that are considered appropriate will be integrated to provide an Intelligent Decision Support System. The technologies that will be explored are Case-based Reasoning (CBR), Rule-Based Systems, Artificial Neural Networks (ANNs), Data Warehousing and Data Mining. Literature will be used to explore the application of each technology in a specific problem domain, and additional references will be provided to confirm or extend the findings.

4.4 CASE-BASED REASONING AND ITS USE IN AN ELECTRIC DISTRIBUTION BUSINESS PLANNING PROCESS

Griffiths et al (1999) explain their use of CBR in the development of a knowledge mediation tool to support the business planning process for Northern Electric Distribution Ltd (NEDL). Both NEDL and colleges function in large, complex domains and operate under rules imposed by Government appointed bodies. These being the external regulator and the FEFC.

The developers, Griffiths et al (ibid), report that their knowledge mediation tool uses cases to provide access to detailed knowledge about the business and to support decision making. It enables users to understand how cases relate to current business problems. Advantages that can be achieved through using CBR for building software systems in large and complex domains are identified. The knowledge content of the system can be built up incrementally as the system is used. New cases are created and added to the Casebase as part of the problem solving process and the knowledge of the system increases in the areas where the system is most frequently used

They also argue that the tool has the potential to empower users.

Evidence provided by the work with NEDL establishes that an adequate solution to a problem should be available for re-use if the same problem occurs again. The case that can provide the solution needs to be available for adaptation and become a new case. The authors, Griffiths et al do acknowledge that adaptation is difficult. They also say that developing a suitable representation for the storage of cases in case memory and finding an appropriate algorithm for the retrieval and re-use of cases can be an issue. They draw attention to the need for the user to ensure that the information retrieved by the tool is in fact the expected information. NEDL identify the need for a user interface where a business manager can express requirements and be presented with information in an aggregated and accessible form. This is a need similar to that of the Further Education colleges where funding bid requirements need to be captured, accessible and offered in an aggregated form.

Further evaluation of the strengths and weaknesses of CBR have been undertaken. Key references to the findings are incorporated in Table 4.1.

Case-Based Reasoning	
Strengths	**Weaknesses**
Technology	
The knowledge content of the system can be built up incrementally. Examples of this are the Clavier, Caseline Swift & NEDL systems. Watson (1994), Kolodner (1993), Bregeault (1997), Jones (1997), Oatley et al (1999), Griffiths et al (1999)	Developing a suitable representation for the storage of cases in case memory and finding an appropriate algorithm for the retrieval and re-use of cases can be an issue. Griffiths et al
New cases are created and added to the system as part of the problem solving process. Griffiths et al (ibid)	Deciding how to represent cases is difficult. Watson
CBR is suitable for building systems in large, complex domains. Griffiths et al	Adaptation is difficult. Watson, Griffiths et al
System knowledge increases in the areas where the system is most frequently used. Griffiths et al	
Existing cases can be adapted to form new cases. Griffiths et al	
A user interface where manager can express requirements can be built. Griffiths et al	
Using CBR avoids the knowledge elicitation bottleneck. Elicitation becomes the easier task of adding new cases. Klein et al (1988b), Watson (ibid), Jones (ibid)	
CBR can use a number of cases to reach conclusions rather than having to use a complete set of rules which may possibly be contradictory or complex. Kolodner (1991), Zeleznikow and Hunter (1994)	
People	
People are able to understand how cases relate to current business problems. Griffiths et al	The user must ensure that the information that has been retrieved by the tool is in fact the information that was expected. An example of this is the NEDL tool. Griffiths et al
It complements human reasoning and problem - solving. Kolodner (ibid)	
It uses cases as a good way to justify decisions. Kolodner (1991)	
It is intuitive to both developer and user. Zeleznikow and Hunter (ibid)	
Organisation	
It recalls previous cases to inform decision making. Watson, Kolodner (1991), Zeleznikow and Hunter, Ram (1993), Leake et al(1996), Bregeault (ibid), Simoff (1998), Oatley et al (1998), Oatley et al (ibid), Griffiths et al	
It makes adequate solutions to business problems available for re-use. Griffiths et al	
It empowers users. Griffiths et al	
It allows the use of a partial Casebase. Examples of this are the Clavier, Caseline and Swift systems. Watson	
It provides an explanation to support decision making. Zeleznikow and Hunter	

Table 4.1
Strengths and Weaknesses of Case-Based Technology

4.5 RULE-BASED SYSTEMS PROVIDING FINANCIAL INTERNAL CONTROLS

Changchit et al (2001) describe an experimental expert system they developed to maintain an effective financial internal control system to assist auditors in making complex decisions. To test the expertise captured in the system rule set and ensure the validity of the system, they developed test cases and used them to establish whether the advice offered by the system was as good and timely as human advice. They also examined the systems knowledge and decision making capabilities. The developers discovered that an Expert System can sometimes be used to double check experts' reasoning. They also found that installing an Expert System of the same kind as theirs might save time and money by allowing weaknesses to be detected in the internal controls of a financial system and solving the weaknesses more quickly.

Through the use of only one auditor during system development Changchit et al (ibid) established that a system's knowledge could become firm specific or expert specific. They also explained that managers do not have experience with Expert Systems and may not feel comfortable using them. In addition to this they stated that managers might provide incorrect inputs to the system and not understand the outputs. Changchit et al added that managers might find it difficult to work with an Expert System and may resist considering the advice given by the system.

An additional evaluation of rule-based systems is given in Table 4.2.

Rule-Based Systems	
Strengths	**Weaknesses**
Technology	
Test cases can be used to examine whether the expert system offers sufficiently good and timely advice as the human expert. Changchit et al (2001)	The system's knowledge may be firm-specific or expert specific. Changchit et al
They have the ability to work with incomplete or uncertain information. Klein et al (1988b), Turban (1992)	Expert Systems only work well in narrow domains. Jackson (1990), Turban , Klein and Methlie (1995)
Knowledge and decision-making capabilities of the expert system can be examined. Changchit et al (ibid)	Rules can be circular, inconsistent or open textured. Open textured predicates contain questions that cannot be answered in the form of production rules or logical propositions. Zeleznikow and Hunter (1994)
People	
An Expert System can sometimes be useful to an expert to double check the expert's reasoning. Changchit et al	Managers do not have experience with Expert Systems. Changchit et al
Experts tend to use and combine uncertain pieces of knowledge and eventually come to a conclusion about which they can use i.e. MYCIN and Prospector both reason with uncertain knowledge. Jackson (1999).	Managers may not feel comfortable using Expert Systems. Changchit et al
	Managers may provide incorrect inputs, not understand system outputs, find it difficult to work with an Expert System, or resist considering the advice it gives. Changchit et al
	It is difficult to extract knowledge from humans. Jackson (1990), Turban, Phelan et al (1998)
	Experts may assess situations differently, yet be correct. Turban , Berson and Smith (1997)
	The vocabulary or jargon that experts use is frequently not understood by others. Jackson (1990), Turban
Organisation	
Installing an Expert System might save time and money by allowing weaknesses in internal control systems to be detected and solved more quickly. Changchit et al	Manual knowledge acquisition using knowledge engineers and domain experts is very time and resource consuming. Liu and Olivis (2000)
It can be used when the expert is not available because the expert's knowledge has been captured. Klein and Calderwood (1988a), Sprague and Watson (1989), Turban (ibid)	Help is frequently required from knowledge engineers who are rare and expensive – a fact that makes Expert Systems construction rather costly. Turban

Table 4.2
Strengths and Weaknesses of Rule-Based Systems

4.6 NEURAL NETWORKS AND BUILDING SOCIETY MARKETING

Furness (1997) provides examples of 'supervised' and 'unsupervised' ANNs being used by Building Societies for marketing purposes. One Building Society uses direct mail to promote a new investment product to existing savers. An initial test mailing achieves a 2% product take up response rate. A Multi Layer Perceptron (MLP) net is used to analyze the response from the test mail campaign and find a way of targeting the roll out campaign, so as to double the response rates to 4% and bring in new investment product holders. Furness (ibid) discusses the account base used for this exercise and how it could be extended to incorporate additional variables. His conclusions are that ANNs work well in complex situations involving many variables and demographic and geodemographic data. Other key points he identifies are that ANNs allow data to be modeled without assumptions having to be made about the underlying reasons for patterns in the data.

He explains that large, noisy data sets, containing many records, that each contain a large number of variables, are used in market analysis and ANNs are capable of representing these data sets analytically. The evidence he provides shows that when a particular variable is not available throughout the marketing database it may still be possible to model it, if those parts of the database where the variable is present are used for training and testing purposes. He also states that Building Society marketing activities often use time series data. An example of this is when product sales data together with data on advertising and promotions, competitor activity and external economic factors are used on a daily or weekly basis and may cover a long period of time. The evidence demonstrates that in this context the ANN can be an alternative to more conventional autoregressive forecasting models. In situations where the underlying dynamics are nonlinear and even chaotic, ANNs are known to be more effective than conventional methods.

Furness confirms the availability of public domain and commercial ANN software but warns that users should review requirements in detail before committing money and time to any product. He adds that users should consider the compatibility of data with other software packages and would be well advised to get expert advice before tackling any problem of a substantial size themselves.

Through the Building Society examples provided by Furness it was discovered that training is slow; network design and the selection of training and test data are difficult and 'over-fitting' and 'over-extrapolation' can occur. The evidence provided confirms that ANNs do not generate an explicit set of rules that the user can interpret to understand the reasoning behind a solution. This can lead to users having less confidence in the ANN's predictive capabilities. Furness verified that ANNs place greater computational demand on the production environment than conventional regression or rule-based models.

An evaluation of Artificial Neural Networks is given in Table 4.3.

Artificial Neural Networks (ANNs)	
Technology	
Strengths	**Weaknesses**
ANNs deal with noisy, conflicting and partial data. Liu and Olivis (2000), Furness (1997)	Raw data must be coded into a suitable input. Furness, Berson and Smith (1997)
The predictive capability is nonlinear. Furness (ibid), Tolle et al (2000)	ANNs require inputs in the range 0 - 1. Berson and Smith (ibid)
They can be used in complex situations involving many variables. Furness	They cannot explain their results. Berry and Linoff (1997), Furness, Berson and Smith (ibid), McGarry et al (1999), Oatley et al (1999)
Public domain and commercial ANN software is available. Furness	Training is slow. Furness, Berson and Smith
They allow data to be modeled without assumptions having to be made about the underlying reasons for patterns in the data. Furness	Designing the ANN and selecting appropriate training and test data are difficult. Furness, Berson and Smith
When a variable is not present throughout a database it can still be modeled if the part of the database where the variable is present is used for training and testing. Furness	ANNs may not converge to provide the best model of the data and may produce an inferior solution. Berry and Linoff (ibid), Berson and Smith
When time series data are used ANNs can be an alternative to autoregressive forecasting models. Furness	A network can become too tied to the training examples. A designer needs to know when to stop training to avoid this. Furness, Berson and Smith
	Some experimentation is usually needed if a satisfactory network configuration is to be achieved. Berson and Smith, Liu and Olivis (ibid)
	A representative training set and a large number of examples must be chosen. Furness
	Preprocessing of data are necessary. It can assist in highlighting important input characteristics. Sharman (1997).
People	
Users should consider the compatibility of data with other software packages. Furness	User acceptance of ANNs can be severely limited. Furness, Walczak and Scharf (2000)
Users should get expert advice before tackling a problem of a substantial size themselves. Furness	
Organisation	
ANNs produce results empirically, without the need to develop statistical prediction models. Tolle et al (ibid)	ANNs place greater computational demands on the production environment than regression or rule-based models. Furness

Table 4.3
Strengths and Weaknesses of ANNs

4.7 USING DATA WAREHOUSING AND DATA MINING TO PROVIDE DECISION SUPPORT FOR THE HOUSING AND DEVELOPMENT BOARD OF SINGAPORE

Ang and Thompson (2000) explain how a Housing and Development Board (HDB) in Singapore provides affordable, public, high quality homes. The successful Data Warehouse developed by HDB is one of the first to be developed by a Government agency. HDB need the Data Warehouse to be business driven, user led, subject oriented, integrated, time variant, flexible, and non-volatile and to provide easy user access to accurate and consistent corporate information, to inform planning and decision making and to facilitate forecasting. Ang and Thompson (ibid) confirm the Data Warehouse is designed to handle large repositories of disparate data and changing exogenous factors such as public demand for flats, and shifting population trends and to bring these together in coherent reports to meet the needs of top management. The Data Warehouse enables HDB to be more responsive to changing environmental conditions.

The evidence provided by Ang and Thompson establishes that the integrity, consistency and accuracy of clean data affect the quality of the management reports that are produced. They add that this affects the quality of the decisions being made and is an important determinant of the efficiency and effectiveness of the Data Warehouse. These factors also tend to raise user confidence in, and acceptance of, the Data Warehouse. The incremental approach that has been adopted for the development of HDB's small highly focused Data Warehouse also results in benefits being obtained earlier and disruption of operational systems being minimized. It provides an opportunity to learn for IT staff and users and is easier to manage and less risky than a larger Data Warehousing project.

Ang and Thompson state that it can be seen from the experiences of HDB that Data Warehouse development is not simply data field conversion or mapping. The conversion of one field may depend on the value of another field or may depend on the value of the same field in another record. Data must be cleansed and transformed. Customized programs must be written and business rules rationalized to ensure consistency. They add that data are not easily accessible due to most operational databases being geographically or logically dispersed. Ang and Thompson state that users who become proficient in accessing the Data Warehouse realize that some types of data are not available. Consequently, user feedback on new types of data that should be included results in upgrades and improvements to the Data Warehouse. Ang and Thompson stress that it is important that users understand the difference between the operational and decision-support data, as the aim of the Data Warehouse is not to store all the data available but to selectively store those data that are essential for planning and decision making.

Ang and Thompson found that the Data Warehouse project provided an intimate insight into the fears and apprehensions of end-users. Each department had data they regarded as theirs to collect, store, and maintain, and usually they owned both the system and its data. Although the Data Warehouse provided access to timely, consistent, and accurate information to support decision-making, departments were extremely reluctant to share their data. Ang and Thompson discovered that dual ownership was adopted to address this problem. The Chief Information Officer owned the Data Warehouse architecture, and the respective user departments owned the data. Access to the Data Warehouse could only be granted to users if the data owner (the user department), authorized it. HDB actively promoted this spirit of cooperative learning and doing amongst the departments and they became more willing to share the data and eventually learnt that the data actually belonged to HDB. HDB recognized they were introducing change and found people issues were more difficult to resolve than technical issues. To obtain the most from the Data Warehouse continual, formal, systematic user training was provided together with regular 'hand-holding' follow up sessions. Users gained a better understanding of the Data Warehouse functions and used the Data Warehouse to full advantage. They became accountable for the production of timely and accurate information. Technical system quality was important, but just as important, if not more so, was the need to understand the human issues involved in technical change.

An evaluation of the strengths and weaknesses of Data Warehousing and Data Mining is presented in Table 4.4.

Data Warehousing / Data Mining	
Technology	
Strengths	**Weaknesses**
The Data Warehouse is integrated, time variant, flexible and non-volatile. Page (1996), Ang and Thompson (2000), Inmon (2000b), Inmon (2000e)	The Data Warehouse development is complex. The data must be cleansed and transformed. Customized programs must be written and business rules rationalized. Ang and Thompson, Inmon (2000c), Inmon2000d)
It handles large repositories of disparate data. Ang and Thompson (ibid), Inmon (2000a)	Data are not easily accessible due to operational databases being geographically and logically dispersed. Steele (1996), Ang and Thompson, Inmon (2000c)
It establishes the integrity, consistency and accuracy of data thus producing clean, quality data. Ang and Thompson, Inmon (2000a), Inmon (2000d)	
It stores historical data. Inmon (2000c), Inmon (2000d), Inmon (2000e)	
It provides quality, aggregated data. Steele (1996), Inmon (2000d),	
Data Mining techniques can be used to uncover hidden, unexpected patterns, trends and meaningful new correlations in the data. Page (ibid), Pass (1996), Berry and Linoff (1997), Duffy (1997), Bedeman (1997), Inmon (2000e)	
People	
People gain better understanding of the Data Warehouse functions, use the Data Warehouse to better advantage and become accountable for the production of timely, accurate information if they receive adequate training. Ang and Thompson	User feedback results in upgrades and improvements to the Data Warehouse. Ang and Thompson, Inmon (2000d)
	Users need to understand the Data Warehouse contains decision support data not operational data. Ang and Thompson
	Users have fears and apprehensions about a Data Warehouse. Ang and Thompson, Inmon (2000d)
Organisation	
It provides user access to timely, consistent, accurate corporate data for the purpose of decision support. Page, Ang and Thompson, Inmon (2000c)	
It can handle changing exogenous factors. Ang and Thompson	It provides a corporate view of data. Inmon (2000c)
The quality of the data affects the quality of management reports which in turn affect the quality of the decision making. Page, Ang and Thompson	Departments usually own both the system and the data. They regard the data as their own and are reluctant to share it. Ang and Thompson
The integrity, consistency and accuracy of the data are an important determinant of the efficiency and effectiveness of the Data Warehouse. Ang and Thompson	
An incremental development approach results in benefits being obtained earlier and disruption of the operational systems being minimized. Ang and Thompson	

Table 4.4
Strengths and Weaknesses of Data Warehousing and Data Mining

4.8 TECHNOLOGY SELECTION

Strengths and weaknesses of CBR, Rule-Based Systems, ANNs, Data Warehousing and Data Mining have been identified in Sections 4.4 - 4.7. The learning that has been achieved through investigating the use of these technologies in specific domains, together with key literature references confirming or extending these findings will be used to underpin the selection of the technologies to be used as components of the Expert Advisor System experimental prototype. The appropriateness of each technology will be evaluated.

4.8.1 CASE-BASED REASONING

FE Colleges are large complex domains and Griffiths et al (1999) confirm that CBR technology has proved suitable for use in these types of domain. They also corroborate that new cases can be created and added to a system as part of the problem solving process, thus incrementally increasing the knowledge held in the system. In addition to this they state that system knowledge increases in the areas where the system is most frequently used. CBR could be incorporated in the Expert Advisor System to allow these benefits to be achieved and enable the system to be available for use whilst still continuing to grow and gain knowledge in key areas.

Klein and Calderwood (1988a), Watson (1994) and Jones (1997) all declare that adding new cases to a casebase avoids the knowledge elicitation bottleneck that occurs when expert knowledge has to be captured. Inclusion of cases in the Expert Advisor System would avoid this bottleneck and reduce the length of time required to capture knowledge and the complexity of knowledge capture process. Added to this, Zeleznikow and Hunter (1994) explain how the knowledge gained from a number of cases can be used to reach conclusions. Colleges using the Expert Advisor System need to gain knowledge from a number of cases to reach conclusions and make decisions relating to the complex task of completing funding returns.

Griffiths et al (ibid) describe how people are able to understand how cases relate to current business problems and how user interfaces can be built where business requirements can be expressed. In addition to this, Kolodner (1991) indicates that cases complement human reasoning and problem solving and are a good way to justify decisions, whilst Zeleznikow and Hunter (ibid) describe how CBR is intuitive to developers and users and provides explanations to support decision making. The Expert Advisor System needs to provide facilities for capturing business requirements and facilitating human understanding. It needs to be intuitive to developer and user and provide explanations to substantiate decisions that have been made. In fact one of the CSFs that were identified in Section 3.9 was for the prototype *to provide facilities to enable Senior Managers to make informed operational and strategic decisions and substantiate those decisions.* CBR offers the facilities that are required to meet this CSF.

A commercial 'off the shelf' Case-Based Reasoning package has been acquired for use as a component of the Expert Advisor System. The package is CBR Express, Authoring version 2.0 R1, release 1990 - 1996. This software uses Windows 3.1. It has been chosen because it incorporates a casebase containing records (cases) which do not need to conform to a universal format and supports fuzzy searching where searches retrieve records that are similar to the search description as well as those that are identical to it. Liu et al (1991a, 1991b, 1991c) state that it incorporates an automated reasoning tool for information management that provides the potential for expanding a casebase into a full expert system or policy management program. It uses a programming language and environment that supports the integrated use of case-based reasoning, forward chaining rules, schemas (frames), object oriented programming, database access, utilities and interface support. Inference (1990-1996) and Watson (1997) confirm that it provides a development or authoring environment and uses a memory efficient search engine. It offers an open system approach, a natural language interface, a rule-based approach and makes provision for weighting factors. The memory efficient search engine in this package overcomes the difficulty identified by Griffiths et al of developing a suitable representation for the storage of cases in memory. The package also provides case adaptation facilities. Case adaptation is a process that Watson (ibid) and Griffiths et al have identified as difficult. Adaptation is also a facility required in the hypothesis introduced in Section 1.2:

> ***CBR principles can be used together with other knowledge discovery techniques to provide useful adaptive systems***

The features provided by this package are not incorporated in the relational database software currently in use in the colleges and are important to the development of the Expert Advisor System. Provision of a natural language interface is one of the Critical Success Factors for the Expert Advisor System that was identified in Section 3.9. A rule-based approach could incorporate the rapidly changing funding rules and constrain the acceptable answers to case questions. Weighting factors could be used to alter the importance of case questions. An open systems approach is an essential aspect of the progressive development of an integrated system. The chosen package has the added advantage that it can be used with Microsoft SQL Server and Oracle. Both are used extensively in colleges. This CBR package will be a leading component in the Expert Advisor System and will assist colleges in their search for business benefits through informed decision making influencing the completion of ISR Funding Returns. John Gordon (1998) the Director of the North West Artificial Intelligence Group, confirms that industry has found that inclusion of CBR as a system component can make this type of success achievable:

> 'The major achievements of artificial intelligence systems as far as industrial applications is concerned, have been the component parts of artificial intelligence like Knowledge-Based Systems, Case-Based Reasoning, Data Mining, and Neural Networks. It's the component parts that lead to business benefit.'

4.8.2 RULE-BASED SYSTEMS

The findings of Changchit et al (2001) show that managers do not have experience with rule-based systems and may not feel comfortable using them. Managers may provide incorrect inputs, may not understand outputs and may resist considering advice given by the system. This reaction from managers would prevent the CSF requirement that was given in Section 3.9 from being achieved. The CSF required the Expert Advisor System *to provide facilities to enable Senior Managers to make informed operational and strategic decisions and substantiate those decisions.* In addition to this Jackson (1990), Turban (1992) and Berson and Smith (1997) explain the difficulties surrounding knowledge elicitation. Again cooperation in the knowledge elicitation process would be required from managers who were experts. Based on these findings rule-based Expert Systems are not considered appropriate for use in the complex and volatile domain of Further Education. Colleges operating in the current, politically and financially driven environment would find it difficult to provide the level of trust needed for an Expert System to be developed tested and implemented.

4.8.3 ARTIFICIAL NEURAL NETWORKS

Furness (1997) has shown ANNs to be suitable for use in complex situations, involving many variables, and has identified their appropriateness in working with data sets where data are noisy, conflicting, and incomplete. He has also identified their nonlinear predictive capability. All these features make ANNs attractive for use as a component of the Expert Advisor System but ANNs have not been chosen. Furness, McGarry et al (1999) and Oatley et al (1999) all confirm that ANNs cannot explain their results. This would be unacceptable in the current, uncertain environment of Further Education. Training data of the correct type and quality, as identified by Sharman (1997), would be extremely difficult to provide owing to the rapidly changing funding rules and the tight time constraints imposed by the FEFC. Furness identified the need to code data and indicated that the use of ANNs would require greater computational effort. Colleges would find it difficult to facilitate the coding of data and be reluctant to use any system that could possibly impair the performance of their MIS. All these factors would prevent the CSF that was given in Section 3.9 from being achieved. The CSF required the Expert Advisor System *to provide facilities to enable Senior Managers to make informed operational and strategic decisions and substantiate those decisions.* ANNs will not be a component of the Expert Advisor System.

4.8.4 DATA WAREHOUSES AND DATA MINING

Colleges rely heavily on database technology developed in the 1980s for the management and control of many of their operational business processes. Relational Database Management Systems (RDBMS) give users a fast On Line Transaction Processing (OLTP) capability. The granularity of the stored data provides detailed knowledge of individual transactions. Whilst this level of detail is important to Operational Managers it is not what is required by Senior Managers. Monthly enrolment reports, enrolment trends over the year, or enrolments in specific months over a number of years may provide more significant information for Senior Managers. They need to view aggregated data rather than details of individual enrolments on individual courses.

The need for aggregated data to support new information requirements does not change the need for OLTP systems but identifies a new need where the OLTP systems are retained and the informational systems are implemented as a set of parallel systems drawing their data from the operational OLTP systems. The traditional use of data are extended from simply supporting the functional areas of the college to becoming a broader strategy for strategic management information to support Senior Managers in their decision making. Managers who are business decision makers need integrated, consistent, timely, accurate and appropriate information delivered in the right format, to the right people, at the right time. This information must allow the Managers to identify critical facts and business trends and enable them to make informed decisions relating to the completion of ISR Funding Returns.

In recent studies Inmon (2000a, 2000b, 2000c, 2000d and 2000e) declares that Data Warehouses are integrated, time variant, flexible and non-volatile, and provide a corporate view of data. He states that they can take data from disparate sources and produce repositories of historical, consistent, accurate, quality data that is suitable for Data Mining and informed decision making.

In Section 3.9 CSFs for the Expert Advisor System were defined. These required the prototype to provide facilities:

- for consistent, accurate data to be available
- to view detailed data for different time periods
- to view aggregated data for different time periods
- to provide graphical representation of data for quick and easy assimilation
- to provide easy extraction of comparative information
- to enable Senior Managers to make informed operational and strategic decisions and substantiate those decisions

- for decision making information to be in the right place at the right time, and
- to achieve improved system performance.

The repositories of integrated, time variant, flexible, non-volatile, historical, consistent, accurate, quality data that Inmon (ibid) described would make data available that complied with the first CSF. It could also be used as the source for the *extraction of detailed data* and *aggregated data* requested in the second and third CSFs, and for the production of charts that would provide the *graphical representation of data* requested in the fourth CSF. Together the second, third and fourth CSF data would provide the *comparative information* requested in the fifth CSF. In doing this a contribution would be made towards achieving the sixth and seventh CSFs - *to provide facilities to enable Senior Managers to make informed operational and strategic decisions and substantiate those decisions,* and *for decision making information to be in the right place at the right time*. The removal of the complex decision support information queries from the OLTP system to the Data Warehouse would also *improve the performance of the OLTP system* and contribute to the eighth CSF being achieved.

The application of the principles of Data Warehousing and Data Mining will be part of the Expert Advisor System. It will assist in the achievement of all these CSFs. Relational database OLTP data from the MIS and other disparate sources at outside college centres will be used as an input to the system.

4.9 TECHNOLOGY SELECTION CONCLUSION

The Expert Advisor System will incorporate a CBR component. The commercial 'off the shelf' CBR package that will be used incorporates a rule-based approach and consequently has the potential for handling the rapidly changing funding rules and constraining the acceptable answers to case questions. The rule-based element of the CBR package will be used in the Expert Advisor System but a separate Rule-Based System package will not. ANNs will also not be components. Relational database data will provide an input to the Expert Advisor System and the principles of Data Warehousing and Data Mining will be adopted. This selection of technologies will contribute to achieving the CSFs that require facilities to be available for providing consistent, accurate data, for allowing detailed data relating to different time periods to be viewed, for allowing aggregated data relating to different time periods to be viewed, for providing graphical representation of data for quick and easy assimilation, for providing easy extraction of comparative information, for enabling Senior Managers to make informed operational and strategic decisions and being able to substantiate those decisions, for decision making information to be in the right place at the right time, and for achieving improved system performance.

CHAPTER 5 - USING THE COMMONKADS METHODOLOGY TO DESIGN THE EXPERT ADVISOR SYSTEM

5.1 INTRODUCTION

In Chapter 2 it was found that as a result of new legislation many organisational and technological changes occur. This results in organisations operating in complex, demanding and rapidly changing environments where organisational issues, problems and opportunities and risk management need to be considered when new systems are designed, and technology is used to enable and reinforce the legislative changes. It was established that organisations are aware of new decision support requirements that are emerging, and that there is a need for an Intelligent Decision Support System that would enable them to learn from past experience, assist them in making projections about the future, give them access to auditable data trails that substantiate their decisions, and help them to become smart, learning organisations.

Chapter 3 investigated the FE Sector and discovered that informed decision making, up-to-date knowledge and an understanding of past decisions were required to assist in the completion of the ISR Funding Returns. It also revealed that multiple stakeholders would be interested in the provision of such a system. It established that the system must be able to operate in a volatile environment with rapidly changing rules, would be required to comply with legislative requirements, encompass data management facilities, facilitate risk management, enable projections to be made, be capable of acquiring knowledge, and provide informed decision making.

Chapter 4 explained the problems in the Health Service that were analogous to those facing Education. It also discussed how banks, like colleges, were being forced to adopt new technologies, and explained the factors that had an impact when the technologies were introduced. It continued to describe the use of CBR in the development of a knowledge mediation tool to support a business planning process. In addition to this, it described an experimental Expert System that was developed to maintain an effective financial internal control system to assist auditors in making complex decisions. It then explained how ANNs were used by building societies for marketing purposes. Finally an explanation of the successful development of a Data Warehouse was given. The strengths and weaknesses of CBR, Rule-Based Systems, ANNs and Data Warehouses were identified and appropriate technologies were selected as components of the Expert Advisor System experimental prototype.

Although the technologies have been selected, the system that will use these technologies still needs to be designed. A suitable methodology must be chosen, and recognition must be given to the need for the methodology to not only offer the functionality of conventional methodologies, but to be suitable for the design of a Knowledge Based System (KBS). The first half of this chapter focuses on evaluating methodologies and selecting one that is appropriate for the design of the experimental prototype, whilst the remainder of the chapter uses the chosen methodology to produce the models that will support the development of the prototype. This evaluation of different methodologies and their suitability is necessary to test the following research hypothesis that was introduced in Section 1.2 and to justify the selection of CommonKADS:

> ***CommonKADS Models are well suited to providing a template for the design and documentation of Decision Support Systems that need to operate in rapidly changing domains.***

Design Considerations

Through attendance at the FEFC meetings, seminars and workshops that are given in Appendix H, and through discussions with senior staff at the College that requires the prototype, it is clear that the College has the same system design needs as commerce now that it is expected to operate as a business, and its survival is dependant on the funding it receives from the ISR Funding Returns. Talks with many of the College staff also confirm the need for the methodology to model the college socio-organisational environment. They have raised my awareness of the rapid and varied changes that are happening in their environment. This has alerted me to the importance of these changes, and also to the impact that human, financial, technological and political factors can have on the successful analysis, design, testing, implementation and use of the Expert Advisor System experimental prototype.

5.2 METHODOLOGIES

This section explores the methodologies that are being evaluated for use in the analysis and design of the prototype. Gregory (1995) says that during the last decade Soft Systems Methodologies (SSM) have had considerable success as general purpose problem solving methodologies. He adds that the ability of SSM to address unstructured (soft) problems can be contrasted with traditional Operational Research which aims at solving structured (hard) problems. He says that although there is a contrast this does not amount to an incompatibility. He explains how during the process of SSM analysis a *soft* problem will often turn into a *hard* problem which can be solved by structured methods. In view of these statements both *Hard Systems Methodologies* and *Soft Systems Methodologies* will be explored. Also as explained in Section 1.4 I became aware of the CommonKADS methodology through attendance at a conference. This was of particular interest because it took account of socio-organisational factors and handled knowledge. This methodology will also be explored.

Information Technology & Organisations (2001) explain that **Multiview,** a Soft Systems Methodology, incorporates a combination of methodologies and uses a contingency approach where the methodology used will depend on the particular circumstances where it will be applied. In other words, different methodologies will be used for different situations. They explain how the level of uncertainty in a situation is critical to the choice of methodology. The complexity and how ill-structured the system is, its current state of flux, the number of users affected by the system, the skills needed by the users and the skills they possess, and the level of experience and skill of the analysts, determine the level of uncertainty. FE is an environment with much uncertainty. Owing to this the contingency approach offered by Multiview may be appropriate for the design of the Expert Advisor System. Multiview is the Soft System Methodology that will be evaluated.

Hutchings (1996) talks about a small sample of the many Hard Systems Methodologies that are in use. He discusses Structured Analysis, Design and Implementation of Information Systems **(STRADIS)**, the Yourden Systems Method **(YSM)**, **MERISE,** a methodology that is widely used in France, Spain and Switzerland and the Structured Systems Analysis and Design Methodology **(SSADM)**. All of the methodologies seem worthy of further investigation but because of its use in Government computing SSADM is the Hard Systems Methodology that has been chosen for further investigation and evaluation.

The three methodologies that will be investigated further are Multiview, SSADM, and the KBS Analysis and Design Support methodology CommonKADS.

5.2.1 MULTIVIEW

Avison and Fitzgerald (1988) describe Multiview as a Soft Systems Methodology. Wood-Harper et al (1985) add that it is a methodology used to structure the tasks for the analysts and users during analysis and design activities. Checkland (1993) explains its purpose further. He says it incorporates the human activity system which is relevant to tackling 'soft' ill-structured real world problems. Checkland (1999) also comments on the soft tradition of assuming that the world is problematical and always more complex than any of our accounts of it lead us to believe. He then points out that the process of enquiry into this world can be engineered as a learning system, one in which soft systems thinkers have the option to adopt the hard systems stance if they want to.

Avison and Fitzgerald (ibid) state that Multiview is used in relatively small organisations and is sometimes used with 'microcomputers'. They say it considers different perspectives or views.

Some of these could be organisational, technical, human-orientated or economic. Wood-Harper et al (ibid) add that it creates a theoretical framework for tackling computer systems design which takes account of the views of all the people involved in using the system. Wood-Harper (2000) also says he has learnt a number of lessons whilst using Multiview across a range of action research projects. The Waterfall Life Cycle model proved inappropriate when put into practice, the methodology was not a 'guarantor of the truth', the political dimension of development was important, and the methodology was interpreted by users and analysts. These findings led him to reflect that the methodology was still evolving and development is contingent upon the methodology, the problem situation and the development team.

5.2.2 SSADM

Cutts (1987), Avison and Fitzgerald (1999) and Lewis (1998) describe SSADM as a Hard Systems Methodology. Avison and Fitzgerald (1988) add that it is a Government sponsored methodology. This is confirmed by Olle et al (1991), Longworth (1992), Tansley and Hayball (1993) and Lewis (ibid). In addition to this Longworth (ibid) and Tansley and Hayball (ibid) point out that it provides a non-proprietary de facto standard and Tansley and Hayball declare that it is the standard methodology for a mature software industry.

Tansley and Hayball (ibid) and Avison and Fitzgerald (1988) explain how SSADM is widely used in the design of transaction processing systems such as payroll and accounting systems, but not used in the development of tactical or strategic management systems. Its widespread use in the UK and the fact that it is supported by consultants, accredited training organisations, practitioners and automated tools is substantiated by Lewis. MorningStar Information Systems Ltd. (2000) confirm that SSADM uses the Waterfall lifecycle. Masons (2001) whilst discussing Waterfall methods in general identify SSADM as a good example of such a method. Both state that the Waterfall Lifecycle concentrates on producing highly accurate and stylized representations of the requirements that are captured. They add that although the output from the requirements analysis may be meaningful to analysts it is unlikely that it will be meaningful to the user. They state:

> 'While in theory such a Waterfall approach is capable of capturing requirements accurately, in practice, such methods are capable of creating ambiguity and uncertainty because of the very detail of resulting documentation.'

Hicks (1991) says SSADM is suitable for use in well structured environments, whilst Tansley and Hayball add that it is suitable for conventional data processing applications and is appropriate for medium or large systems. Avison and Fitzgerald (1988) and Tansley and Hayball also state that the Micro version of SSADM is suitable for small systems. Longworth describes it as a tried, tested and widely used methodology where users are not locked into a single supplier and software support and training are available. He adds that it is a stable product that will only change in a controlled and considered way in the light of experience and developments in technology. He states that it is well documented and has publicly available documentation.

5.2.3 COMMONKADS

A research project named KADS-II started in October 1990. Its aims were to build on work done in the KADS-I project of 1983 and to develop a comprehensive method for KBS development. Gustafsson and Menezes (1994) explain how the KADS-II research project, number 5248 was partially funded by the Espirit Programme of the Commission of the European Communities. They confirm that the methodology produced was named CommonKADS.

Tansley and Hayball, and Schreiber et al (1993) describe the CommonKADS methodology as one which is suitable for the development of knowledge-based systems. Tansley and Hayball add that CommonKADS is a relatively new de facto European standard methodology. They also identify its suitability for the development of systems with either small or large KBS elements. They say it supports knowledge acquisition and is suitable for the development of generic, general-purpose, bespoke, embedded, and adaptable or hybrid KBS systems. Both Tansley and Hayball, and Gustafsson and Menezes (ibid) state that it is a model based-methodology.

Whilst talking about knowledge engineering, Montero and Scott (1998) discuss the problem of domain analysis. They explain how current analysis and design approaches in business systems in the commercial world, frequently make the assumption that the requirements and the domain concepts for a given system are either well-known or well-defined, and that those concepts can easily be captured. They observe that for most large-scale commercial system developments this is not the case. They say that the problem is exacerbated by the *complexity* of new systems, and the trend towards *iterative* and *evolutionary* development where the 'discovery' of new requirements can take place at any point in the development lifecycle. They also mention the need to *acquire* and *structure* domain knowledge. They say that the *acquisition* of knowledge and the *structuring* of knowledge are essential to the success and long-term viability of the software system.

Tansley and Hayball (1993) explain how the CommonKADS methodology *structures* and systematizes KBS development. They describe how its structured approach and methods lead to better development control and result in a more maintainable system than the *unstructured*, *iterative* or *evolutionary* approaches usually adopted for KBS development. They also say that maintenance and enhancement activities are based on well documented, well-structured design and this results in costs and risks being reduced. They add that it provides support for knowledge acquisition and has a library of models available for re-use. In addition to this Schreiber et al (ibid) say in contrast to other methodologies CommonKADS uses strategic knowledge to facilitate the building of complex, flexible knowledge-based systems. Tansley and Hayball explain how the model of expertise encompasses domain, inference, task and strategic knowledge. Sociaal Wetenscappeelijka Informatica (1999) describe how KADS-II considers strategic management as a new factor in the system development process. Their description of this approach is:

> 'The strategic management dimension is concerned with the decision making viewpoint; what are the decisions to be taken, what is their impact on business practice, what risks are involved and what is their costs? In KBS development these issues are particularly pertinent since KBS development can have significant effects on the functioning of an organisation.'

Tansley and Hayball, Gustafsson and Menezes, and Schreiber et al (1993) confirm the availability of a library of CommonKADS models, which can form a template and be used again or modified for use in other systems. The use of existing models could reduce the costs which are incurred and minimize the risks. Research undertaken by Tansley and Hayball, and Schreiber et al (1993) establishes that the CommonKADS model-based methods, also known as model-based reasoning, are used because they accurately represent part of a domain and its behaviour in the real world. It is essential that the design of Intelligent Decision Support Systems that operate in volatile environments and have to respond to rapid change are able to accurately model their domains. In addition to this Schreiber et al (1993) confirm that CommonKADS incorporates the principles of multiple models and of knowledge-level modeling as a way to describe problem-solving expertise in an implementation-independent way. They state that both these underlying principles are essential to the building of KBS.

Sociaal Wetenschappelijke Informatica (ibid) state that the Waterfall Life Cycle used in KADS-I proved to be inadequate when used commercially. It lacked the flexibility that could be provided through an iterative, incremental development process. They add that KADS-II incorporating the Spiral Life Cycle offers this, is flexible and supports project control, feasibility, metrication, cost-estimation and techniques such as formal methods, rapid prototyping and generic reusable components. Both Schreiber et al (1993) and Tansley and Hayball confirm that KADS-II uses the review, risk, plan and develop steps in its spiral lifecycle.

Schreiber et al (2000) illustrate the flexibility of CommonKADS when they say the knowledge-modelling framework is similar in spirit to modern object-oriented component frameworks. The templates are what one could call 'patterns of intensive tasks' in O-O jargon.

5.2.4 METHODOLOGY SELECTION

This research into methodologies has identified important capabilities within the CommonKADS methodology that have led to it being selected as the methodology that is most suitable for use in the analysis and design of an intelligent knowledge-based decision support system that will operate in a volatile environment. The system will be required to adapt and respond to rapidly changing decision support requirements that must be authenticated by auditable data trails. It will also need to function effectively when complicated internal and external constraints are imposed. In addition to this, the methodology will be expected to meet the requirement specified as a CSF in Section 3.9. This is the need *to use a development methodology that is flexible enough to cope with rapid change and unclear requirements during the early stages of development.*

The following factors are ones that have influenced the decision to choose CommonKADS as the analysis and design methodology.

The Waterfall Lifecycle

Schreiber et al (1993) state that SSADM and Multiview use the Waterfall Life Cycle model. This is substantiated by Tansley and Hayball, Gustafsson and Menezes, and Sociaal Wetenschappelijke Informatica. Tansley and Hayball however reveal that the Waterfall method has often failed to deliver what managers want and does not realistically describe the development process. Taylor (1992) states that system requirements are frequently unclear in the early stages of systems development. Using the Waterfall method, when the requirements are identified it is often too late to modify a design and the design process has to start again from the beginning. Due to this limitation methodologies using the Waterfall lifecycle will not enable colleges to achieve the Critical Success Factor identified in Section 3.9 which highlights the need to use a development methodology that is flexible enough to cope with rapid change and unclear requirements during the early stages of development. Rapid changes relating to the funding methodology often result in different system requirements and outcomes becoming necessary. SSADM and Multiview will not be used for the development of the Expert Advisor System because they use the Waterfall Life Cycle.

Risk Assessment

Schnell (1998) says the Spiral Life Cycle is adaptable enough to cope with changing requirements. In addition to this the work of the University of Cincinnati (1999) reveals that the Spiral Life Cycle includes the best features of the Waterfall Life Cycle plus risk analysis. They add that it can meet the need for a risk driven methodology. College Managers confirmed that they have to assess risks associated with the use of hardware and software, economic risks relating to resourcing issues, legal risks and risks governed by politics and performance problems. Risk analysis relating to performance and the figures in the ISR Funding Return is extremely important to colleges. The FEFC (1998b) have drawn the attention of colleges to performance indicators in their circular 98/04. They state that performance indicators relating to student recruitment, student commitment to their learning programmes and student achievement, particularly in relation to the National Targets for Education and Training (NTETs) and value for money, should be used to allow reliable comparisons to be made between institutions. The Expert Advisor System not only has to assist Senior Managers in their decision making relating to performance issues but also has to be developed in an environment where performance is a serious issue.

The review and risk assessment element of the CommonKADS methodology Spiral Life Cycle model, which tackles the most uncertain project areas, lends itself to the rapidly changing situation in colleges where financial, time and resourcing constraints frequently impair the successful progression of a project. Gustafsson and Menezes say that during the risk stage alternate development strategies and ways of managing the strategies are considered. Further Education Colleges frequently have to assess risks and manage things differently. The FEFC (1999b) confirm the need for risk assessment in their statement:

> 'Institutions are asked to update their risk analysis, outlining the effects of variations in risk factors on their plans.'

The risk assessment element of CommonKADS will enable Senior Managers to assess risks and vary strategies where appropriate. The risk assessment capability of CommonKADS will be useful to colleges and other organisations operating in similar environments, particularly those which receive funding from external sources and have to comply with external rules and constraints. Risk assessment is important to these organisations.

Knowledge Elicitation and Models

Tansley and Hayball, Schreiber et al (1993) and Hickman et al (1989) confirm that CommonKADS incorporates knowledge acquisition methods and techniques, a model of expertise, a library of interpretation models and user analysis techniques to overcome the problems of knowledge acquisition, elicitation, interpretation, analysis and modeling. College managers have confirmed that the Expert Advisor System needs to acquire knowledge of past funding bids and statistical returns, and inform college managers on the formulation of new funding bids and returns. These research findings validate the need for the CommonKADS methodology to be used in the analysis and design of the Expert Advisor System prototype. Other Intelligent Decision Support Systems that operate in similar environmental conditions and are expected to meet comparable user requirements could also benefit from the use of this methodology.

CommonKADS

For the reasons outlined above, CommonKADS will be used as the methodology for the analysis and design of the Expert Advisor system. I now explore how CommonKADS models can produce a template for the design and documentation of Intelligent Decision Support Systems that need to operate in rapidly changing domains.

5.3 THE ORGANISATION MODEL

5.3.1 THE PURPOSE OF THE ORGANISATION MODEL

Analysis of the socio-organisational college environment is extremely important whilst colleges are experiencing rapid change and have to manage the ensuing people, organisational and technical issues that were identified during talks with college technical and administration staff. Wielinga et al (1992) say that the KADS Organisational Model provides an analysis of the socio-organisational environment in which the KBS will have to function and be accepted, and includes descriptions of functions, tasks and bottlenecks in the organisation. De Hoog et al (1993) declare that KBS are more widely used now and there is less risk of KBS failure through technical issues. He states that, when a KBS is prototyped, the interaction with people, many of them non-technical, increases and organisational issues become very important. The need for an Organisation Model is confirmed in his declaration:

> 'The risks involved in a KBS project are moving from technical to social areas. Developers are frequently frustrated by unexpected obstacles in the social realm'

Through my work as Head of Information Systems, prior to working at Sheffield Hallam University, I can confirm that the Expert Advisor System experimental prototype will be developed and tested in an environment where management restructuring frequently takes place. I also know that the procurement of any software needed for the Expert Advisor System may prove awkward during a period when the college is experiencing many financial constraints and is attempting to survive in a competitive, volatile environment.

Other Senior Managers in the college used for the case study have stated that resourcing problems will be present. Difficulties will be created due to people with inadequate skills and a lack of commercial 'know how', value for money issues, and the distribution of a large portion of the salaries bill at the top of the staffing structure. All these issues will add to the time needed to design, develop and implement an appropriate system to assist them. Added to this Touche Ross (1992) recognize that there is likely to be some reduction in staff performance as a result of the attitude changes that will occur during the period of transition resulting from incorporation. Morgan (1990) states that fear, insecurity, lack of knowledge and resistance to change will affect attitudes. All these socio-organisational issues are affecting the College and could hinder the design, development and implementation of the Expert Advisor System. The design methodology will need to be capable of documenting and considering environmental and change issues such as these.

De Hoog et al participated in the KADS-II ESPIRIT project. They explain the main goal of the Organisation Model as:

> 'the identification and storage of data about organisational features, which are relevant for decision making related to the knowledge-based system'

This goal of the Organisational Model is synonymous with the goal of the Expert Advisor System. The Organisational Model for the college being used for this research is presented in Figure 5.1.

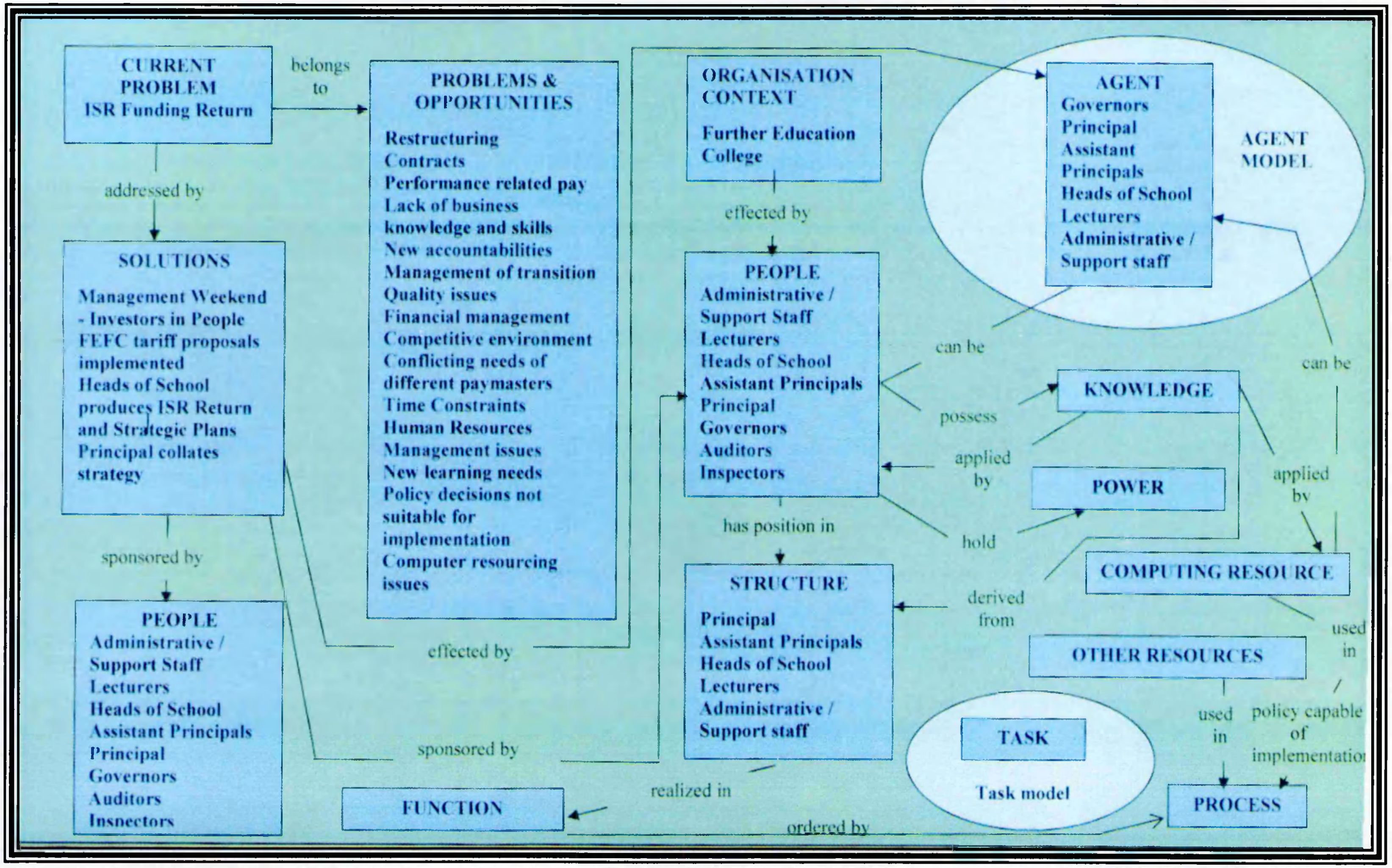


Figure 5.1
The Organisation Model

5.3.2 THE DESIGN OF THE ORGANISATION MODEL

The Further Education College used for this research provides the *organisational context* for this particular model. Through meetings with FEFC auditors and inspectors, senior managers, lecturing, technical and administrative staff it was found that the College needed a system that could provide decision support information to assist in the effective management of *problems*, and the exploitation of *opportunities*. Many problems were identified that could directly or indirectly affect the production of ISR funding bids.

During discussions the managers felt the Expert Advisor System should initially focus on the provision of decision support information for ISR Funding Returns. They also identified other areas where they would like the Expert Advisor System to be used to meet college requirements as opposed to FEFC requirements. Examples of these were:

- course and student profiling to determine profitable and non-profitable opportunities,
- forecasting to plan and budget against predicted enrolments,
- pricing and marketing of courses,
- outlet analysis to monitor the success rates of offering courses at different locations, and
- business unit analysis within the College to monitor the success rates of different Schools or programme areas.

It was determined that these areas would be outside the scope of this work although they could be used as a basis for future research.

In the Organisation Model the ISR Funding Return has been chosen as the *current problem.* One element of the *solutions* that will contribute to completing this return is an *'Investors in People'* weekend for the Senior Management team. This weekend enables them to work without interruption, communicate effectively and consider funding and strategic planning issues such as *FEFC tariff proposals*, whilst making a contribution to the college gaining the 'Investors in People' award. *Implementing these tariff proposals* in the operational system will have a significant impact on the *completion of the ISR Funding Returns*. It will effect growth and expansion and will have operational and strategic implications.

The *function* in the model is the management function that produces the ISR Funding Returns and presents them to the College Governors for approval or revision prior to submission to the

FEFC within the nominated time span. The *process* is producing the returns. The current *structure* is the staffing structure of the College being used for this research. There is no standard structure amongst colleges however and structures frequently change as colleges try to survive. McGavin (1999a) reported the plight of Gwent Tertiary College from a restructuring exercise:

> 'The largest FE College in Wales was plunged into a financial crisis by a restructuring exercise, a two-year investigation by the National Audit Office has found. The 70-page report on Gwent Tertiary College says a lack of planning, poor monitoring and "often misleading" financial information led to a deficit of nearly £7 million being run up in a year"

The College used as a basis for this research, like Gwent Tertiary College, had been involved in restructuring and was concerned about its finances. Despite growth and expansion having been achieved, a flatter structure had been introduced to reduce the need for additional staff, to improve communications and to reduce the wages bill. Due to the fast rate of change and frequent restructuring, the College, like many others, failed to define how its functional units related to each other and what their responsibilities were. **This resulted in *assumptions* being made concerning the *Structural* element of the Organisation Model.**

During the investigative work for the Expert Advisor System interviews with College staff took place to analyse the roles of *people* who were agents or stakeholders in the system. This research concentrated on the organisational roles of the people but not on their knowledge or power. *What* individual perceptions of a problem were, *what* attitudes people had to a problem solution and *what* responsibilities they carried were investigated. The findings of this research are given in Table 5.1.

People	Perceptions of the ISR return funding problem	Attitudes	Responsibilities
Administrative Staff	Additional unplanned administrative duties	Reluctance to undertake task due to pressure of work and dispute on pay for new accountabilities still unresolved	Typing, Spreadsheets, Filing, Reception, Enrolment, Coding and Data Entry duties
Support Staff	Additional unplanned, unscheduled work. Resourcing inadequate to deal with new work.	Reluctance to undertake tasks due to pressure of work and dispute on new accountabilities not resolved. Additional training needed.	Purchase, installation, updates, housekeeping, development work on hardware, software, networks and MIS. Help desk and Ad hoc queries. Word Processing technical support. Production of Statistical Returns and ad hoc returns.
Lecturers	Another task which could result in more work and responsibilities	Willingness to become involved in additional work if it could benefit the college and the impact on individual workloads was recognized and managed effectively	Enrolments, provision of study notes and exam material, lecturing, administration, student support, collection and collation of statistics.
Heads of School	A new task which requires more training and understanding if it is to be done effectively	Willingness to become involved but would like operational outcomes to be regularly monitored against strategic plans	Management of students, lecturers, timetables, rooming allocations, funding bids, resourcing, course provision, internal and external competition, marketing and administration
Principal	A new task which must be undertaken to meet internal and external needs	An important task in the survival exercise which must be understood and managed effectively	The successful operation and survival of the college
Governors	A task which must be undertaken to meet internal and external needs	An opportunity to combine commercial and educational skills to further the work of the college and ensure its survival and ability to provide a quality education for students	The successful operation and survival of the college

Table 5.1
The Organisation Model - People and their Role

Completing ISR Funding Returns is a task that college people had not undertaken before Incorporation. It is a complex task of which they have limited understanding. A substantial amount of the required *knowledge* needed to complete the task is acquired by interpreting MIS data. Figures from completed returns are used to assess patterns that have occurred in the past. Situational knowledge at different points in time cannot be extracted from the MIS because information in the relational database has been overwritten. Past returns have often been built using information gained from incomplete, inaccurate data. Colleges need an Expert Advisor System to help them make informed decisions that influence the completion of ISR Funding Returns. The knowledge needed for the returns is very important to colleges. The FEFC (1999c) have stated they intend to use outcomes from the regional review process on matters such as strategic planning, financial management and management and governance to identify colleges which are performing poorly. The regional review process will have influenced the decision resulting from the FEFC (1999g) findings on Bilston College reported by McGavin (1999b).

> 'Bilston Community College is to close following a damning report detailing the financial crisis at the college'.

The college involved in this research wants to use the Expert Advisor System to gain knowledge to inform the decision making that influences the completion of their financial returns.

The *computing resource* in the college is client server hardware, the FECAS MIS using Ingres relational database technology, Microsoft Access database software and Microsoft Excel spreadsheet software. A need for knowledge has been identified but the college but does not have a KBS.

5.4 THE TASK MODEL

5.4.1 THE PURPOSE OF THE TASK MODEL

During discussions with college managers it became clear that they expected explanations of the tasks the system would do and what the tasks would achieve. The CommonKADS *Task Model* provides a simple schematic that can be used to communicate with college managers and assist them in understanding the tasks the Expert Advisor System will perform. Wielinga et al (1992) and Gustafsson and Menezes (1994) confirm that the CommonKADS *Task Model* specifies how the function of the system is achieved through the tasks the system performs. They add that the model documents the result of the analysis of the current and / or future solutions, scopes a KBS solution and supports the feasibility of the project.

5.4.2 THE DESIGN OF THE TASK MODEL

The *Task Model* is given in Figure 5.2. It demonstrates how the *task* of producing the ISR Funding Return in the changing, volatile, competitive *environment* of a Further Education college is performed. It identifies the *KBS subsystem,* which is the CBR package, and the *other subsystem,* which is the collection of the Microsoft Access and Excel packages. The college MIS system provides a system *input.* The system *output* is the set of total figures compiled from aggregations of the data, detailed data, and graphs such as bar charts or pie charts that are used to inform decision making. The Task Model demonstrates how the *Agent Model* will identify the people, hardware or systems that perform the task and will use information specified in the *Communication Model* to operate in the domain defined in the *Organisational Model.* The task will require *features* that are FEFC requirements and its successful completion will be realized through the use of the knowledge encompassed in the *Expertise Model.*

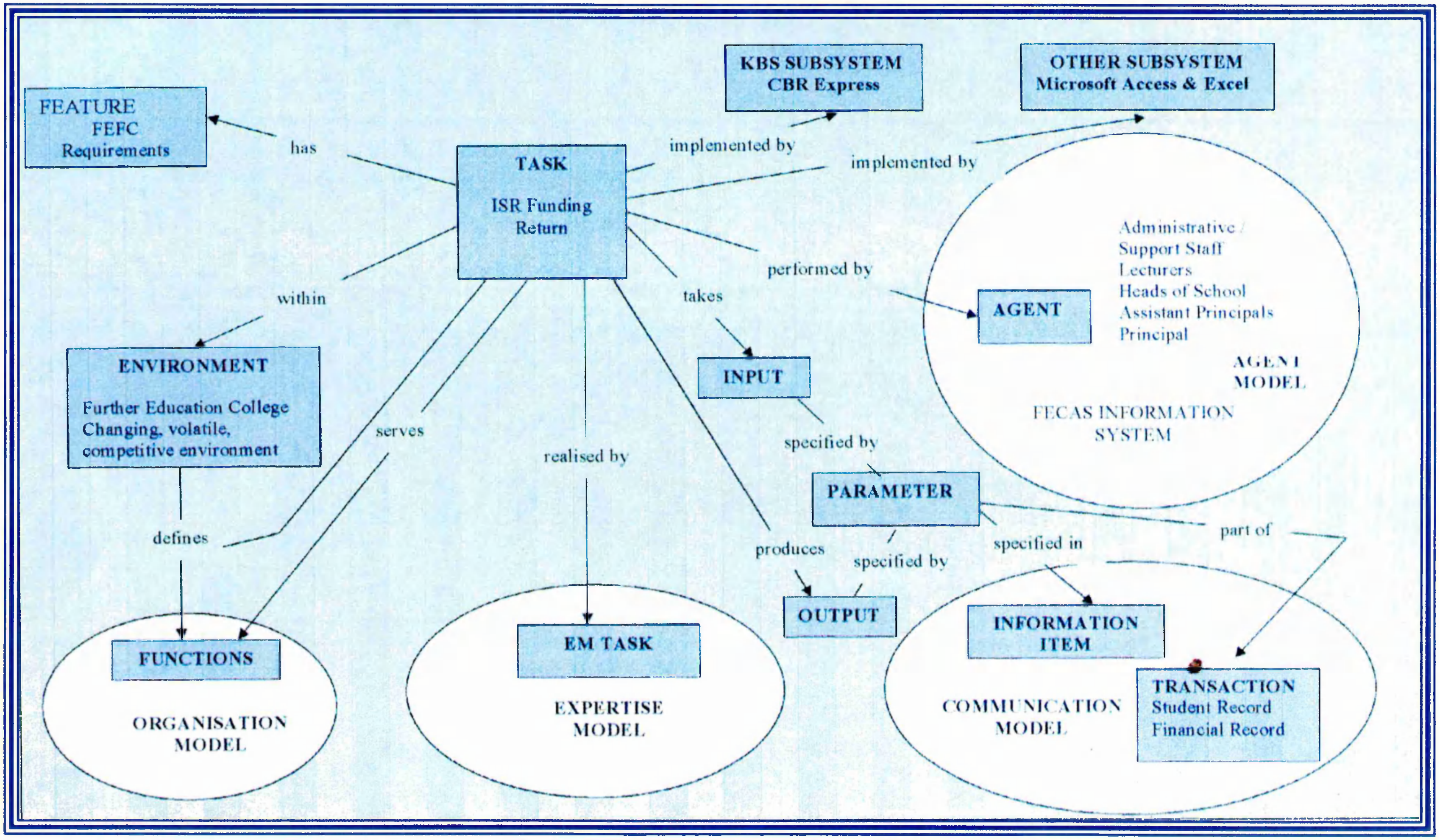


Figure 5.2
The Task Model

5.5 THE AGENT MODEL

5.5.1 THE PURPOSE OF THE AGENT MODEL

The *Agent Model* is used to provide the developer and the College with understanding of the system and its users and to identify how agents will perform their tasks. Gustafsson and Menezes (1994) confirm that this to be the purpose of the Agent Model.

5.5.2 THE DESIGN OF THE AGENT MODEL

An *agent* can be the KBS, a person, hardware or software. The Management team and Database Administration team are important *agents* in the college Agent Model. They use the *application* and *strategic knowledge* described in the Expertise Model to perform the *task* of completing the ISR Funding Return. Finance is a *constraint* that restricts the purchase of hardware, software and the use of staff time or the recruitment of staff with the appropriate specialist skills that are required to produce the ISR Funding Return. Participation and co-operation between the computer programs and the users of the Expert Advisor System is shown as interaction between the Agent and Communications Model. Management and technical capabilities of the people involved, and the knowledge acquisition capabilities of the Expert Advisor System are the *capabilities* in the Agent Model. The retrieval and comparison of cases and their conversion into knowledge are the *reasoning capabilities*. The *Agent Model* is presented in Figure 5.3.

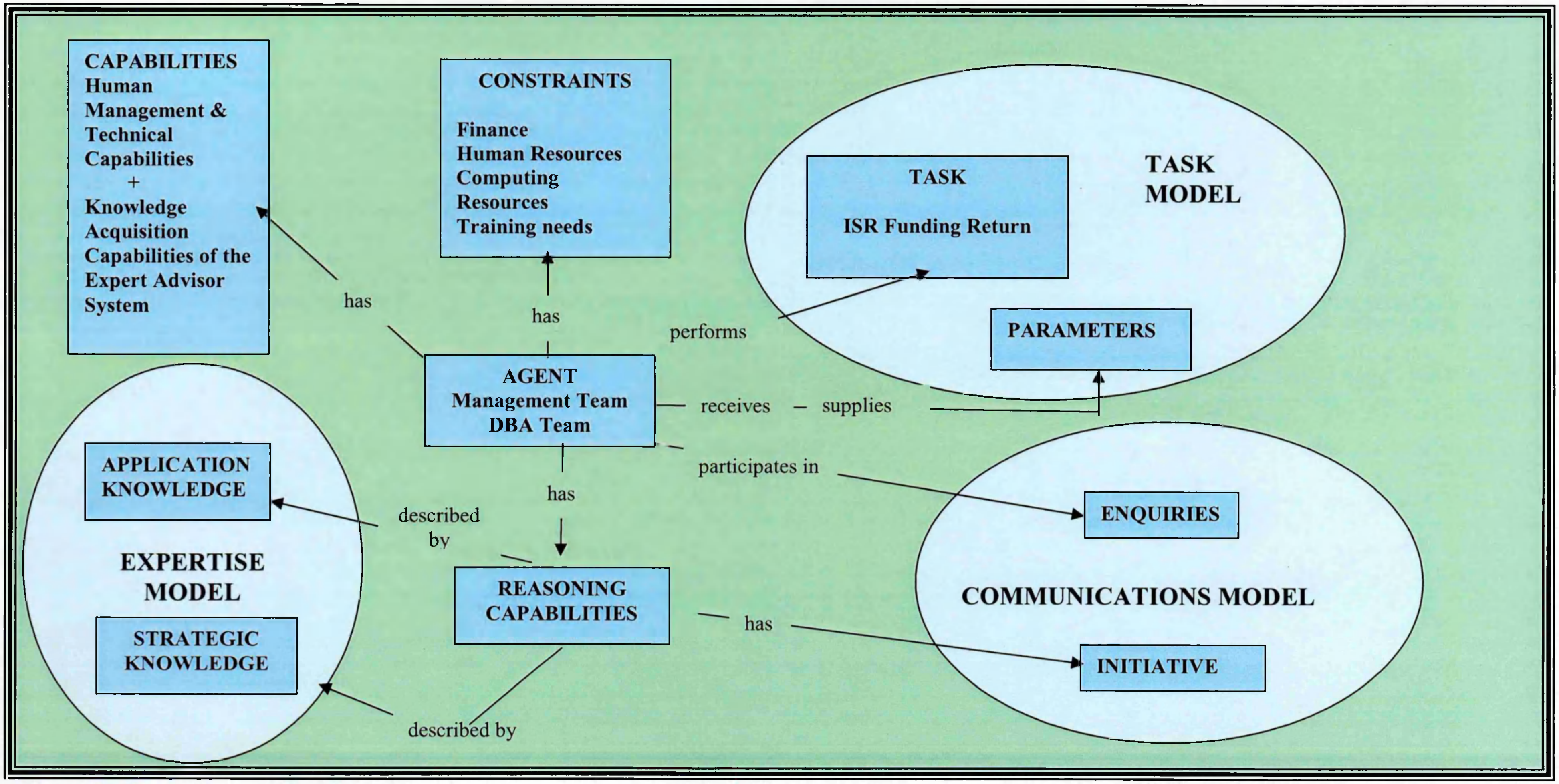


Figure 5.3
The Agent Model

5.6 THE EXPERTISE MODEL

5.6.1 THE PURPOSE OF THE EXPERTISE MODEL

Gustafsson and Menezes (1994) explain how the Expertise Model shows the problem solving behaviour the system is required to perform and how the input to the model is the problem solving performed by the human 'expert'. The model encompasses the strategic knowledge that is used to decide which goals are needed to solve a problem. It is also used to suggest new approaches or to introduce assumptions when a partial solution is arrived at because information is not available, or because contradictory information is present.

5.6.2 THE DESIGN OF THE EXPERTISE MODEL

The *problem solving method* is the Case-Based Reasoning used by the Expert Advisor System. The Expert Systems element of the CBR enables the encapsulation of rules that constrain the answers to different case questions relating to the provision of the ISR Funding Returns. The natural language interface allows searches for information to be made in English rather than a programming language. Microsoft Access and Excel are used to apply the principles of Data Warehousing and Data Mining to allow complete and accurate historical aggregated data to be stored, retrieved and displayed as totals and charts at different points in time. S*trategic knowledge* is gained by retrieving matching or partially matching cases, using weightings to alter the significance of different factors and possibly adapting a partial case solution to become a new case. Knowledge is also acquired through the retrieval of data, aggregated data counts and graphics such as bar charts or pie charts for different points in time

The *task layer* provides control over the inference steps specified in the inference layer and also specifies the sequence in which the inference steps will be executed. The steps specified for an ISR case are contained in a case BNF report. The *inference layer* provides the theory relating to the use of the domain layer. Its role is

a) to state what the potential inferences are that can be made using the knowledge specified in the domain layer, without specifying which inferences actually need to be made or the order in which they need to be made. The CBR Expert System component offers this facility.

b) to model possible inferences as knowledge sources. Case question data, aggregated counts derived from the data and charts and the results of 'what-if' projections are knowledge sources

c) to model the data elements that are produced when the knowledge source operates on data elements and produces new data elements. The data elements are modeled as meta-classes. The Expert Advisor System uses a meta-class input to retrieve detailed case data relating to a particular category of funding bid. In the prototype this could be either 'ISR' or 'DLE'. ‘Categories’ are in fact 'classes'. The term ‘Category’ was used rather than ‘Class’ because it was already in use in the college.

The *domain layer* is knowledge about the Further Education College problem domain and the FEFC rules relating to the ISR Funding Return.

The Expertise Model schema is presented in Figure 5.4.

Problem Solving Knowledge

PROBLEM SOLVING METHODS

Use of CBR incorporating an Expert System and a Natural Language interface

Access & Excel to implement the principles of Data Warehousing & Data Mining

STRATEGIC KNOWLEDGE

Acquired through case retrieval, the application of weighting factors & potentially through case adaptation

Acquired through data retrieval, aggregated data counts & graphics for different points in time and 'what-if' projections

TASK KNOWLEDGE

CBR provides control over the inference steps and specifies the sequence in which they are executed. The BNF report documents this activity

INFERENCE KNOWLEDGE

States what potential inferences can be made

Models possible inferences as knowledge sources

Models the new data elements that are produced when the knowledge source operates on existing data elements. Data elements are modeled as meta-classes.

DOMAIN KNOWLEDGE

Declarative knowledge about the Further Education College problem domain

FEFC rules relating to the ISR Funding Return

Expert Advisor System Knowledge

Figure 5.4
The Expertise Model

5.7 THE COMMUNICATION MODEL

5.7.1 THE PURPOSE OF THE COMMUNICATIONS MODEL

Gustafsson and Menezes (1994) explain how the Communication Model models the integration or co-operation of the future system with the user, other agents or other system components. It considers how computer programs and users of the system work together and specifies the environment in which the knowledge-based system (KBS) must work. The model does not cover human to human communication because the KADS structure is not yet able to offer much support for task negotiation, and because it is hard to describe human communication in a way which allows chunks of knowledge or information to be transferred. The model uses *explanations, initiative* and *dialogue* to allow human-computer interaction to take place.

5.7.2 THE DESIGN OF THE COMMUNICATIONS MODEL

The following scenario provides a detailed understanding of how the Communications Model operates in the Further Education College. The Communications Model schema that it relates to is given in Figure 5.5.

The agent, who is a member of the management team, *explains* the need for funding information. Another agent who controls the Expert Advisor System and is a member of the database administration team takes the *initiative* and performs a natural language search using the CBR component of the Expert Advisor System. The search is a *transaction enquiry.* Search *parameters* are passed to the *Task Model* that specifies how the CaseBase search function will be performed. Either matching, or partially matching cases, or no cases are retrieved. The cases are the *information item.* The *discourse* relates to acceptance of the case, alteration of weighting factors if required, and a rerun of the search, or adaptation of a partially matching case, to form a new case. If there is no case match a new case is developed. The DBA team gains knowledge from the case retrieval process and now become *involved* in a new *transaction enquiry* to gain knowledge about the data that support the case question solution. Snapshots of data relating to different points in time are held in the Data Warehouse. Access and Excel use the *transfer task* which is the problem solving method of the *Expertise Model* and the Data Warehouse data to *realize* the system output that informs management decision making. The system output will be detailed data, aggregated data counts and graphics such as bar charts or pie charts that support each question in the case solution. The Expert Advisor System is menu driven. The menu provides an *interface* that enables the user and the system to enter into a *dialogue.*

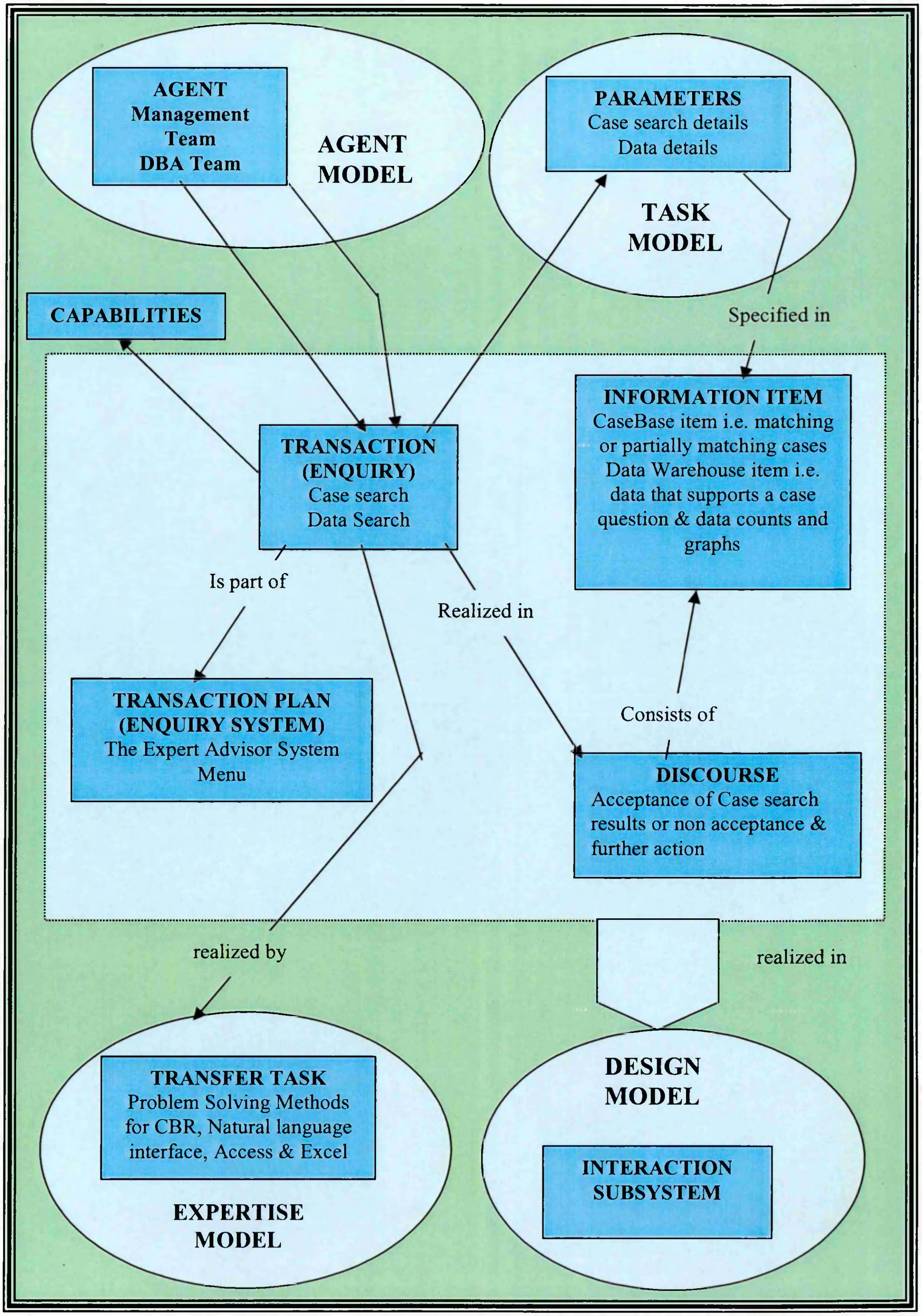


Figure 5.5
The Communication Model

5.8 THE DESIGN MODEL

5.8.1 THE PURPOSE OF THE DESIGN MODEL

The Design Model shows the techniques needed to support the other models. It provides a framework for keeping analysis and implementation separate, ensuring quality, keeping the system specification and the hardware platform separate, considering environmental factors such as run time requirements, building reusable components, and designing the human / computer interface. Gustafsson and Menezes (1994) state that the Application Design, the Architecture Design and the Platform Design constitute the Design Model.

5.8.2 DESIGNING THE APPLICATION, THE ARCHITECTURE AND THE PLATFORM COMPONENTS OF THE DESIGN MODEL

The Application Design Model shows the decomposition of the Expert Advisor System into the MIS, CBR, Microsoft Access and Excel. Details are given in Figure 5.6.

The Architecture Design Model shows the application specification and how it is realized in the architecture. Details are given in Figure 5.7.

The Platform Design specifies the target language and the hardware and software platforms. Details are given in Figure 5.8.

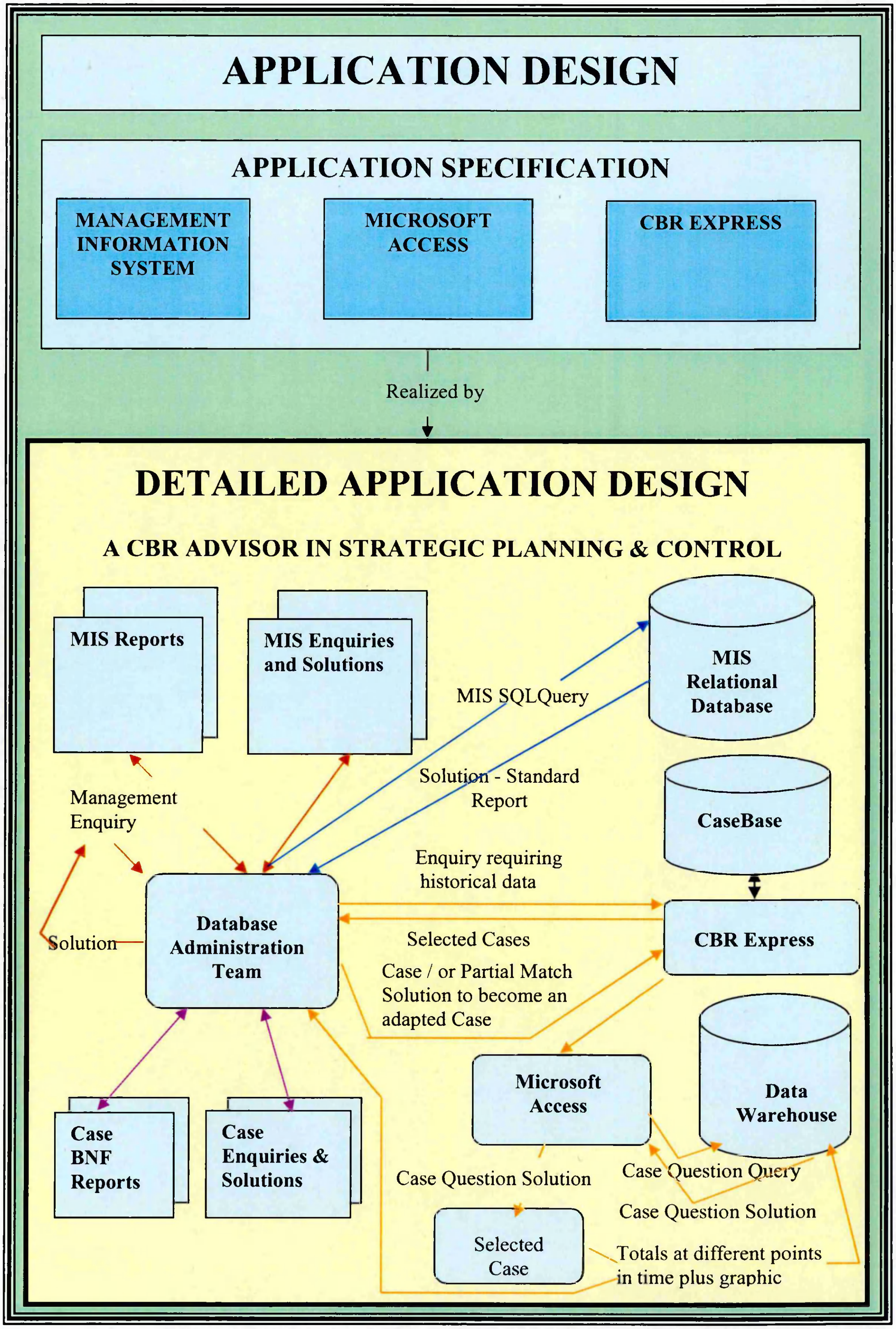


Figure 5.6
The Application Design

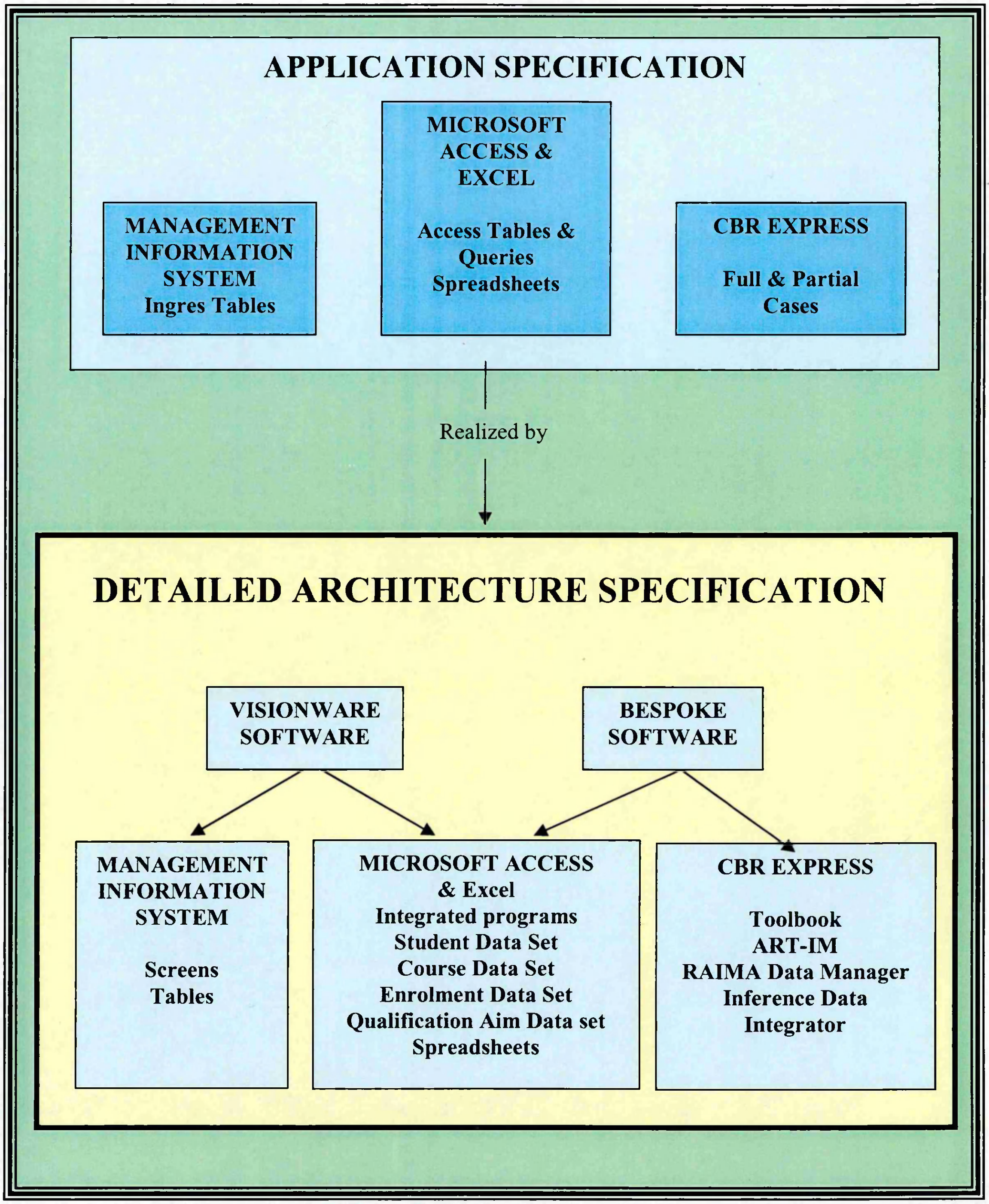


Figure 5.7
The Architecture Design

LANGUAGE SPECIFICATION

Languages:
- Access Basic
- SQL

CBR Express:
- uses software packages to produce a dynamic case base search environment
- a graphical User interface written in Toolbook
- a case matching mechanism which is part of ART-IM the Automatic Reasoning Tool used for Information Management
- a database layer provided either by RAIMA Data Manager or Inference Data Integrator
- a communications link to SQL Server and Oracle Databases using the Inference Data Integrator
- Q+E Databases library from Pioneer Software used to reach additional databases
- ART-IM development environment which supports the development of Expert Systems. The features of ART-IM are integrated into a single inference engine and all can be used simultaneously. It includes
    - A powerful forward-chaining rule system
    - Object-oriented data representation (schema)
    - A procedural language for user-defined functions and messages
    - A data conversion utility for communication with external data sources
    - A procedural interface for integration with user- written programs
    - A windows development environment
    - Kernel support for high-speed case matching, AND
- C libraries used as DDLs

Realized by

IMPLEMENTATION PLATFORM

PACKARD BELL LEGEND 605 ELITE 486 DX
BIOS Phoenix
Conventional memory 640K
RAM 19,712K
Extended Memory 1,024K
VGA Colour Monitor
DOS 5.00
Windows 3.11
PS/2 Style Mouse
Discs Floppy 3.5" 1.44M; Floppy 5.25" 1.2M; Fixed 181M; Fixed 503M
LPT Port; Comms Port 2

Figure 5.8
The Platform Design

5.9 DESIGN METHODOLOGY CONCLUSIONS

The major system design features offered by CommonKADS, which influenced the success of the Expert Advisor System, were firstly the power of the Organisation Model to capture the socio-organisational environment where the KBS would be developed. Secondly, the provision of support for knowledge elicitation. This made it easier to tackle the problematic areas of the Further Education domain where many experts disagreed. These areas were where the system was not limited to a single, clear area of expertise, where the knowledge of one expert could not cover the entire domain, and where the domain had poorly defined or ambiguous descriptions.

Although the value of the CommonKADS methodology was confirmed through its use in the analysis and design of the Expert Advisor System, a significant constraint in the Organisation Model became obvious. It was found that the *Structure* element of the Organisation Model could not be accurately represented and assumptions had to be made. As stated in Section 5.3.2 due to the fast rate of change and frequent restructuring, the College used for this work, like many others, failed to define how the functional units related to each other and what their responsibilities were. This resulted in assumptions being made relating to the structural element of the Organisation Model for the Expert Advisor System.

Crequer (2000) wrote about a report on Bolton College that stated that the college was the latest college inspection casualty. It catalogued a list of failures of control and worsening performance and a £6.8 million debt, and drew attention to the continuing problem of restructuring. Crequer said:

> 'The Principal is absent on long-term sick leave and the Senior Management structure was revamped twice in the two months before inspection. There were more than 30 redundancies pending'.

This statement confirms that restructuring is happening in other colleges. These colleges would also have difficulty defining the structure element of the Organisational Model.

This constraint needs to be recognized when CommonKADS is used in a complex, volatile environment such as that of the Further Education Sector. Due to the rapid rate of change assumptions have to be made where facts are unknown and cannot be represented accurately in the structure element of the Organisation Model.

CHAPTER 6 - PREPARATION FOR THE DEVELOPMENT OF THE EXPERT ADVISOR SYSTEM

6.1 DEVELOPMENT CONSIDERATIONS

This chapter will build on the work of Chapter 4 where the technologies were selected, and the work of Chapter 5 where the methodology was selected and used to design the CommonKADS models. It discusses important factors that need to be considered during system development, and the problem of system degradation occurring when an OLTP system is used to acquire decision support information. It also provides a detailed explanation of the architecture and the case structure that will be used in the development of the prototype.

6.1.1 DISASTERS AND COMPLEXITY

During the development of the Expert Advisor System consideration will be given to statements such as those made by Abbott (2000). He says that software companies and IT professionals are not eager to share their disaster stories with the public but application failures happen with alarming regularity. He goes on to say that the Wall Street Journal estimates that 50 per cent of all corporate technology projects do not meet expectations, and that 42 per cent of software projects are abandoned before getting off the ground. He then continues to mention that changing software requirements are a necessary evil in today's evolving market and business practices are shifting at a rapid rate. These comments serve as a reminder of what was stated about government IT projects in Section 2.4.2, and the colleges' perception of the ISR funding methodology and the associated software in Section 2.6.

Issues such as integration failure need to be considered when the technologies that have been selected for use in the Expert Advisor System are brought together. Care also needs to be taken when the student record data from the MIS system are used by the Expert Advisor System and data integrity needs to be maintained, and system degradation needs to be avoided. In addition to this consideration needs to be given to the unstable FEFC / LSC software which provides unpredictable results. The complexity of the ISR funding methodology also needs careful assessment.

6.1.2 PROJECTIONS AND WHAT-IF SCENARIOS

Not only do system problems need to be considered, but also the financial changes that are happening. Dearing (1997) says, ironically, when most organisations decide on new accounting software they do not look beyond today's flurry of functional requirements. These organisations develop extensive lists of requirements such as, can the software do budgeting, allocation, or cash applications. Yet, he says they fail to consider how the dynamic nature of today's business environment will affect those requirements in the future. Further Education colleges are organisations that will need to consider their future financial requirements. With the complexity of the ISR funding methodology and the sort of statements currently being made in the press about funding, the colleges will be looking beyond the usual financial systems expectations and looking for an Intelligent Decision Support System to help them with their funding bids. Kingston (2003) reported in the Guardian that colleges are being warned they will not enjoy the cash bonanza next year that some had been hoping for following the Government's announcement of an extra £1.3bn for Further Education. He says the Association of Colleges have told their members that changes in the sector's funding system will have the net effect of wiping out the expected 2% real-terms cash increase and leaving growth pretty much in line with inflation. He reports that Peter Pendle, the General Secretary of the Association for College Management says:

> 'It just underlines that although we've had the extra money, the sector continues to be underfunded and we've had years and years of underfunding. It's going to take something quite considerable to turn this round'.

Statements such as this demonstrate the financial difficulty that is facing colleges. They also emphasize the importance of ISR Funding Returns and the projected figures in the FEFC strategic planning returns. The relationship between these two returns was explained in Section 2.8. An understanding of the Further Education financial situation, the importance of the actual and the projected figures in these returns and an awareness of the vulnerability of colleges reinforces the need for the Expert Advisor System to make provision for projected figures and 'what-if' scenarios. These are features that will be part of the development of the Expert Advisor System.

6.1.3 HINDSIGHT, FORESIGHT AND OVERSIGHT

Decision Point Applications (2000) explain the requirements of financial decision support systems further. They define other features that a decision support system must provide. These are:

- *Hindsight:* to look into the past in detail to get authoritative characterizations of past reality

- *Foresight:* to use authoritative hindsight to develop reasonable forward-looking projections of costs and revenues in any given area of the organisation

- *Oversight:* to get both an overview and deep detail within a specific area of the organization

Each of these features will be a characteristic of the Expert Advisor System and enable informed financial decisions to be made based on the student record data from the MIS, the FEFC funding rules and the FEFC tariff funding unit.

6.1.4 DATA QUALITY AND DATA MANAGEMENT

Raedel Financial Solutions (2001) have highlighted another important issue for financial decision-makers. It affects the provision of auditable data trails. They say that over the past decade the quantity of data available to decision-makers has increased exponentially and continues to do so at an accelerating rate. Like the Commercial Sector, the FE Sector is also experiencing growth in the quantity of data they handle. Sections 2.9.4, 2.9.11 and 2.9.13 discussed growth in student data that colleges are required to collect to meet FEFC requirements. These are data that are used to substantiate financial decisions.

Trillium Software (2002) draw attention to the problems of data management that were discussed in Section 2.2. This is an important issue that needs to be considered when handling a vast quantity of data. They say that business and technical managers are having a 'hard time' (sic) presenting a viable cost justification for implementing data quality in their organisations. They suggest that the problem lies in a disconnect between the individuals that actually see data quality problems and the decision makers that need to understand the bottom-line impact of data quality in their companies. They add that businesses will lose revenue and reduce operating efficiencies if they do not pay attention to data quality. These comments from Trillium Software are relevant to many organisations but in this case they provide a reminder of the critical need for data management and data quality in Further Education. Inaccurate, incomplete and wrongly coded student data can contribute significantly to colleges underachieving on their ISR funding bids.

The findings from the Raising Quality and Achievement Programme (RQA) (2000) illustrate this problem area of Further Education. Whilst reporting on the Further Education Development Agency (FEDA) projects they said that in 1997 the quality, quantity, detail, timeliness and accessibility of information from one college's MIS needed to be improved. In addition to this they said the college had found that there was a lack of faith in the data on their system being accurate. There was also doubt about whether the student retention and achievement figures were true, and whether they could be used to judge any year on year improvement. In addition to this there was constant disagreement between the curriculum areas and 'the system' about whose data was correct. Although the college knew their funding and reputation were suffering there was doubt about whether the college's performance was actually better than that recorded on their system. The Raising Quality and Achievement Programme (ibid) also stated that the college said that they were probably not unique in finding that their ISR data consistently produced different results when it was used with the FEFC software compared to when it was used with their own kite-marked software. This shows a need for quality data and data management. It also emphasizes the difficulty the college was experiencing with FEFC ISR software.

These needs were highlighted again by the Association of College Managers (ibid). They reported that Willis, the Director of Quality and Standards at the National Learning and Skills Council, said that over the past five years FE colleges had increased student numbers by 70%. Willis added that achievement rates had risen slightly and retention rates had remained steady. She also described how statistics showed that only 56% of 16 - 18 year olds who started a learning programme had achieved their qualification and how the figure for learners over the age of 18 was 51%. She continued by explaining how these aggregated figures concealed considerable variations between colleges. She said that average retention rates varied between 77% and 99% and average achievement between 34% and 96%. She then stated that the aim of the LSC was to tackle both the bottom and middle ranges of these figures. For colleges these percentage figures raise the question whether the data, and the software that they have used to produce their submissions to the FEFC / LSC, are producing correct results? Are these true percentage figures?

In the light of these comments, the colleges need to consider data quality and data management issues and the effect they have on their ISR Funding Returns. They need to ask if their returns show student enrollment, retention and achievement accurately, and if they are bidding for all the funding for which they are eligible. These questions are important. They mean that data quality and data management need to be considered when the Expert Advisor System is developed.

6.1.5 RULES FOR GAINING KNOWLEDGE

Astera (2001), whilst talking about rules relating to mortgage banking, say the proliferation of rules, and the speed at which they change, poses a formidable challenge. They reveal how business rules are embedded directly in program code when typical software development is used. They then describe how procedural logic explains how the program works and business logic explains what the program does. They also point out that, when this approach is adopted, programmers are usually the only ones who understand the implementation of the business rules and are also the only ones who are able to change them. In addition to this they say that because business rules are intertwined with other program elements, changing the rules requires a significant amount of lead-time. They also add that changes can have unpredictable effects on the functionality of an application as a whole and make extensive testing necessary.

Colleges also have the problem of handling the rules relating to the FEFC / LSC funding. These are rules that are rapidly changing and the use of conventional software development methods to meet financial decision support needs could lead to similar problems to those outlined by Astera. A sample of typical changes to FEFC funding rules is given in Figure 6.1.

Learning and Skills Council
Operations Directorate
Technical Information Note
Further Education: Effects of Funding Changes 2002/03

For load banded learning aims, the 2002/03 values are again very similar to 2001/02, except that:

- the funding for 3 and 6 guided learning hour courses has been reduced to more accurately reflect the likely costs involved
- a new load band for short courses was introduced, meaning the funding learning aims of 9-13 guided learning hours has decreased and for 14-19 increased
- for learning aims of above 600glh, the funding has been reduced to reflect the proportionately reduced costs of delivering these programmes

Source: LSC (2003)

http://www.lsc.gov.uk/news_docs/Technical-Information-Note.doc

Figure 6.1
Changing Funding Rules

Astera (ibid) talk about ways in which the problems of conventional software development can be overcome. They suggest that rules should be written in a language that can be understood by the business managers. This provides people who understand the way in which the rules are used in the business with a direct understanding of how they are implemented in the software. Astera add that if rules were handled in this way they would be easy to change and give businesses greater flexibility and allow them to react to changes in business and regulatory environments. They say that in addition to this, maintenance costs would fall because changing rules would require less programmer time and effort. The Expert Advisor System will take note of Astera's suggestions and use the facilities offered by the CBR Express package selected for use in the Expert Advisor system in Section 4.9. The rules will be written in English and facilities will be provided for inserting, amending and deleting rules. Maintenance will become a task that can be undertaken by those with business knowledge.

6.1.6 KNOWLEDGE POWER

Gallagher Financial Systems (2002) talk about knowledge management as another perspective of our expectations of systems. They say that in the business world knowledge is power. Knowledge is what enables businesses to grow and succeed and without knowledge a business cannot survive. They reveal how knowledge can be considered to be a business asset - perhaps the most important asset a business has. They state that a primary business concern must be how to capture and harness knowledge. This is an issue that needs to be addressed for the College that features in the case study. Section 5.2.4 described how one of the factors that influenced the choice of the CommonKADS methodology was its ability to handle knowledge elicitation. In addition to this the importance of knowledge-based decision making and its role in completing the ISR Funding Return was discussed in Section 3.1. The Expert Advisor System will be a knowledge-based system.

6.1.7 PAST DECISIONS

Brookfield (2000) discloses how often in the Public Sector, individuals make decisions where outcomes are far from certain. He reveals how uncertainty directs individuals to seek other mechanisms to support decisions. He explains how a combination of ignorance and the necessity to act, in a time constrained way, forces individuals to possibly follow the actions of others to seek out some convention which might provide guidance. The Expert Advisor System will provide this guidance through the provision of cases that show how past decisions relating to ISR Funding Returns were made. This will remedy the situation that was explained in Section 2.6 where the need for knowledge and understanding of past decisions was explained. It will also avoid the situation that was described in Section 3.1 when Princeton (2001) reported that it was stated that over 90 per cent of respondents to a survey said their organisation did not keep and share information on how past decisions were made.

Section 3.9 identified CSFs that were the need *to view detailed data and aggregated data for different time periods.* Access to this historic data would provide an audit trail to substantiate past decisions and would comply with the FEFC audit regulations for the ISR Funding Returns. Expert Advisor System facilities that provided cases and the supporting data would assist *Senior Managers in making informed operational and strategic decisions and substantiating those* *decisions.* This is another of the CSFs that were identified in Section 3.9.

6.1.8 JUST IN TIME DECISIONS

The Expert Advisor System is an Intelligent Decision Support System that aims to assist in better decision making. Comshare (2002) think of better decision making as providing 'Just in Time Information'. They say that just as there is value in manufacturing on a just in time basis, there is value in having information when it is needed - not before and not after. They explain how decisions are more informed with up to date data, time is not wasted researching issues that do not apply, and decision-makers are not burdened with facts they do not need. The Expert Advisor System will not only provide historic information but will be capable of working on current data and providing 'Just in Time Decision Making'. In doing so it will assist in achieving one of the CSFs that was defined in Section 3.9. The CSF identifies the need *for facilities to be provided to enable Senior Managers to make informed operational and strategic decisions and substantiate those decisions.*

6.1.9 THE EXPERT ADVISOR SYSTEM

The Expert Advisor System will be an Intelligent Decision Support System that uses data management techniques to achieve data quality and to handle large quantities of complex data. It will make provision for acquiring knowledge, managing changing rules, understanding past decisions relating to ISR funding bids, and will provide facilities for making projections and investigating 'what-if' scenarios. It is a system that will use data to substantiate decisions relating to past situations (hindsight), provide data that will enable projections for the future to be made (foresight) and provide detailed data that can be aggregated to produce totals and charts which will provide an overview of specific areas where decisions need to be made (oversight). It will offer intelligent decision making facilities to inform management in the smarter, learning organisation.

Rollins (2002) says that software technology evolves in phases and that each new phase begins with assumptions of the current era change, rendering existing solutions inadequate. He states that this creates an 'inflection point', where new assumptions are the catalyst for innovation and new solutions emerge. The Expert Advisor System prototype will bring existing technologies together in a new and different way to provide a data driven and knowledge driven system. It will provide learning that will contribute to the provision of innovative solutions to meet emerging needs in the advancing area of Intelligent Decision Support Systems.

6.2 CAPTURING REQUIREMENTS

Morris (2001) talks about relational database technology and identifies the problems which can happen in all organisations using SQL and Relational Database Management Systems (RDBMS). He explains how, as the number of users of a system increases so do the demands being made upon the system. He describes how this is just like a road system where increased traffic leads to congestion, increased waiting time and contention for resources. He also discusses how the characteristics of online real-time transactions are vastly different from those of ad hoc queries, and says that compromise will inevitably lead to degraded online performance. Later in his discussions he suggests that online real-time transactions and ad hoc queries should be performed on different machines. Although these statements relate to many organisations using RDBMS, Colleges are beginning to realize how relevant they are to them, as they try to acquire decision support information from OLTP systems and experience problems. System performance is an issue that needs to be addressed in the design of the Expert Advisor System architecture. Section 6.1.1 recognized that this need must be considered when disasters and complexity in corporate technology projects were discussed.

During conversations with the DBA team at the College used in the case study, the team emphasized that the college MIS was suitable for transaction processing but was not suitable for running queries to meet information needs. The DBA said the ad hoc queries that were made to obtain information for completion of the ISR Funding Returns frequently had many table joins and were often used to aggregate figures. These queries made heavy demands on the MIS and it was not unusual for them to impair system performance and response times. The DBA also pointed out that technical staff often worked weekends or started work at 6.00 am in the morning to run these sort of queries or to run SQL updates. Staff were not happy about this, but it was necessary that they should do it to avoid system degradation happening when the MIS was being used for transaction processing between 8.00 am and 10.00 pm. The DBA team also explained how SQL updates were often necessary when data had been coded and keyed into the MIS system and then the FEFC rules changed. The option often was to complete an ISR Funding Return using out of date data and underachieve on the funding, or to do the SQL update at an unsociable time to avoid impairing the performance of the MIS when it was being used for operational purposes. They also mentioned SQL updates being performed to correct data when discrepancies were discovered and stated that there was a definite need for data quality and data management.

I analysed a sample of 500 MIS queries and the following statistics were produced:

Number of queries with zero table joins	2%
Number of queries with 1-3 table joins	65%
Number of queries with 4-10 table joins	25%
Number of queries with > 10 table joins	8%

Interviews with the DBA team, and shadowing the team whilst they undertook their operational work, confirmed that queries with a large number of table joins impaired the performance of the MIS and resulted in a slow response to enquiries for decision support information. The team requested that the Expert Advisor System should not make intensive computational demands on the MIS and stated that it must be able to produce decision support information quickly. Interviews with other college managers confirmed the need for quick access to decision support information and revealed that, although they would like to be able to access this type of information from their desktops, initially they would prefer the DBA team to do this task for them.

6.3 THE EXPERT ADVISOR SYSTEM ARCHITECTURE

I found a major challenge of this research was to develop an Expert Advisor System architecture that would maintain the integrity of the existing MIS, provide a desktop enquiry facility, incorporate a user-friendly interface, include case and system adaptation, and integrate different 'off the shelf' packages. I also had to make provision in the design for dealing with incomplete, inaccurate, inconsistent data, storing historical data and providing graphical output to comply with the Critical Success Factors documented in Section 3.9. The architecture I designed to support these needs brought together the technologies identified as components of the system and used the principles of Data Warehousing as decided in Section 4.9.

The schema of the architecture provided later in Figure 6.2 shows how data that are relevant to ISR Funding Returns are extracted from the MIS then cleansed to achieve complete, accurate and consistent data, and also scrubbed to provide one common data format. They are then stored in a Data Warehouse. This data management provision addresses the issue raised by Trillium Software (2002) in Section 6.1.4. where they say business and technical managers are having a hard time presenting a viable cost justification for implementing data quality in their organisations and that businesses will lose revenue and reduce operating efficiencies if they do not pay attention to data quality. Discussions relating to the impact of data management on the accrual of funding took place with senior managers at the College and the importance of the Data Warehousing procedures were recognized. They agreed that this aspect of the Expert

Advisor System would help them to become more confident in their ISR Funding Return figures relating to enrolment, retention and achievement and enable them to optimize the funding.

Section 6.1.1 identified the need for integration to be considered carefully when the Expert Advisor System was developed. The Microsoft products, Access and Excel are part of an integrated software suite and CBR Express has facilities for integration with other products. Through using these products together the integration process was simplified and the products were brought together and easy access to decision support information was provided.

Ang and Thompson (2000) confirm that the architecture attributes that have just been discussed encompass the principles of Data Warehousing when they state:

> 'A Data Warehouse is a repository of summarized data (current as well as historical) assembled in a simplified format tailored for easy end-user access. These data are culled from existing operational systems and are structured for analysis and decision making'

The complete architecture for the Expert Advisor System is provided in Figure 6.2. Details of the Data Warehouse population procedure, the OLTP enquiry procedure, the decision support enquiry procedure and the procedure for storing decision support enquiry solutions are then provided and related to the specific part of the architecture given in Figure 6.2 that they use.

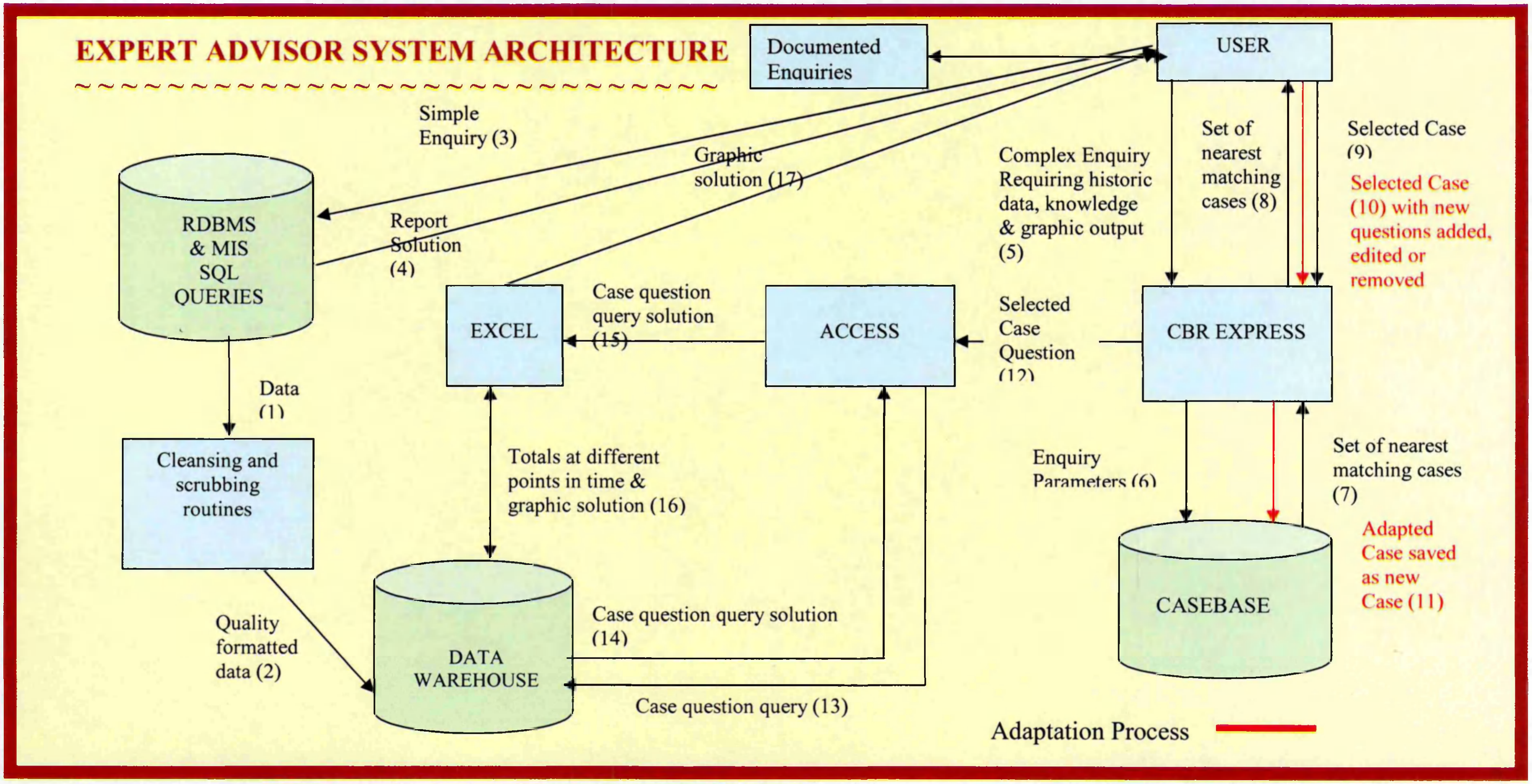


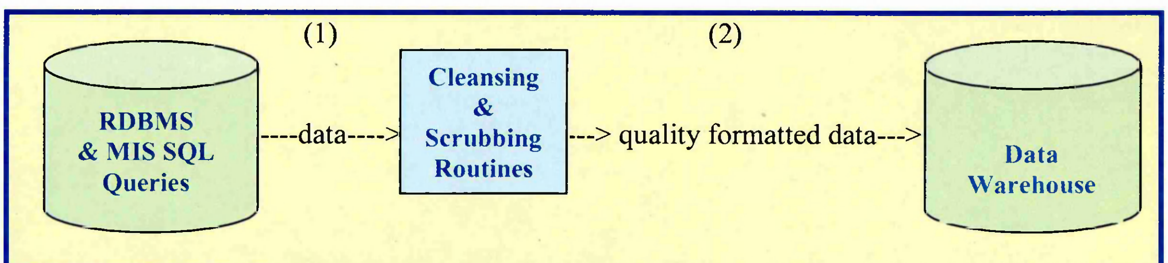
Figure 6.2
The Expert Advisor System Architecture

6.3.1 DATA WAREHOUSE POPULATION PROCEDURES

Section 2.2 talks about how many organisations have a need for data quality and data management. In addition to this, Section 3.3.4 speaks about the role of the FEFC auditors and discusses a statement by NILTA (2001a) that says the FEFC is very keen to see auditable college data. NILTA reports that the FEFC announced that Colleges must strive for 100% supporting evidence for their funding bids or risk a 'qualified' audit report and loss of funding. This highlights the need for effective data management in Further Education colleges. Section 3.3.5 also emphasizes the need for effective data management when it points out how FEFC inspectors gave a college a bad grade and said that the college had taken no steps to analyse their information needs or to develop a prioritized information and data management strategy

The importance of data quality and data management is considered when the procedure for populating the Data Warehouse in Figure 6.2 is used. This procedure is given in Figure 6.3 and discussed in detail. The data (1) that are extracted from the MIS are cleansed and scrubbed to produce quality, formatted data (2) and are stored in the Data Warehouse. TechTarget (2003) describe these data management procedures when they say:

> 'data scrubbing, also called data cleansing, is the process of amending or removing data in a database that is incorrect, incomplete, improperly formatted, or duplicated'.



Source: Figure 6.2 The Expert Advisor System Architecture

Figure 6.3
Cleansing and Scrubbing Data

Intelliclean (2003) explain how the key to effective data cleansing lies in having the knowledge needed to determine what constitutes acceptable data and what constitutes 'dirty' data. They add that knowledge of business rules, domain knowledge, equational theories and similarity functions are some of the forms of knowledge that are needed for data cleansing to be effective.

6.3.2 OLTP ENQUIRY PROCEDURE

When a transaction processing enquiry is made to meet operational needs and the architecture shown in Figure 6.2 and in Figure 6.4 is used, a simple SQL enquiry is made to the MIS (3) and a report containing the solution to the enquiry is produced (4). An example of this sort of enquiry could be:

What are the contact details for the student called John Smith?

This type of information would not be stored in the Data Warehouse as it would not be relevant to decision making. It would be operational information that was only stored in the MIS. Figure 6.4 shows how the procedures for an OLTP enquiry form part of the Expert Advisor System architecture that was provided in Figure 6.2.

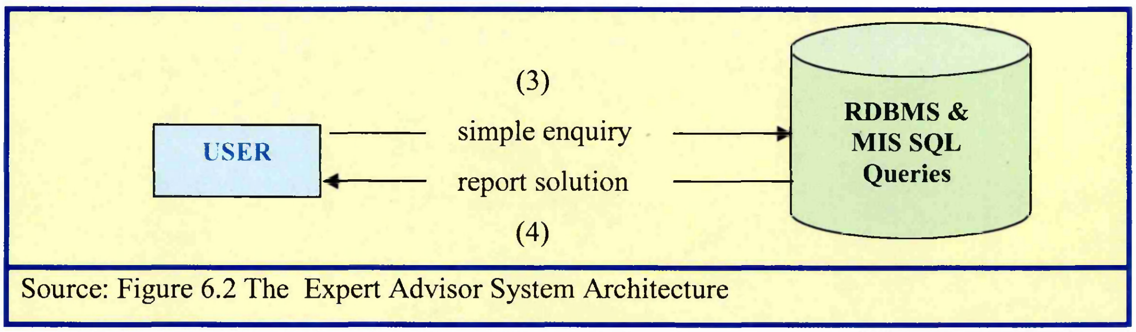


Figure 6.4
OLTP Enquiry

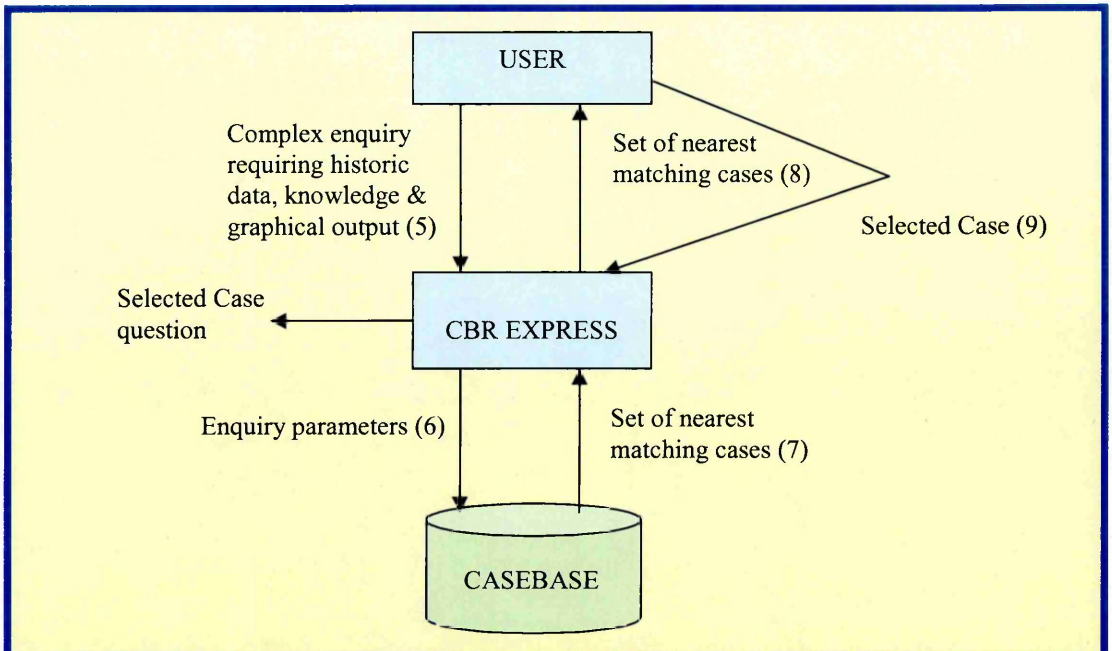
6.3.3 DECISION SUPPORT ENQUIRY PROCEDURE

Teradata (2003) explain how a Data Warehouse is a database designed to support decision making. It is a subject-oriented, time-variant, nonvolatile collection of data which supports the management decision making process. The Data Warehouse in Figure 6.2 stores student data to support the decision making for the ISR Funding Return. The prototype data are stored for 1994, 1995 and 1996. Inmon (2000f) explains how a snapshot of data from the operational database is used to create records in a Data Warehouse and how the snapshot relates to a particular point in time. He continues by explaining how data in the snapshot are fundamentally different from data values in the operational database in that they cannot be updated. The Data Warehouse snapshots of historic data remedy a situation described by the college managers in Section 4.3. The managers highlighted the difficulty that faces them when the operational MIS data are continually overwritten. This prevents decision support information being extracted for different time periods and prevents comparisons being made. In addition to this Section 2.8 explained how auditable data trails that supported the figures in ISR Funding Returns needed to be available to FEFC inspectors and auditors during their visits to colleges. Data Warehouse snapshots for the point in time of each ISR Funding Return can provide these data trails. They also allow the College to keep and share information on how past decisions were made. In Section 6.1.7 Princeton (2001) gave details of a survey outcome that showed that organisations were not doing this.

Snapshots of historic data in the Data Warehouse will be especially useful for the college when the points in time correspond to the ISR Funding Return census dates. The Association of Accounting Technicians (2003), whilst reporting on a presentation by Peter Jordan of the LSC, say the tri-annual census dates are 1st November, 1st February and 15th May. In addition to this The Association of Learning Providers (2000) point out that the current FEFC tri-annual census points are designed to suite a three term academic year. They argue that the work-based route operates on a true roll-on-roll-off basis, with trainees joining and leaving programmes throughout the year. They also say that it is common for students to be recruited onto many programmes of learning and workforce development, become qualified and leave in the period between the census dates. They strongly recommend that providers keep monthly records. If this happens monthly snapshots in the Data Warehouse will also prove useful to the College.

When a complex enquiry for decision support information is made, access to the historical data stored in the snapshots in the Data Warehouse are often required to allow comparisons to be made. In addition to this, in Section 3.7, managers from other colleges made the point that information was not enough. They said they also wanted graphical output to be available so that they could quickly and easily assimilate the information that was produced. The College also defined this need as one of their Critical Success Factors for the Expert Advisor System in Section 3.9. The Expert Advisor System architecture has to make provision for this graphical output.

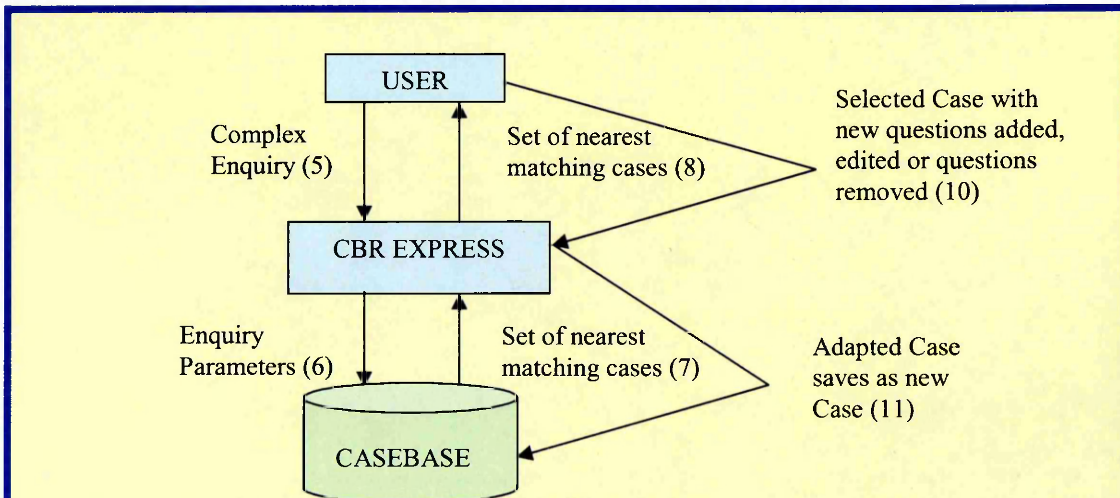
When a decision support enquiry is made the procedure given in Figure 6.5 is followed. Figure 6.5 is part of the overall procedure that has already been provided in Figure 6.2. The user makes a natural language enquiry (5) to the CBR component of the Expert Advisor System. The enquiry parameters are passed to the casebase and a casebase search is performed (6) to identify cases with questions in them that match, or partially match, the descriptor in the user natural language enquiry. Cases that are identified are displayed in order according to their closeness of match. The number of cases that are displayed as a result of a search can be set in the system parameters. The CBR component identifies matching and partially matching cases (7). The cases are displayed for the user to evaluate how closely they match the enquiry (8). The user then selects one of the cases (9) that has been found through the search and accepts it as providing an appropriate solution to the enquiry they have made.



Source: Figure 6.2 The Expert Advisor System Architecture

Figure 6.5
A Decision Support Enquiry

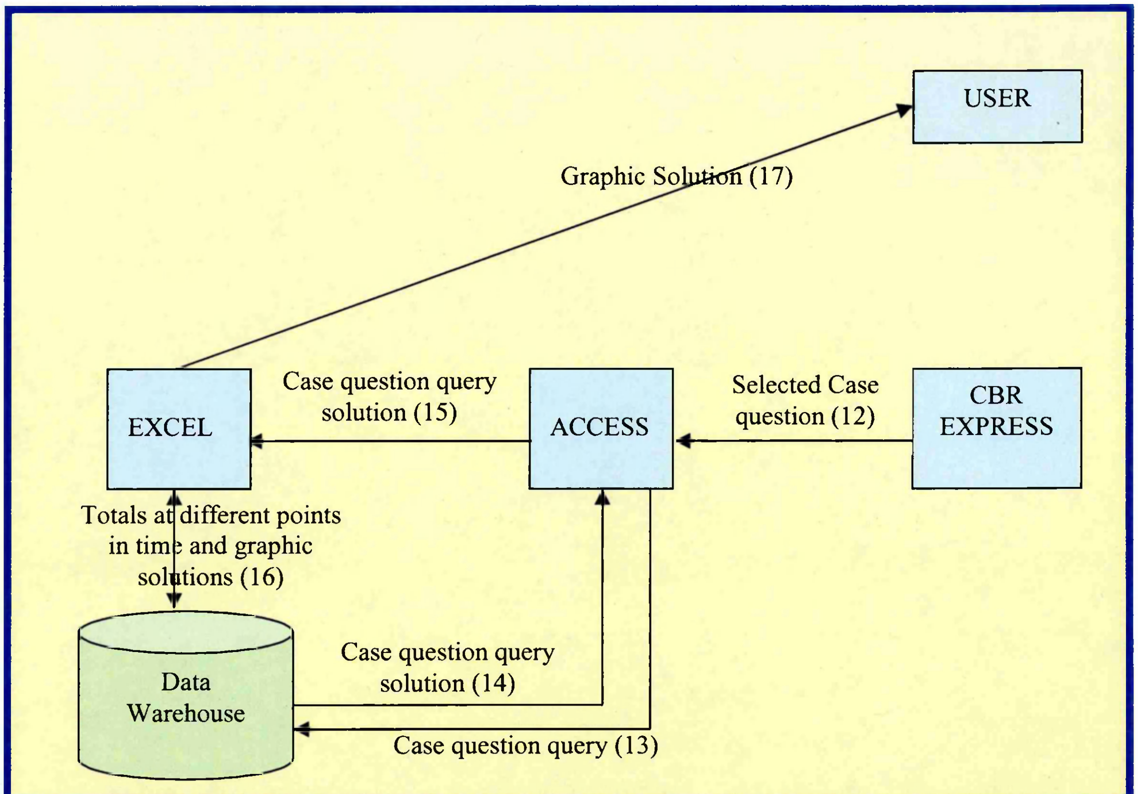
Alternatively the user selects the case that is the nearest match to their need and adapts it by adding new questions, editing existing questions or by removing any irrelevant questions to form a new case. If no case match is available through the search facility a completely new case is constructed (10). The new Case is saved in the Casebase (11).



Source: Figure 6.2 The Expert Advisor System Architecture

Figure 6.6
The Case Adaptation Procedure

The user identifies an individual question in the selected case (12) for which they wish to view aggregated or detailed data relating to different time periods in numeric and / or graphical form. This decision support information is requested from the Data Warehouse via a menu developed using MS Access (13). Excel retrieves the decision support information from the Data Warehouse (16) and displays it for the user (17).



Source: Figure 6.2 The Expert Advisor System Architecture

Figure 6.7
Providing the Solution to a Decision Support Enquiry

6.3.4 STORING DECISION SUPPORT ENQUIRY SOLUTIONS

When the selected case question (12) is new and no solution is stored in the Data Warehouse a query is developed in MS Access to retrieve the related data from the Data Warehouse (13). The retrieved data (14) are passed to Excel (15) and the data and graphical output that form the case question solution are stored in the Data Warehouse. The solution is passed to the User (17).

6.3.5 IMPLEMENTING THE EXPERT ADVISOR SYSTEM ARCHITECTURE

The Expert Advisor System architecture given in Figure 6.2 is based on the CommonKADs Application Design Model that was discussed in Section 5.8.2. The discussions on populating the Data Warehouse, providing an OLTP enquiry facility, a decision support enquiry facility, and making provision for storing decision support solutions has clarified how the MIS, CBR Express, Access and Excel components have been integrated to meet the college requirements.

6.4 THE CASE STRUCTURE

Empolis (2003a) say that knowledge is the lifeblood of every enterprise today. They add that too often neither customers nor employees have access to the information and data they need and support staff waste precious time searching for recurring problem cases. Empolis continue by quoting Professor Wolfgang Wahlster, the Head of the German Research Institute for Artificial Intelligence. Professor Wahlster says that, in the next decade, software must become more intelligent. It needs to have a better understanding of what people want from it and has to be able to communicate more easily with people. These statements from Empolis and Wahlster identify the need for intelligent systems such as the Expert Advisor System that interact with people and provide access to information and data relating to current and past problem situations.

Empolis (2003b) proceed by describing their virtual property letting system that uses CBR. They say the Virtual Letting Assistant uses fuzzy logic to allow the selection of properties which match customers' requirements. They also reveal how the system provides 24-hour self-service from anywhere in the world and how using CBR has increased the success rate of their customers' service by approximately 54%. In addition to this they say that property customers can access the system according to their needs, and tenants are provided with a better and faster service. They also point out that all staff members can operate and maintain their system and higher productivity can be achieved because staff do not need to handle routine tasks such as recording customer requirements. They also feel their system offers user friendliness and an excellent standard of customer care. Empolis also say the system allows users to consider any alternatives that are available.

In addition to this commercial perception of the role and adequacy of a CBR system, King (2001) of the Three Rivers District Council provides a public services' perception of a CBR system. He says that Inference CBR is used in their Customer Service Centre Integrated Planning Management System. He explains how it provides a logical decision making process for complex planning enquiries and states that, subject to funding being available, the service will be web-enabled by 2005. In addition to this Sayers and Duffield (2002) talk about another CBR system that has other uses in the Public Sector. They say that Bexley Council was one of the lead councils in the Cabinet Office INFOSHOP project which won the Government Computing - IT Innovation of the year award for their system. They explain how their CBR system was developed for staff to use to answer planning and building control, health and safety, and food safety queries. They add that their system has been adapted and taken forward by many authorities.

These examples from the commercial and Public Sectors provide an indication of the capabilities of CBR systems and the diversity of their use. These are systems that have been designed and developed to meet different requirements and user expectations. They provide a service for a wide range of people and have been implemented in organisations with a variety of structures, cultures and financial accountabilities. Each organisation has used their system to respond to changing market needs and CBR has helped them. Despite these successes, Bergmann et al (1999) explain how putting knowledge to work by using CBR is not something that can be done immediately. They say a process needs to be put into place to capture the business parameters that are used for decision making, to acquire quality cases that are described according to these parameters and to maintain the quality of the Casebase over time.

Providing a procedure is not easy. Kolodner and Leake (1996) explain how cases come in many shapes and sizes. They say that they may cover a situation that evolves over time (as in designing a building or following a patient through several illnesses), they may represent a snapshot (as in choosing a particular type of window for a building or recording a judge's ruling), or they may cover any size time slice in between those extremes. They represent a problem solving episode (as do medical and architectural cases), associate a situation description with an outcome (as in legal cases), or some combination of this. They say that, what is common to all cases is that they represent an experienced situation. That situation, when remembered later forms a context in which the knowledge embedded in the case is presumed to be applicable. When a similar situation arises, those decisions and the knowledge that went into making them provide a starting point for interpreting a new situation or solving the problem it poses.

All the factors that have been discussed will have an impact on the structure and content of the cases used by the Expert Advisor System, as will the capabilities and flexibility of the CBR software package that was selected as a component of the Expert Advisor System in Section 4.9. The main factor, however, that will influence and drive the design of the case structure will be the FEFC / LSC ISR Funding Return and its requirements. The standard procedure for handling cases in CBR Express, the chosen package, is to use multiple questions in a case to arrive at a single problem solution. This procedure does not match the requirements for the handling of cases in the Expert Advisor System.

An ISR Funding Return contains many questions and each question requires a solution. Each solution is required to have supporting data in a format specified by the FEFC. This data trail is used to confirm the accuracy and legitimacy of the data and to establish that it meets FEFC audit regulations. I decided that the ISR Funding Return would be represented in a case as a series of questions. The possible answers that complied with the FEFC funding regulations for each question would form the rules in the Expert Systems part of the CBR component of the Expert Advisor System. Each answer that was selected from the rules would provide a problem solution for an individual question in the case. I decided that I would develop queries, Access Basic procedures, macros and forms using MS Access Version 2 to create a retrieval system for the data that substantiated the solution to each question in a case. This development work for the prototype is described in the next chapter.

CHAPTER 7 - DEVELOPING AND IMPLEMENTING THE PROTOTYPE

This chapter brings together the CommonKADs models that were described in Sections 5.3 - 5.8, the system architecture that was provided in Section 6.3 and the case structure that was explained in Section 6.4. All of these play an important part in supporting the development and implementation of the Expert Advisor System experimental prototype.

The ISR Funding Return is an important driver in the research and development work undertaken to provide the experimental prototype. However, to achieve simplicity and readability, some aspects of development that are discussed in this Chapter are related to a single question in the return. Nevertheless, the development work has been completed for the whole return, and development examples for other questions in the return are referenced in the Appendices. Owing to this the Appendices may seem rather long, but it is felt that the examples must be provided to demonstrate that development and implementation is based on the complete ISR Funding Return and that an adequate sample has been used for testing and evaluation. The results of the testing and evaluation of the experimental prototype are referenced in this Chapter and described in detail in Chapter 8.

7.1 THE PROTOTYPE

The Expert Advisor System experimental prototype imports a representative sample of student data taken from the MIS database. Kolodner (1991, 1993), Watson (1994) and Bregeault (1997) identify database entries as a valid method of representation for case data when it is used for CBR. They state that case data can be stored as numbers, texts, plans or multimedia and can be represented as predicates and frames. The Expert Advisor System uses functions from CBR Express, the CBR package that was selected in Section 4.9, to develop cases that represent ISR Funding Returns. The package can support all these storage and representation methods. ISR Funding Return cases that are developed store case data as numbers and text but do not use the other alternatives. The alternatives are available to provide a flexible system where future development can cope with rapidly changing requirements and for use with applications that are outside the scope of FE considered specifically in this research. This system flexibility will also assist the College in coping with the need for technology change management that was identified in Section 2.2.

7.2 THE MENU

The Expert Advisor System menu, given in Figure 7.1 is designed to offer user friendly access to information that enables management to gain knowledge and make informed decisions. The *current problem* identified in the CommonKADS Organisation Model, that was shown earlier in

Figure 5.1, is an FEFC ISR Funding Return requesting information. Supporting data have to be supplied to substantiate the figures provided by the College in this return. The menu offers facilities for the *people* identified in the CommonKADS Organisation Model to use their *knowledge* and *power,* together with the *computing resource,* part of which is the *Expert Advisor System*, to perform the *task* of completing the ISR Funding Return and extracting the supporting data.

Figure 7.1
The Expert Advisor System Menu

Testing and Evaluation of the Menu Facility

Sections 8.4.1 - 8.4.7 provide details of the testing and evaluation of 'Viewing Questions in Cases', 'Displaying Case Data', 'Displaying Historical Data and Charts', 'Inserting and Adapting Cases', 'Queries and SQL, 'Metadata Tables' and 'BNF Reports'. The results of the testing demonstrate the fitness for purpose of each of these menu facilities, and in doing so they also demonstrate that *the CommonKADS Models are well suited to providing a template for the design and documentation of the experimental prototype Decision Support System menu facility* and contribute to the achievement of hypothesis 1.

Integrating CBR and Other Technologies to give Access to Knowledge Discovery

The menu is the interface that provides access to CBR and the other technologies that enable knowledge discovery to be accomplished. In other words the menu facilitates the use of *CBR principles, together with other knowledge discovery techniques to provide a useful and adaptive system.* In doing so it contributes to the achievement of hypothesis 2.

In addition to assisting in the completion of the ISR Funding Return, the Expert Advisor System experimental prototype permits supporting data for ISR Funding Returns to be extracted for funding validation by the FEFC auditors. The FEFC (1997) state that auditable data trails enable management to fulfill information requests from the FEFC auditors or inspectors during their assessment of college management and governance. The data trails allow the college internal auditors to adopt the audit approach defined by HM Treasury Internal Audit Standards. This approach requires the internal auditors to obtain and record relevant, reliable and sufficient audit evidence to support audit findings and recommendations. The LSC (1998) specifies that colleges should adopt this approach. The FEFC (1999h) describe how, in addition to this, the auditable data trails enable external auditors to acquire funding information that substantiates funding bids, thus making it possible for them to confidently sign forms that include statements such as that given in Figure 7.2. The tasks performed by the internal and external auditors and the inspectors all validate the successful completion of the ISR Funding Return.

Annex I

Audit Report on Student Data Returns 1999-2000

THE FURTHER EDUCATION FUNDING COUNCIL

Cheylesmore House
Quinton Road
Coventry CV1 2WT

Telephone 024 7686
Fax 024 7686 3100

(Reference Circular 99/43)

External auditors of colleges, higher education institutions, some specialist designated institutions and external institutions are requested to photocopy, complete and return this form to the Council's funding team at the Coventry office by 5 February 2001.

Name of Council-funded institution in 1999-2000

FEFC code of institution in 1999-2000

Name of sponsoring college in 1999-2000*

FEFC code of sponsoring college in 1999-2000*

(*external institutions only)

1
This section of the audit report should be completed by external auditors for all institutions.

The Statement of Responsibilities and the Basis of the Opinion Apply to all Sections of the Audit Report

Statement of responsibilities

The principal or equivalent of an institution certifies that the funding units claimed have been calculated from data correctly extracted from the institution's records, which accurately reflect enrolments during 1999-2000, in accordance with the guidance and definitions set out in *Funding Guidance 1998-99* and other relevant guidance. The external auditor's responsibility is to form an independent opinion, based on our audit of the funding claim, and to report our opinion.

Basis of our opinion

We conducted our audit in accordance with relevant auditing standards issued by the Auditing Practices Board, and with the guidelines for institutions and their external auditors set out in Circular 99/43 and its supplements. An audit includes examination on a sample test basis of evidence relevant to the funding unit claim returned by the college to the Council, and of the individualised student record (ISR19) which supports it. We planned and performed our audit in order to obtain all the information and explanations which we considered necessary in order to provide us with sufficient evidence to give reasonable assurance that the funding unit claim is free from material misstatement, whether caused by fraud or other irregularity or error.

Figure 7.2
FEFC Audit Report on Student Data Returns 1999 - 2000

The menu also offers facilities for viewing historical data in graphical format and for viewing the supporting data at individual student level or viewing calculated totals based on the aggregation of the data. It provides facilities for the DBA team to fulfill the managers', auditors' and inspectors' requests for information. It also allows the DBA team to meet changing needs when funding rules change or information requirements change and cases need adapting and the associated data need retrieving. Note that case adaptation and the associated data retrieval are referred to as system adaptation in this thesis.

7.2.1 AN OVERVIEW OF MANAGEMENT FACILITIES

The menu provides facilities that enable the user to access functions offered by the CBR package. These functions allow the case structure I developed to be used to define a set of case questions representing a funding bid, to identify funding constraints and to permit specialists to ensure all constraints are represented. The CBR package functions allow case questions to be answered appropriately and permit weights relating to specific questions to be changed to alter the scoring and show their importance. Functions I have developed are used to gain access to the detailed data that support the solution to each case question; the totals derived from aggregations of the data and charts representing the data to be viewed at different points in time. These functions are described in Sections 7.3 - 7.7.

7.2.2 AN OVERVIEW OF ADMINISTRATOR FACILITIES

The menu provides administrator facilities that enable the DBA team to access CBR package functions for inserting and adapting cases in accordance with the case structure I developed. It also provides access to functions I have developed for creating and adapting queries and SQL and inserting and updating metadata tables. In addition to this the menu provides access to a CBR package function for viewing the BNF reports that detail the order of inferences made by the Expert Advisor System. Each menu icon and its associated procedures are discussed in more depth in the Sections 7.3 - 7.9.

7.3 SEARCHES AND FUZZY LOGIC

Empolis (2003a) say that their knowledge management work is based on CBR technology. They add that the intelligent solutions they have been developing for more than 10 years are solutions that meet employee and customer needs relating to interaction, individuality and service. They state that, in contrast to conventional search engines, CBR systems contain a Knowledge Model of the application domain which they operate in. Empolis reveal that these models are not universal, but are specifically designed to meet the needs of an application area. They also state that it is possible to develop an intelligent search ability which even shows reasonable results when given fuzzy or incomplete requests. Moreover, they say that the results are ranked and complemented by variants and alternatives. They explain that not only are matches produced but information is valued as 'more' or 'less suitable'. They say the system communicates with the user and specific queries narrow down the information request to reduce the amount of relevant matches. Empolis (2003a) feel that CBR systems lead the user step by step to a choice of possible solutions that can assist them in resolving their specific problem.

Whilst describing their virtual property letting system that uses CBR, Empolis (2003b) say the fuzzy logic used allows properties which match the customer's requirements to be selected. They give details of how the CBR search facility eliminates problems. They also explain how, if CBR were not used, there could be a search that was too specific and the system would respond with 'no match found' or there could be a search that was too general and the system would respond with hundreds of matches and put them in no particular order. They say their Virtual Letting Assistant always returns a match then sorts the matches in closeness of order to the customer's requirements. They also reveal that their CBR system is the only online letting agent system in Ireland with a 'fuzzy logic' facility and divulge how this has strengthened their corporate image and improved their success rate.

These comments from Empolis are reflected in the Expert Advisor System experimental prototype's ability to meet the College and FEFC / LSC needs. The system provides interaction between the user and the technology and offers an intelligent decision making service for the individual, the College and the FEFC / LSC.

7.3.1 DEVELOPING ACCESS TO THE SEARCH FACILITY

Like the Empolis Letting Assistant, the Expert Advisor System experimental prototype provides a search option that uses 'fuzzy logic' and offers facilities similar to those described by Empolis. This facility is an important function that is used to access cases that are appropriate to the needs of the college and discover knowledge to inform funding decisions. Through accessing the Expert Advisor System menu option, 'Viewing Questions in Cases + Natural Language Searches' a search screen can be displayed. The screen provides facilities for the user to provide a natural language descriptor that is used to search the Casebase for cases that match or partially match their requirements. Cases that are retrieved are ranked according to their closeness of match to the search descriptor. Search descriptors with incorrect spelling or missing letters can be used. The number of cases to be retrieved can be limited by the user. The retrieved cases are viewed and the user selects the case that is most appropriate to their need. This is usually the first of the ranked cases. Each case question that is considered relevant to the knowledge being sought is answered by the user. As the questions are answered the weighting value for the selected case is calculated. The user can answer the questions for any or all of the retrieved cases and compare their final weighting values. When the user has found a case(s) they feel matches their need they click on a book icon displayed on the search screen to return to the Expert Advisor System menu. The user can select another icon to obtain further information about the data relating to the questions in the case(s) and their solutions, if required. Some of the technical procedures that were used to provide the facilities that have just been explained are given in Figure 7.3.

The inclusion of the natural language search facility in the Expert Advisor System complies with a request from the College managers to provide a natural language interface to the system. The managers were aware of their own lack of technical skills and wanted a simple to use facility. The provision of a natural language interface is one of the Critical Success Factors identified in Section 3.9. This facility is provided through the use of trigrams which are a composite part of the CBR Express component of the Expert Advisor System.

Access to Case-Based Knowledge Discovery

The provision of this 'search' provides access to cases, thus providing access to Case-Based knowledge discovery. This facility demonstrates that *CBR principles can be used together with other knowledge discovery techniques to provide a useful system* and contributes to the achievement of hypothesis 2.

7.3.2 COMMONKADS AND THE SEARCH FACILITY

The search facility shown later in Figure 7.3 is used to assist the College in *producing* their ISR Funding Returns. This work has been performed within the current management and staffing *structure* in the *organisational context* of the FE College. The *process* of producing the ISR Funding Return is the *current* problem identified in the CommonKADS *Organisation Model* that was discussed in Section 5.3.2. The *computing resource* is the CBR Express Package that was specified as a component of the Expert Advisor System in the *Architecture Design Application Model* in Figure 5.7. This package is also identified as the *KBS subsystem* in the *Task Model* discussed in Section 5.4.2. The Task Model provides a diagram that can be used to explain the tasks the new system will provide and help College managers in their understanding of the system. Producing the ISR Funding Return is the *task* in this model.

In addition to this the *Communication Model* shows how an agent, who is a member of the Management Team, *explains* their need for funding information. Another agent who uses the Expert Advisor System and is a member of the DBA team takes the *initiative* and performs the search. The search is a *transaction enquiry.* Search parameters that specify how the CaseBase search function will be performed are passed to the *Task Model.* Either matching or partially matching cases or no cases are retrieved. The cases are the *information item.* The *discourse* in the model relates to the acceptance of the case, alteration of the weighting factors if required and a rerun of the search, or adaptation of a partially matching case to form a new case. If there is no case match a new case is developed. Case adaptation and weighting factors are discussed in more detail in Section 7.6. The DBA team gains knowledge from the case retrieval process and now becomes *involved in* a new *transaction enquiry* to gain information about the data that supports the case solution as described in Section 7.4 and 7.5.

Testing and Evaluation of the Search Facility

Details of testing and evaluation of the 'search' facility are provided in Section 8.4.1. The results of the testing demonstrate the fitness for purpose of the facility. In doing so, they also demonstrate that *the CommonKADS Models are well suited to providing a template for the design and documentation of the experimental prototype Decision Support System search facility* and contribute to the achievement of hypothesis 1.

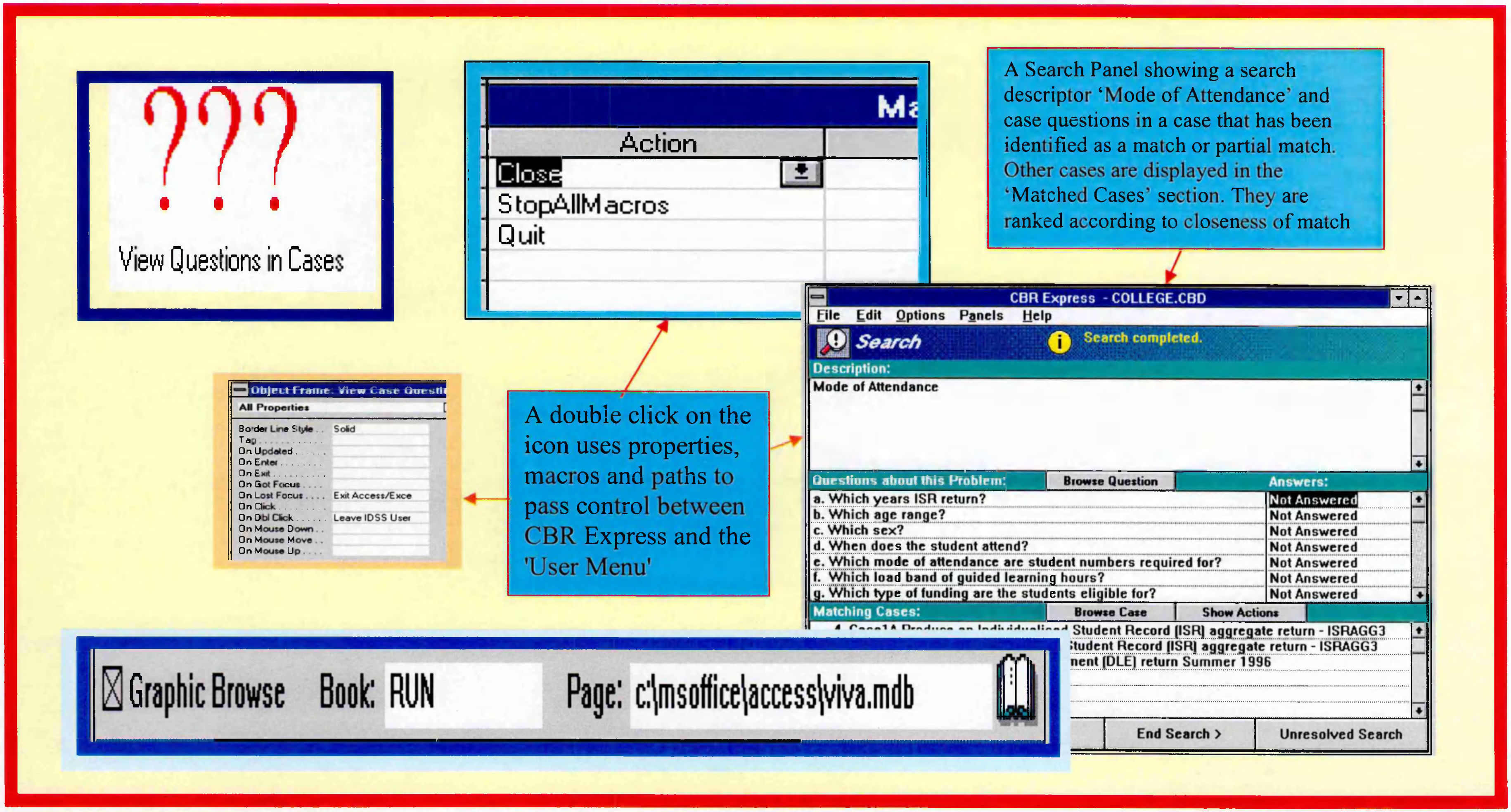


Figure 7.3
User Menu -Viewing Questions in Cases + Natural Language Searches Technical Procedure

7.4 ACCESSING DETAILED CASE DATA

In Section 2.9.6 it was recorded that John Rockett, the Principal of Rotherham College of Arts and Technology had said there was 'tons' (sic) of marketing information, cost benefit information and value-added information but there was no integrated software which allowed colleges to get at the information in detail. In addition to this, access to the detailed data that had been used to substantiate funding bids was also identified as a problem during discussions with the management and the DBA team at the College used for this case study. Consequently this became an important consideration in the design and development of the Expert Advisor System experimental prototype. A menu option 'Display Case Data' was provided. It offered facilities for selecting a category of funding and a case question, as shown in Figures 7.4 and 7.5. In the experimental prototype the categories of funding were ISR or Demand Led Element (DLE).

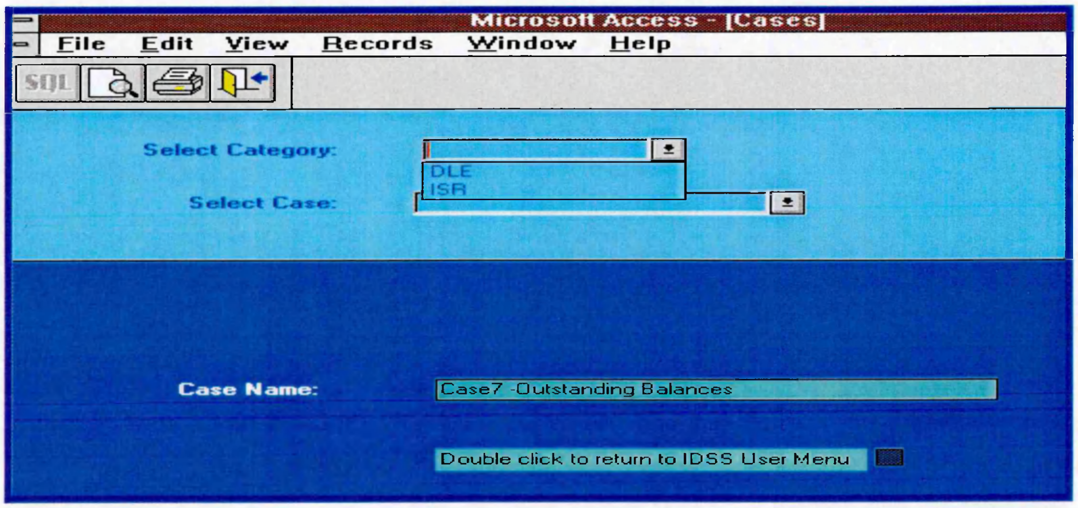


Figure 7.4
Accessing the Category of Funding and the Case Question Data

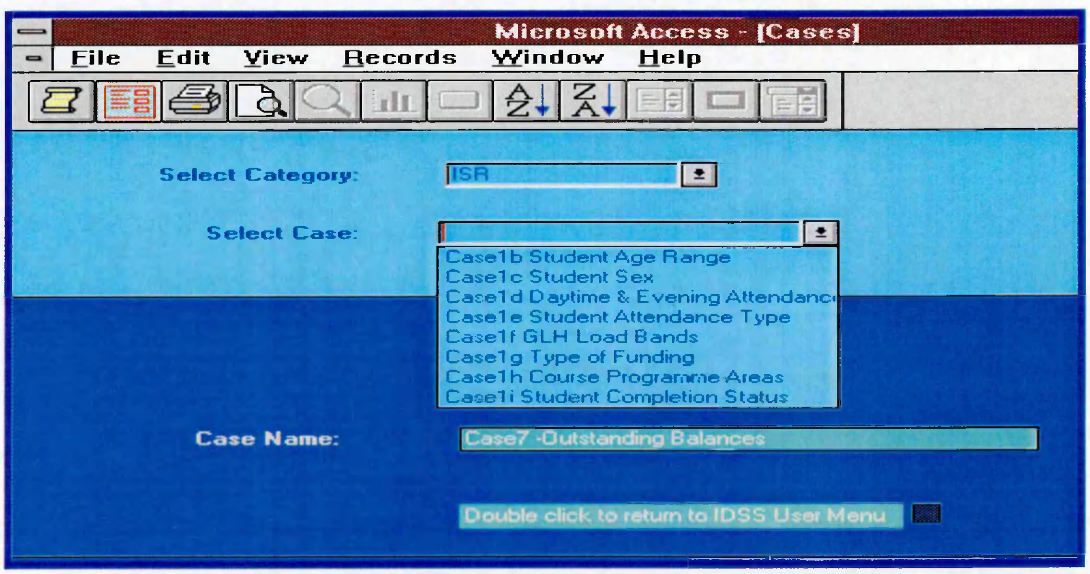


Figure 7.5
Selecting a Question in a Case

Other screens were provided that allowed the user to identify additional parameters for the extraction of the supporting data. An example of this is given in Figure 7.6 where further information about the time period for the case question data is requested. This could be 1994, 1995 or 1996 for the prototype. In a live working system a time period that corresponds to the Data Warehouse snapshot date and is appropriate to the organisational needs would be used. This could be weekly, monthly, quarterly or some other time period determined by the organisation.

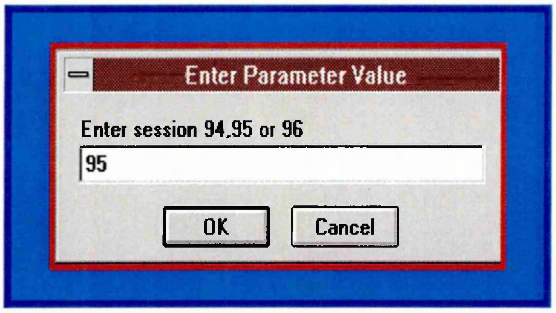


Figure 7.6
Time Period for the Selected Case Question

An additional box that could be displayed would be one that seeks confirmation of gender if the extraction had to be for either male or female. When all the parameters for the detailed data extraction that substantiates the case question have been collected, the system displays the detailed data as shown in Figure 7.7. In doing so it addresses the concerns about not being able to access historic data that were raised by the College managers in Section 3.7. Detailed data for different time periods would not normally be available from the MIS. It would be overwritten.

The case question in the Figure 7.7 is requesting student numbers by age range. The user is able to browse through the detailed individual student data that substantiates the total figure in the solution to the case question, and view the student's age at the date of the ISR Funding Return. Details of the case solutions incorporating the total figures are accessed by using the 'Display Historical Data & Charts' menu option. This is discussed in Section 7.5.

The provision of access to detailed data is useful for gaining the knowledge required to resolve any anomalies that exist or for answering queries raised by FEFC / LSC auditors and inspectors and by College managers.

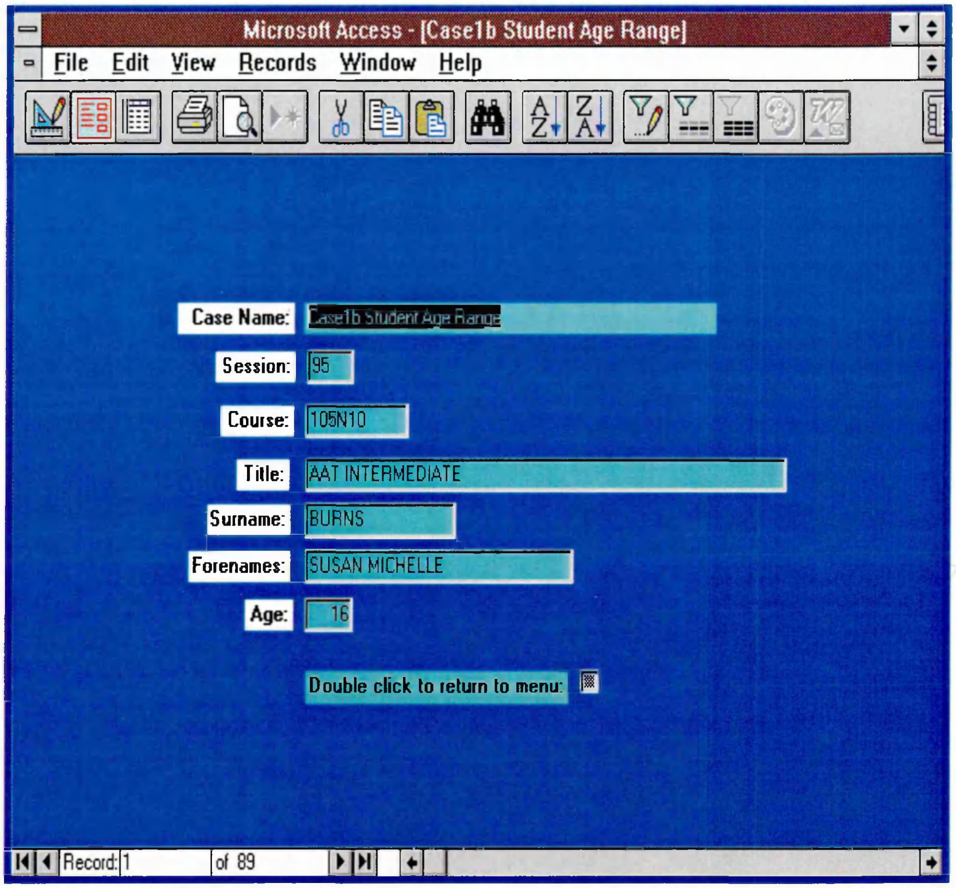


Figure 7.7
Viewing Detailed Data that Substantiates a Case Question

7.4.1 THE NEED TO MEET USER EXPECTATIONS

CMP Media Call Centre (2003) talk about customer expectations and the need to understand what the customer wants. They identify some of the things the customer would like such as access, responsiveness, prompt action, knowing what to expect from a system and for the user to be able to do things right first time. When the Expert Advisor System was developed the College managers, the DBA team, and the FEFC / LSC auditors and inspectors had these expectations. Consequently consideration was given to this when the screens and system functions were developed.

In addition to these expectations that have been identified, Watson (2002) talks about other expectations - programming to meet the user's needs. He explains how event-driven programming vastly improves on older programming models because it transfers the flow of the program from the programmer to the user. He states that it is ideal for creating any type of user-focused application. Watson (ibid) continues by describing how the software just sits idle until the user does something. In other words, the flow of the program is controlled by user-generated events. He says that, at first glance, event-driven programming seems more complex than structured programming, and in a sense this is true. He proceeds, however, by explaining how an event-driven structure eases complexity by allowing programming to be done in the context of what the user is doing. He says that, if the problem can be thought of in the user's terms, programming can be made much more satisfying and less-error prone.

The expectations that College managers, the DBA team and the FEFC / LSC auditors and inspectors identified make it clear that the Expert Advisor System must be developed to meet user requirements. In addition to this, Sections 2.9.1 - 2.9.12 explain the problems with FEFC / LSC ISR software, the vast amount of data that the FEFC / LSC request and the reactions of the colleges to these problems. This again reinforces the need for software to meet user requirements. Consequently event-driven programming has been used in parts of the development of the Expert Advisor System.

7.4.2 DEVELOPING ACCESS TO THE DETAILED DATA

The development work undertaken to enable the detailed data that substantiate a case question to be displayed uses routines developed using Microsoft Access software. Access to such data is an essential part of the task of completing the ISR Funding Return. The detailed data that are displayed allow anomalies to be resolved and are also useful for answering queries made by the FEFC / LSC auditors and inspectors and college managers.

To enable detailed case question data to be displayed I have developed menu icons, forms, macros, queries and Access Basic procedures using Microsoft Access Version 2.0. Figure 7.8 gives a sample of some of these procedures.

Figure 7.8 shows the following technical procedures. The 'Display Case Data' menu icon provides access to the event driven system by using a mouse. A 'Case Select' macro enables the 'Select' form to be displayed. A 'Select Category' combo box is used on the 'Select' form to activate a 'Case Category List' query. This allows the user to select the category of funding. An Access Basic procedure 'Sub Select_Category_AfterUpdate ()' allows the 'Select Category' facility to be reused.

The 'Select Case' combo box on the 'Select' form provides a simple, user friendly facility for identifying a case question from a list of questions that are displayed. A 'Case Limit List' query constrains the case questions that are available for selection to those within the selected category the user has already identified. It also identifies the data extraction query that relates to the selected case question A 'Sub Select_Case_AfterUpdate () Access Basic procedure allows another case question to be selected by the user when they have viewed the data and enables the

'Select' form to be redisplayed.

Data-Based Knowledge Discovery

This facility for accessing detailed data allows the user to gain knowledge about the data and demonstrates that *CBR principles can be used together with other knowledge discovery techniques to provide a useful system.* It contributes to the achievement of hypothesis 2.

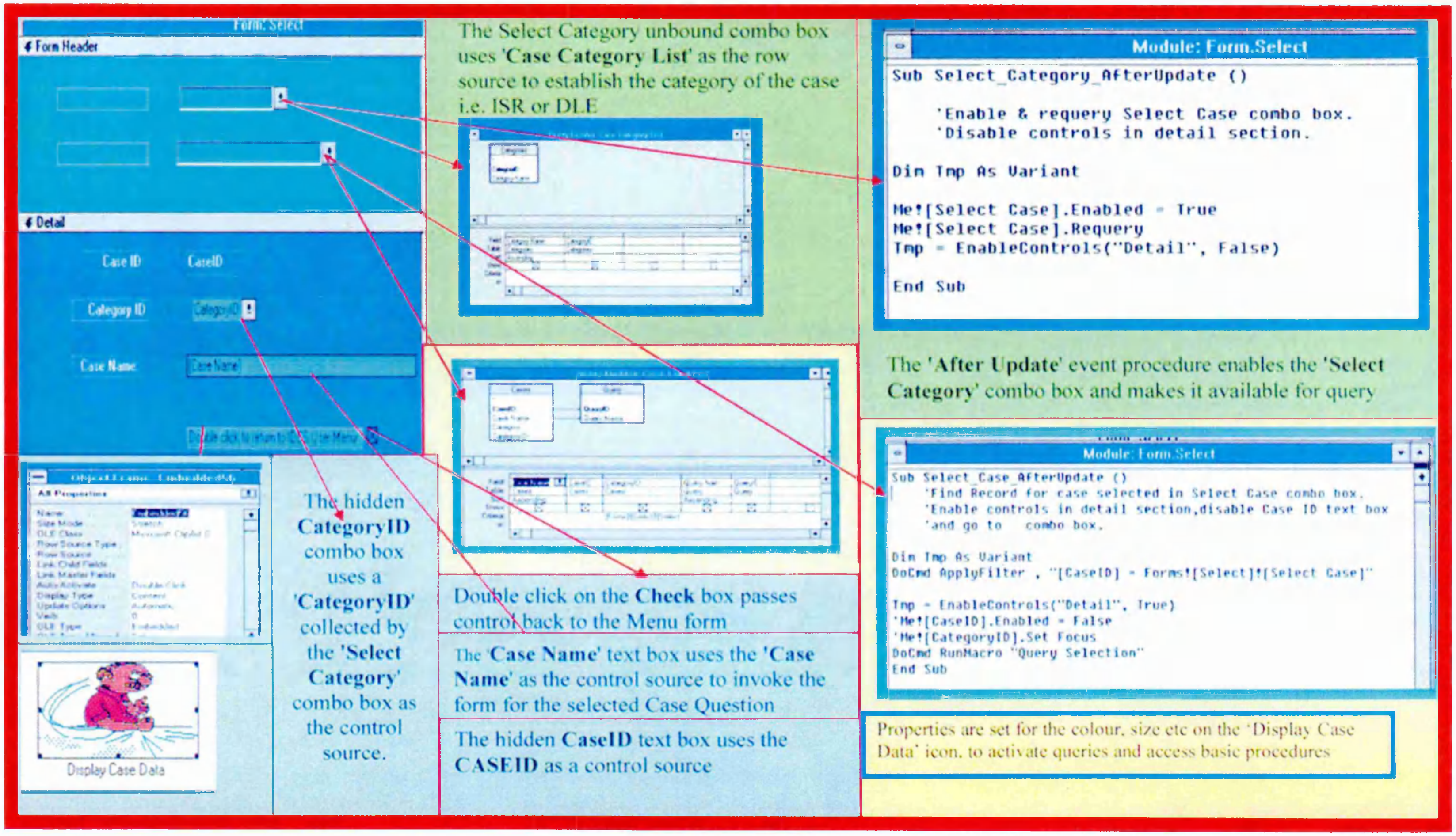


Figure 7.8
User Menu - Displaying Case Data Technical Procedure

A benefit of the style of programming that has been adopted is that the user is provided firstly with a list of categories to select from and secondly with a list of case questions from which to select. This shows the user what data they can expect the program to give them access to. It also increases the chances of the user getting their selection right first time as they are not expected to key in. Clicking on the mouse button to make the selection results in prompt action and demonstrates that a responsive system has been provided. This approach has been adopted to meet the expectations of the college managers, the DBA team and the FEFC / LSC auditors and inspectors that were identified earlier in this section.

7.4.3 COMMONKADS AND DETAILED CASE QUESTION DATA

The 'Accessing Detailed Data' facility is provided to help College Managers and FEFC / LSC auditors and inspectors to resolve anomalies in the detailed data used to substantiate the total figures in ISR Funding Returns and FEFC / LSC audits. This work relates to the ISR Funding Return *process* and is undertaken in the *organisational context* of the College and its current staffing and management *structure*. The ISR Funding Return is identified as the *current problem* in the CommonKADS ***Organisation Model*** that was described in Section 5.3. The *computing resource* is the Microsoft Access package that was specified as a component of the Expert Advisor System in the ***Architecture Design Application Model*** in Section 5.8. This package is identified as the *other subsystem* in the ***Task Model*** in Section 5.4.

The Management team and the DBA team are identified as the College *Agents* in the ***Agent Model.*** They use this Expert Advisor System facility to assist them in the *task* of providing accurate, substantive data for each of the total figures that the College submits in their ISR Funding Return. This Expert Advisor System *problem solving method* permits detailed data to be retrieved and allows managers, auditors and inspectors to gain *strategic knowledge* as shown in the ***Expertise Model*** in Section 5.6. The ***Communication Model*** shows how the DBA team becomes *involved* in the data extraction *transaction enquiry* which enables them to gain knowledge from the data. The Microsoft Access functions use the *transfer task* which is the *problem solving methods* of the ***Expertise Model*** and the snapshots of data from the Data Warehouse to *realize* the system output that informs management decision making.

Testing and Evaluation of the Facility for Accessing Detailed Data

Details of the testing and evaluation of the facility for accessing detailed data are provided in Section 8.4.2. The results of the testing demonstrate the fitness for purpose of the facility. In doing so, they also demonstrate that *the CommonKADS Models are well suited to providing a template for the design and documentation of the experimental prototype Decision Support System facility for accessing detailed data.*

7.5 ACCESSING HISTORICAL DATA AND CHARTS

In Section 3.7 College Managers expressed concern about not being able to access historical data in the MIS and identified the need for a cost effective way of acquiring intelligent decision support information that was based on historical data. They also indicated that graphical output would enable them to understand information quickly and easily. In addition to this the Critical Success Factors that were identified in Section 3.9 included the need *to view aggregated data, to view detailed data at different points in time, to provide graphical representation of data for quick and easy assimilation* and *to provide easy extraction of comparative information.* The menu option 'Display Historical Data and Charts' provides access to information that meets these requirements.

7.5.1 DEVELOPING ACCESS TO HISTORICAL DATA AND CHARTS

Through the selection of the 'Display Historical Data and Charts' menu option a screen is displayed that allows a user to select detailed data, or the aggregated data and charts that provide a solution to a case question. The detailed data are displayed for the period in time selected by the user. The aggregated data and charts are extracted from the Data Warehouse and displayed for the corresponding period in time. Aggregated data and charts for the periods of time relating to other snapshot data held in the Data Warehouse are also displayed. This enables comparisons to be made. The charts allow quick and easy assimilation of information. Anything that appears to be incongruent when the comparison of figures and charts for different time periods are made can be investigated further by browsing through the detailed data that are accessible through this menu option or by using the menu option for displaying detailed data that was described in Section 7.4.

Data-Based and Graph-Based Knowledge Discovery

The provision of this facility for accessing historical data and charts allows the user to gain knowledge about past ISR Funding Returns. It demonstrates that the experimental prototype uses *CBR principles together with other knowledge discovery techniques to provide a useful system* and it contributes to the achievement of hypothesis 2. It facilitates data-based knowledge discovery and graph-based knowledge discovery

An Example of a Case Question and its Solution.

If the question being viewed was 'Which sex?', and 'F' for female and the session '1994' were selected, the names of each female student enrolled in the 1994 session would be displayed. When aggregated data and charts were selected the total number of females, the total number of males and the total number who had no details of their gender would be displayed for each session recorded in the system. The corresponding bar charts or pie charts would be displayed for each session. The session would be 1994, 1995 or 1996. These dates correspond to the dates of the data samples that were available for the development of the Expert Advisor System experimental prototype. The data in the samples were extracted from the MIS, cleansed and scrubbed, and stored in the Data Warehouse as snapshots for each of the years.

A solution to the case question used in this example is displayed in Figure 7.9. Each solution provides an *overview* of the results that were obtained for a case question for different time periods. Decision Point Applications (2000) described the need for this *overview* in Section 6.1.3 as part of the term *oversight* which they were defining. The deep detail which they say is the other part of *oversight* and is needed, is provided by the facilities for accessing detailed data that were described in Section 7.4 or by using the option for browsing detailed data that is provided by the "Display Historical Data and Charts' facility.

What-If Projections

The snapshots of data that are used to provide the figures and charts can also be used to produce projections. For instance, the College may wish to assess the viability of offering courses that would not only attract men but would also attract women who wished to acquire a qualification that would help them to return to work. The college Management Team would need information about the number of women who had enrolled on courses in the previous years, their ages, whether they attended during the day or in the evenings, the type of courses they were enrolled on, their mode of attendance and so on. The historic enrolment figures would be available as comparative information in a solution to a case question that was stored in the Data Warehouse. The snapshots of historic data that were used to provide the figures and graphs would also be stored in the Data Warehouse and could also be used with Excel to provide 'what-if' projections which could be added to the solutions so they were available for future reference.

If the Management Team required the projection to be based on the current information from the MIS then the data could be extracted, cleansed and scrubbed and a new snapshot could be added to the Data Warehouse and could be used for projections. The MIS data have not been through the cleansing and scrubbing process and could be inaccurate and incomplete. This could result in projections that used the MIS data being misleading. In addition to this the MIS data is rapidly changing so projections based on MIS data could produce different results each time they were performed.

Projections can be used by the College to assess situations where they feel they need to test the consequences of changes the FEFC / LSC are likely to make to their funding rules and consider the impact it would have. During interviews with College Managers it was confirmed that this type of decision support information is also frequently needed to influence decisions relating to the internal management of the College on issues that are influenced by the results of the funding bids. Section 6.1.2 stressed the importance of projection facilities being incorporated in the Expert Advisor System. In addition to this, Decision Point Applications (2000) described it as a necessary requirement of a financial decision support system. They referred to it as *foresight* and described it as the need to use authoritative hindsight to develop reasonable forward looking projections of costs and revenues. The Expert Advisor System experimental prototype facility for looking at past cases and their associated data trails provides the *hindsight* that is required.

Strategic Planning Returns and ISR Funding Returns

The College could consider setting up cases that represent Strategic Planning Returns. Supporting data from the snapshots in the Data Warehouse would be available to substantiate the projections that were made for each case question. This would provide an audit trail and simplify the task of reconciling the Strategic Planning Return Projections and the ISR Funding Return actual figures. It would also assist the FEFC auditors and inspectors.

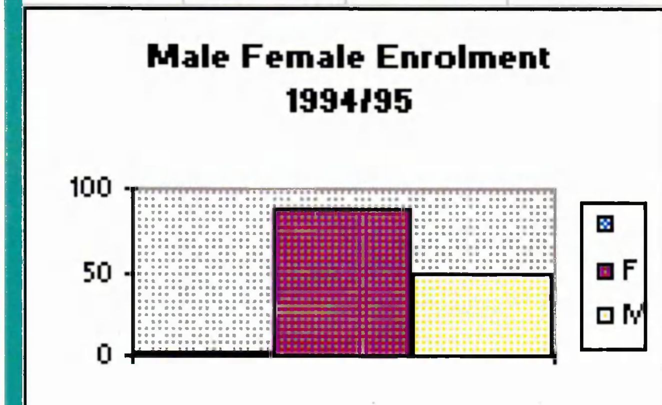
Projection-Based Knowledge Discovery

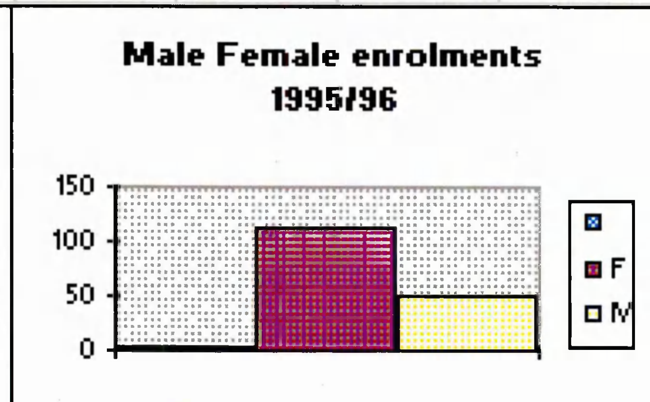
The provision of this facility enables users to gain knowledge from projections. This can assist them in completing their strategic planning returns, optimizing their funding bids and reconciling the two. It demonstrates that *CBR principles can be used together with other knowledge discovery techniques to provide a useful system.* It provides *projection-based knowledge discovery* and contributes to the achievement of hypothesis 2.

Case quesion 1c) Which sex?

Detailed information to support these charts and sheets is held in sheets Case1c 94, Case1c 95, Case1c 96.

Session	Sex	Enrolments	Session	Sex	Enrolments	Session	Sex	Enrolments
94		3	95		3	96		4
94	F	88	95	F	112	96	F	125
94	M	48	95	M	50	96	M	67





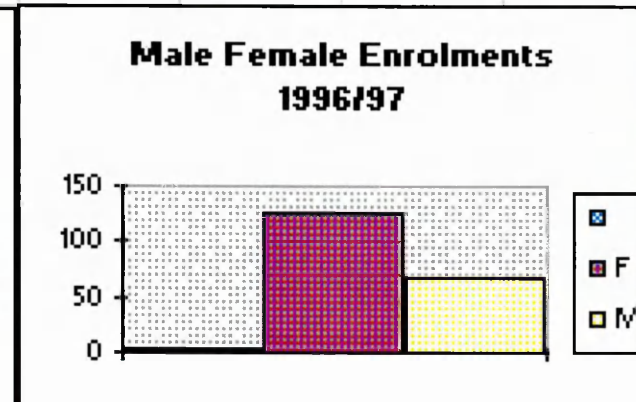


Figure 7.9
Case Question 1c Solution - Yearly Student

7.5.2 COMMONKADS AND HISTORICAL DATA AND CHARTS

The 'Accessing Historical Data and Charts' facility provides College Managers with a quick and easy way to evaluate how they made decisions relating to past ISR Funding Returns. It provides them with access to the data that have been used to substantiate figures in past returns and allows them to make comparisons for different time periods. In doing this it meets the need identified in Section 6.1.7 for people to share information and gain knowledge on how past decisions have been made and also resolves a problem identified by College Managers in Section 3.7. The managers drew attention to the need for the extraction of decision making data relating to time periods where data in the MIS had been overwritten. This solution provided by the Expert Advisor System will not only assist the College Managers but will also be extremely useful to the FEFC / LSC auditors and inspectors when they are validating funding returns and correlating them with the College's strategic planning returns.

This problem of not being able to access data is a part of the computer resourcing, financial management, and management of transition *problems* that were identified in the CommonKADS ***Organisation Model*** in Figure 5.1. The model also shows *problems* such as restructuring, staff contracts, performance related pay, new accountabilities and policy decisions being made that are not suitable for implementation. All of these problems are likely to result in a change in attitude from many staff and will have an impact on the completion of the ISR Funding Returns. These are the kind of problems that were identified in Section 5.3 when it was mentioned that Touche Ross (1992) recognized that there was likely to be a reduction in staff performance as a result of attitude changes that would occur during the period of transition resulting from incorporation.

In addition to this, Jon Cowley (2001), Secretary of the NATFHE Co-ordinating Committee reports on comments made by a Sheffield College lecturer relating to all out strike action that was suspended after College governors and management backed down from their plan to make around 70 compulsory redundancies. The lecturer says:

> 'This would not have happened without our 87 percent strike vote. Before that management were just telling us what to do. They wanted 186 job cuts. Now we have stopped them from thinking they can just do what they want. That is a bit of a victory. But they still want concessions. Already 120 members of staff have gone through voluntary redundancies. Management is still talking about a 20 percent increase in student numbers, but with 10 percent fewer staff. That means everyone will have to work harder, with worse conditions.'

Actions such as these, together with restructuring not only result in changes in people's attitudes but result in people leaving the organisation and knowledge and experience that had been used to complete past ISR Funding Returns disappears. This situation is not relevant just to Sheffield College it is relevant to the FE Sector. The Educational Institute of Scotland (EIS) and the College Lecturers Association (CLA) (2002) confirm this in their statement:

> 'During the years since incorporation most, if not all, Further Education Colleges in the sector have undergone structural change. This change is usually a direct result of financial difficulties and College Managements' believing there is nothing wrong with stripping out a layer of long established posts, expecting long service personnel to reapply for newly 'restructured' posts, retire early and be re-engaged on a part-time / temporary basis or in the worst case scenario be redeployed to a post with significant changes to conditions and in some cases less pay'.

The College used for this case study had frequently gone through the restructuring process. It was found that due to this and the fast rate of change, the College, like many others failed to define how functional units related to each other and what their responsibilities were. As a result of this the *structure* element of the ***Organisation Model*** could not be represented accurately and assumptions had to be made. This was discussed in Section 5.3 and Section 5.9.

The outcome from the development work using the ***Organisation Model*** was the understanding that this constraint relating to the *structural* element needs to be recognized when CommonKADS is used in complex, volatile environments such as that of the FE Sector. Due to the rapid rate of change assumptions have to be made where facts are unknown and cannot be represented accurately in the *structure* element of the ***Organisation Model.***

The statement by the EIS and CLA (ibid) not only confirms the extent of structural change but draws attention to the financial difficulties that are prevalent in the FE Sector. This creates an understanding of the universal need for financial help and highlights the importance of the Expert Advisor System experimental prototype and its contribution to optimizing funding bids.

The Expert Advisor System experimental prototype facilities that enable aggregated figures, historical data and charts to be displayed have been developed using Microsoft Access and Excel. These are shown as the other subsystem in the CommonKADS ***Task Model*** that was discussed in Section 5.4. This model allows the College Managers to understand how the *task* of completing the ISR Funding Return in the rapidly changing, volatile and competitive *environment* of FE will be achieved. Data extractions from the college MIS are cleansed and scrubbed to provide quality data in the specified format that are used to populate the Data Warehouse and provide snapshots of data that are suitable for informing decision making. These snapshots of data are the *input* to this part of the Expert Advisor System. The use of Microsoft Access allows a range of drivers to be used for importing data into the Expert Advisor System.

This fulfills the need identified in the Critical Success Factors for a system that facilitates *the use of data from different sites, different systems and different platforms*. This is essential for the College used for this case study. In addition to the MIS the College has other data held in different systems at different locations. It also has the need to bring this set of data together, cleanse and scrub it and store it in the Data Warehouse in order to achieve the Critical Success Factor that identified *the need for complete, consistent, accurate data.*

The *output* in the CommonKADS ***Task Model*** is the aggregated figures, detailed substantive data, and graphs that are based on historical snapshots. This output allows the Critical Success Factors that identify the need *to view aggregated data, to view data at different points in time and to provide graphical representation of data for quick and easy assimilation,* to be achieved.

The management team and the DBA team are the *agents* shown in the ***Agent Model*** who work within the financial, human and computing resource *constraints.* The training needs that are also identified as a *constraint* are reduced considerably because the Microsoft Access package that was chosen as a component of the Expert Advisor System is one that many of the College staff are already familiar with and use regularly. The management skills and the technical capabilities of the staff working with the Expert Advisor System are used to acquire knowledge from viewing the comparative case data and charts relating to different time periods. The retrieval of this data and the charts is the *reasoning capability* shown in the ***Agent Model.*** The actual data and charts are *knowledge sources* in the ***Expertise Model.*** The retrieval of the data and charts is a *transaction enquiry* in the ***Communication Model*** which the DBA team become *involved* with. Snapshots of data relating to different points in time are held in the Data Warehouse. Access and Excel use the *transfer task* which is the *problem solving method* of the ***Expertise Model*** to *realize* the *output* which is the detailed data, aggregated data counts and graphics that inform management decision making.

To enable detailed historical data and charts to be accessed I have developed menu icons, forms, macros, queries and Access Basic procedures using Microsoft Access and spreadsheets using Excel. Figure 7.10 gives a sample of some of these procedures.

Testing and Evaluation of the Facility for Accessing Historical Data and Charts

Details of the testing and evaluation of the facility for accessing historical data and charts are provided in Section 8.4.3. The results of the testing demonstrate the fitness for purpose of the facility. In doing so, they also demonstrate that *the CommonKADS Models are well suited to providing a template for the design and documentation of the experimental prototype Decision Support System facility for accessing historical data and charts* .

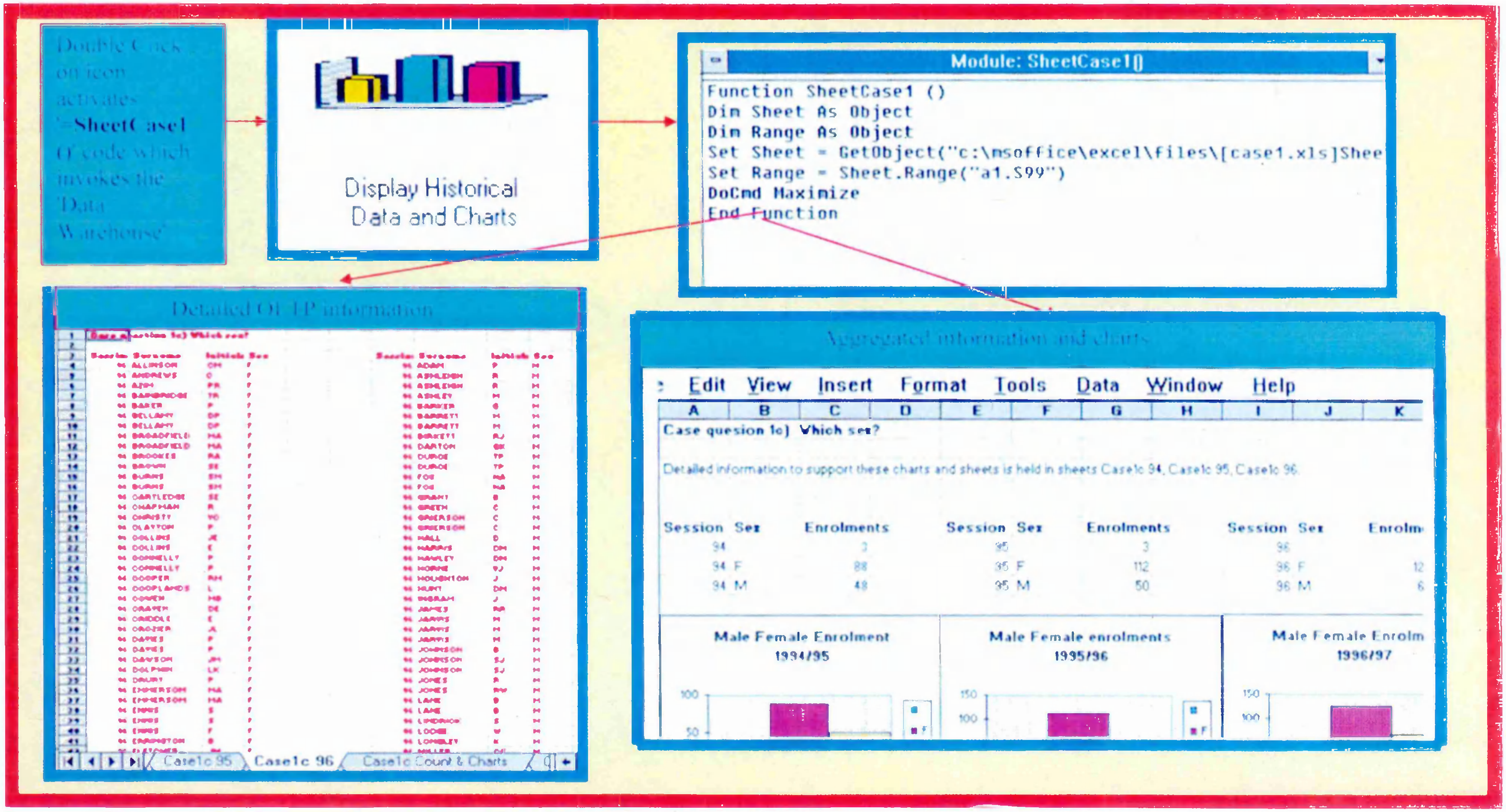


Figure 7.10
User Menu – Displaying Historical Data and Charts Procedure

7.6 CASE ADAPTATION

Adaptation was considered to be an essential part of the development of the Expert Advisor System experimental prototype despite a statement made by Watson (1997) who said

> 'Many CBR Researchers believe there is one great challenge facing them - namely, adaptation. Relatively few commercial CBR systems adapt cases'

The issue of adaptation was considered when CBR was selected as a component of the Expert Advisor System. CBR Express, the chosen CBR component, is one of the few CBR software packages that supports case adaptation but it does not support system adaptation. System adaptation in the Expert Advisor System experimental prototype is where the adaptation process is performed across the other components in the system to make detailed data, totals derived from aggregations of the data, and charts available as a substantive data solution for each question in a case. This is an important part of the Expert Advisor System because each college has to submit data to the FEFC / LSC to substantiate the figures in their funding returns. FEFC / LSC auditors and inspectors examine such data very closely. Through the integration of CBR, Relational Database technology and the principles of Data Warehousing and Data Mining the Expert Advisor System supports system adaptation. The technical procedures for case adaptation in this section, together with the procedures for data adaptation that are explained later in Section 7.8, enable systems adaptation to be achieved, and aggregated counts and charts relating to different periods in time to be produced for adapted cases.

Branskat (1992) states that case adaptation is used when an enquiry is received and a case search fails to find a match with other cases. If the search solution is not adequate or there are some variations in the parameters since the most appropriate case was last used, the case is adapted to form a new case. This situation occurs in the college when Management need knowledge to complete an ISR Funding Return and the case search done by the DBA team does not produce the required results. The DBA team completes the procedure for adapting cases then completes the data adaptation procedure to achieve system adaptation. This results in a new case being added to the CaseBase and the data, together with totals derived from aggregations of the data and graphs, being stored in the Data Warehouse as solutions to case questions. These solutions are made available to enable management to gain knowledge and to inform their decision making.

7.6.1 STRUCTURAL AND DERIVATIONAL ADAPTATION

Case adaptation can be structural or derivational. Kolodner (1993) states that adaptation rules are applied directly to the solution stored in the retrieved cases when structural adaptation is used. She says that the Judge and Chef systems are both examples of systems that use structural adaptation. Watson (1994) says that the rules that generated the original solution are rerun and a new solution is produced when derivational adaptation is used. An efficient CBR may use structural adaptation to adapt poorly understood solutions and derivational adaptation to adapt clearly understood solutions. If a retrieved solution is not to be adapted null adaptation is used. Null adaptation is useful for problem solving involving complex reasoning that has a simple solution. For instance when students apply for an award they answer numerous questions and the LEA carry out a complex reasoning process to determine whether the award application is successful or not. The solution is simple. It grants the award, rejects the award or refers the application.

The Expert Advisor System provides structural adaptation as shown in Figure 7.11, and derivational adaptation as shown in Figure 7.12. Cases can have new questions added, existing questions changed or inappropriate questions removed to make them match a requirement. When this occurs the case is saved as a new case and structural adaptation has taken place. An alternative is to perform a new case search and leave an irrelevant question unanswered. This is derivational adaptation. Procedures in the Expert Advisor System support structural adaptation and derivational adaptation.

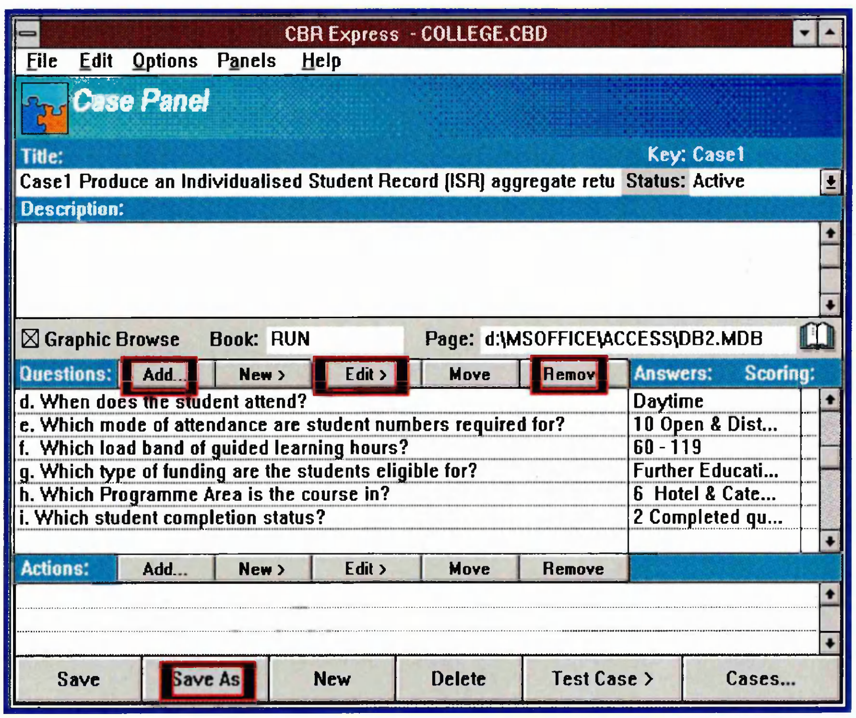


Figure 7.11
Structural Adaptation

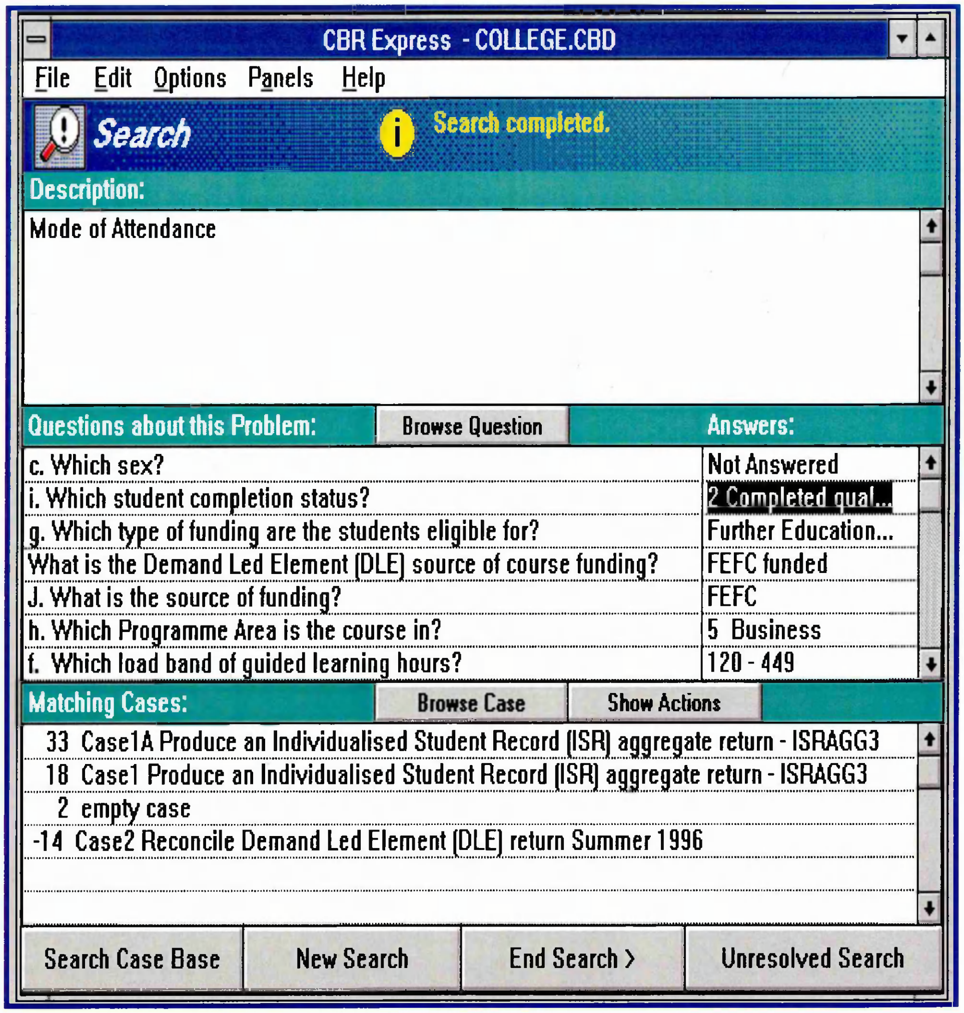


Figure 7.12
Derivational Adaptation

An Example of Case Adaptation

In 1994 - 95 the FEFC (1994a) used Cost Weighting Factors (CWF) A, B, C, D. During 1995 - 96 the FEFC (1994b) used CWF A, B, C, D and E. These factors were used to calculate the income that was due from the FEFC for students on each learning programme. Some learning programmes used different CWF in 1995 - 96 from those they used in 1994 - 95 as a result of the CWF change. The change in the CWF altered the income accrued from a course. This in turn altered cash flow, budgets and investment or sometimes altered the way in which a learning programme was marketed. Similarly performance outcomes sometimes differed from predictions in the strategic plans. If cases had been available that indicated how different situations were handled in 1994 - 95 the case(s) could have been adapted to account for the changing CWFs and used for 1995 - 96.

7.6.2 DEVELOPING CASE ADAPTATION PROCEDURES

The DBA team can select the 'Insert or Adapt Cases' icon on the Administrator Menu of the Expert Advisor System to gain access to the Question Panel and define answers to case questions as Yes / No, text, numeric values within a range, or list answers. This is shown in Figure 7.13.

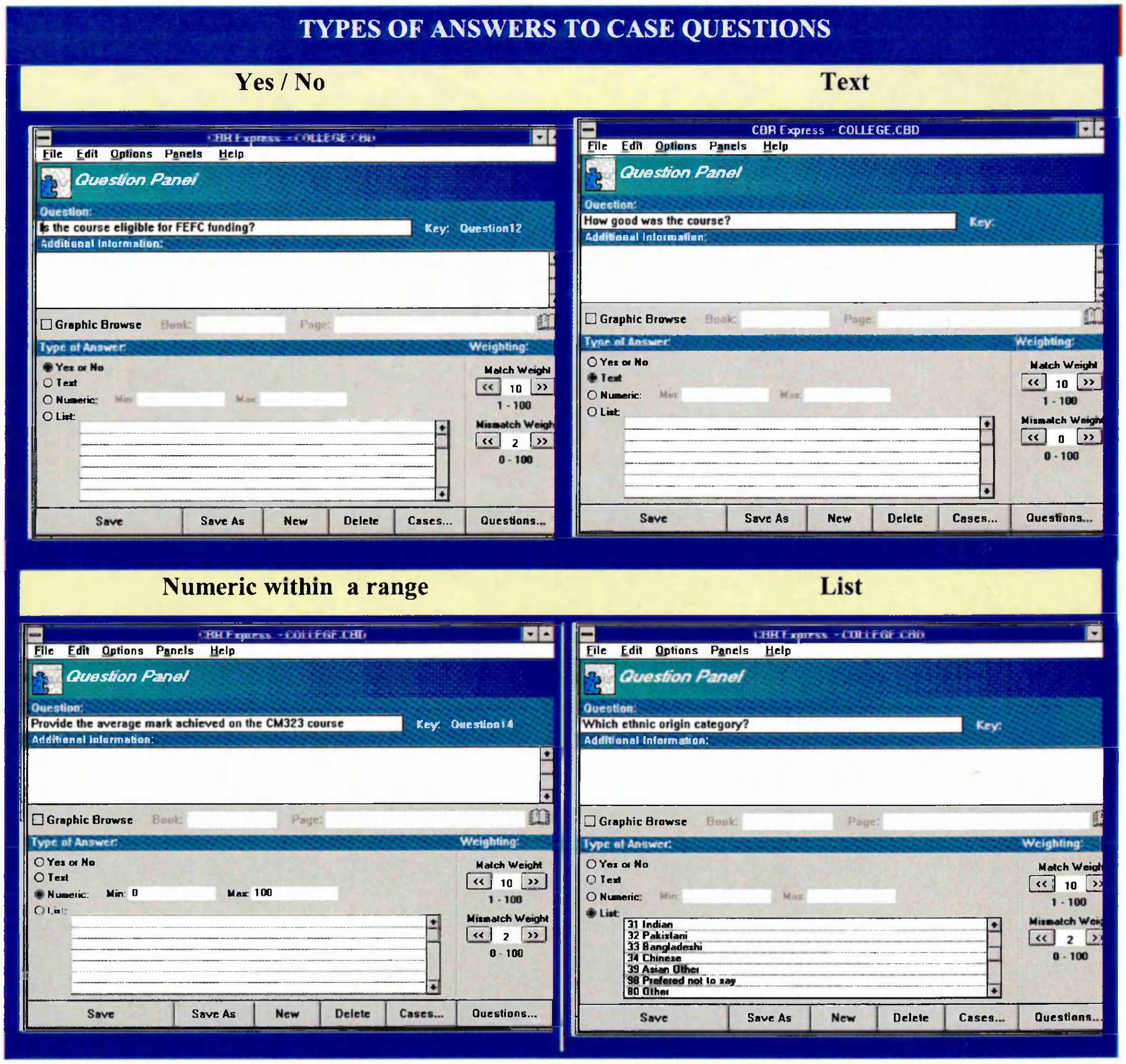


Figure 7.13
Answers to Case Questions Stored As Yes/No, Text, Numeric or Lists

7.6.3 INCORPORATING CHANGES TO CASE QUESTION RULES

Each entry in the Expert Advisor System answer screens, shown in Figure 7.13 is a rule that the system uses. The age ranges in the 'Choose Answer' screen shown in Figure 7.14 corresponds to the age range rule specified by the FEFC / LSC in their funding regulations. If the FEFC / LSC make a change to their funding regulations the answers can be edited so they reflect the changes and the rule base automatically changes. If the FEFC / LSC introduce a new rule an additional answer can be added and again the rule base will automatically change. This facility that allows insertion, amendment and deletion of rules that are written in English is essential in that it enables the College to deal with the proliferation of rapidly changing rules in the FEFC / LSC funding methodology. It also enables the system to be easily maintained by those with business knowledge and the College to react quickly to changes in its business and regulatory environment. Astera (2001) draws attention to this type of need in Section 6.1.5.

Figure 7.14 provides an example of the rules for one question in the ISR funding case used for this research. For completeness the rules used for the other questions are provided in Appendix D.

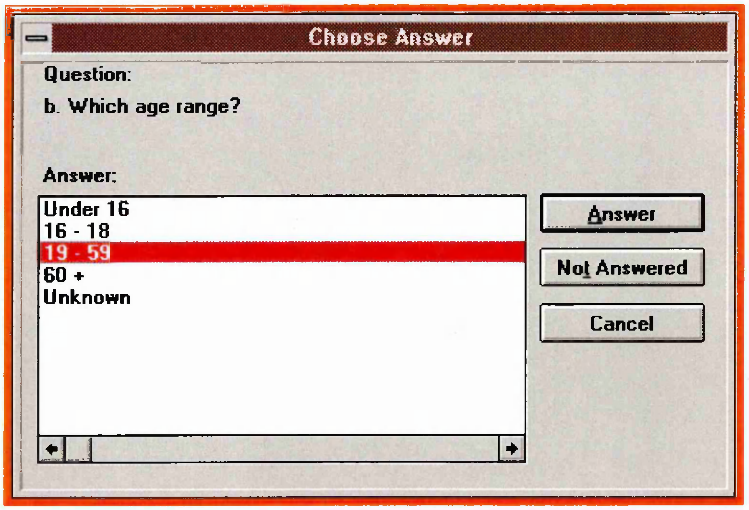


Figure 7.14
Rules Constraining Answers to Case Questions

Example

The FEFC could make a change to their funding regulations and say they would provide funding for the 60 - 65 age range and also introduce a new age range 65 + that they would fund. When the question screen in the Expert Advisor System is edited to reflect these changes the 60 + rule is amended to 60 - 65 and a new rule 65+ is introduced. These rules constrain the answers to the *'Which age range?'* case question. Figures 7.14, 7.15 and 7.16 show the change which takes place.

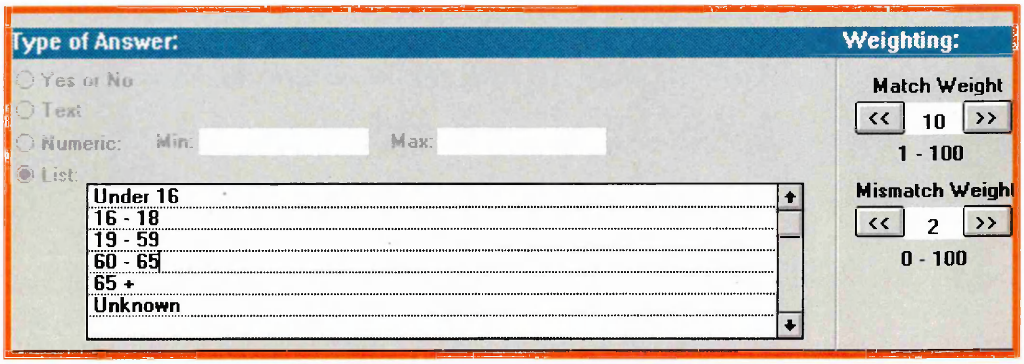


Figure 7.15
Amending an Existing Rule and Inserting a New One

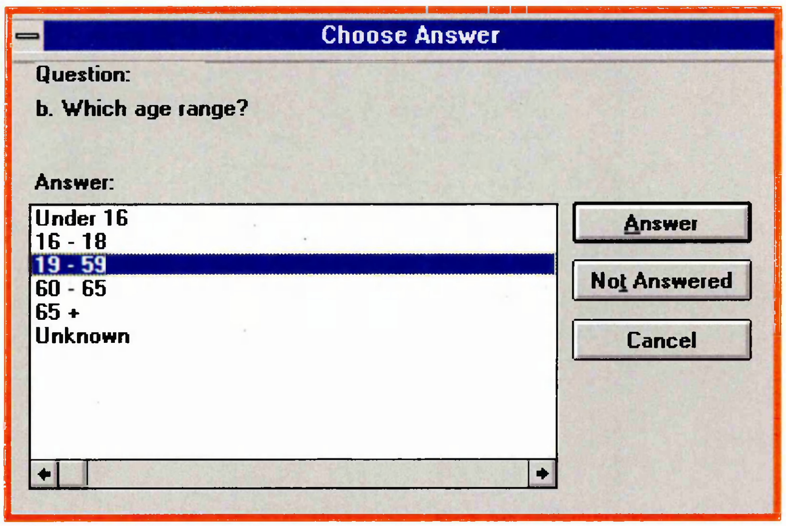


Figure 7.16
The Rule Changes Shown in the 'Choose Answer' Screen

7.6.4 USING WEIGHTS

The 'Question Panel' also provides a CBR facility that allows the weights relating to a case question to be altered as shown in Figure 7.17. The adjustment of these weights increases or decreases the scoring for the case question.

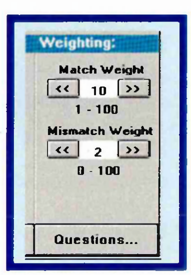


Figure 7.17
Provision for Adjusting Weights

Figure 7.18 provides an overview of the technical procedures that have been used to provide the facilities that have just been described. The diagram shows how I have set the 'On Dbl Click' and 'On Lost Focus' properties of the 'Insert or Adapt Cases' icon to activate macros that I have developed. These close the Expert Advisor System form that contains the menu and also close Microsoft Access. Control is then passed to CBR Express and CBR Express functions are used to display the 'Question Panel' that can be used to insert new questions and adapt or delete existing questions. This results in new cases being added to the CaseBase and new rules being developed.

Case Adaptation

The provision of this case adaptation facility demonstrates that *CBR principles can be used together with other knowledge discovery techniques to provide useful and adaptive systems.* It contributes to the achievement of hypothesis 2.

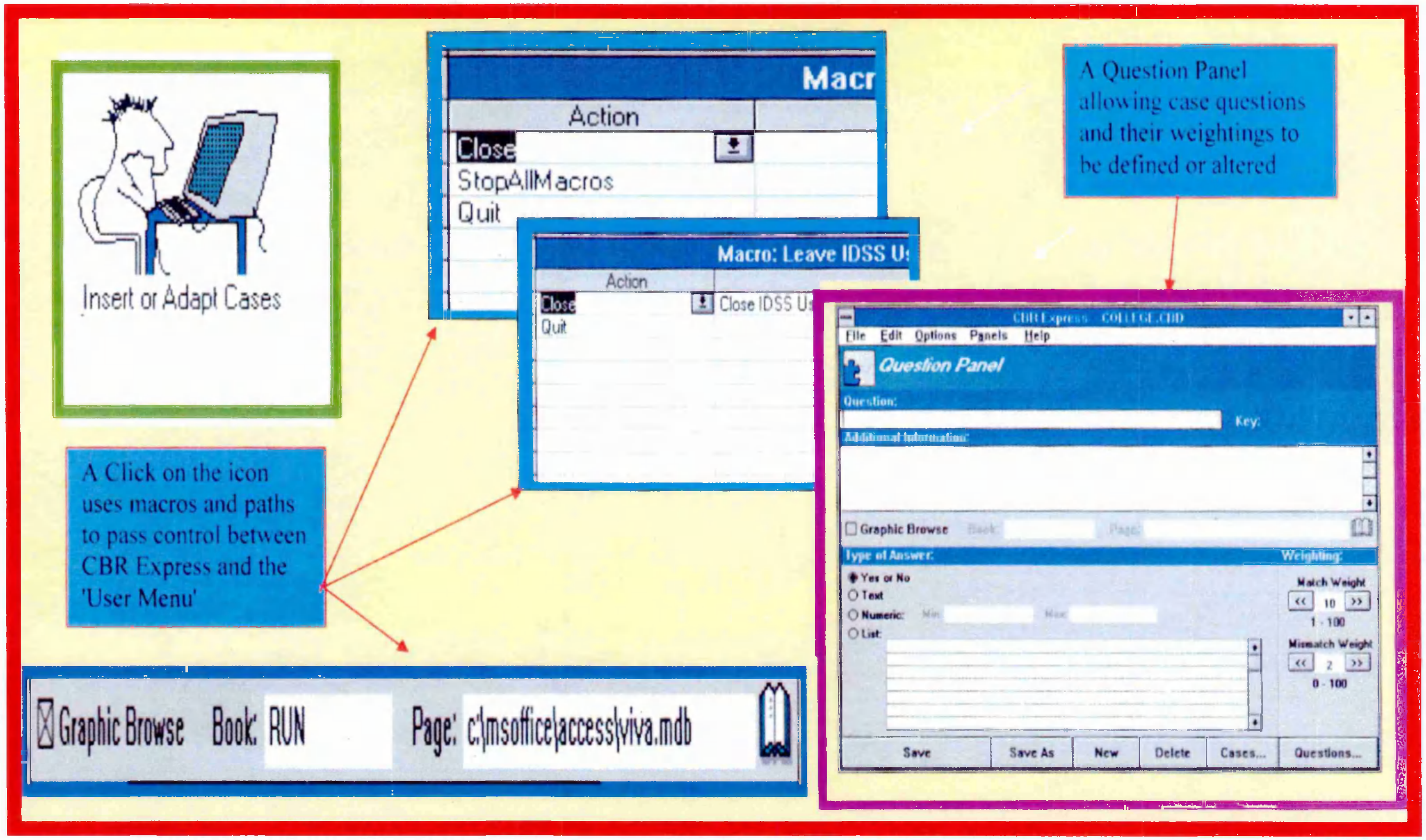


Figure 7.18
User Menu - Inserting, Adapting or Deleting Cases

7.6.5 COMMONKADS AND CASE ADAPTATION

In Section 5.3 the CommonKADS Organisation Model was discussed and the outcomes from interviews with members of the College staff were documented in Table 5.1. The investigative work undertaken during the interviews concentrated on the roles of people who were *agents* or stakeholders in the system, what their attitudes were to the task of completing the ISR Funding Return and what things they were already responsible for. The findings from the interviews are shown in Table 5.1. The reluctance of administrative and support staff to undertake new tasks provided a clear indicator that the Expert Advisor System must provide an easy to use facility for capturing information about how each ISR Funding Return was completed, and that this information would need to be available for re-use in order to provide effective management of a situation where increased workloads were already proving problematic. In addition to this, the lecturers who already had a substantial workload said they wanted the impact of any additional work to be recognized and managed effectively. Lecturers were already actively involved in the difficult and rapidly changing task of collecting the correct student data that was required for the MIS. This was the important data that would be the input to the Data Warehouse and the ISR Funding Returns. Heads of School also requested that operational outcomes should be monitored regularly against strategic plans. It was apparent that if this was to be achieved the College would need to be able to trace the decisions and the way in which they had been substantiated for each ISR Funding Return that was completed and gain knowledge and understanding of these decisions. The cases held in the case base in the Expert Advisor System meet this need.

Schreiber et al (2000) explain the need for the type of investigative work that has been described when they discuss the CommonKADS ***Organisation Model***. They say that the *problem opportunity* portfolio and potential knowledge *solutions* can be created by interviews with key staff members, brainstorming and visioning meetings, discussions with managers, and so on. They add that for a successful knowledge project it is important to identify the various stakeholders who have an interest at the start. Schreiber et al (ibid) identified these as *knowledge providers* who would be the specialists or experts in whom the knowledge of a certain area resides. These would be *knowledge users* who were the people that needed to use the knowledge to carry out their work successfully and *knowledge decision-makers* who were the managers that were in a position to make decisions that would affect the work of the knowledge providers and knowledge users. The knowledge providers at the college would be the academic staff, the knowledge users would be the DBA team and the knowledge decision-makers would be the senior managers. Schreiber et al (2000) stress that knowledge providers, users and decision makers are very different people with very different interests. They also state that divergent views and conflicts of interest are common and it takes effort to understand them. They add that without this understanding a good knowledge solution is not possible. During the brainstorming and visionary meetings and discussions with staff and managers relating to the Expert Advisor System the ***Task Model*** and the ***Agent Model*** were used to provide understanding of the tasks the system would do, what they would achieve and who would perform them.

In Section 3.1 Princeton (2001) drew attention to a survey where over 90 per cent of respondents said their organisation did not keep and share information on how past decisions were made. The 'Insert or Adapt Cases' facility that was shown in Figure 7.18 is provided by the Expert Advisor System to avoid this situation and uses cases to gain knowledge about how past decisions relating to ISR Funding Returns were made. The CommonKADS ***Expertise Model*** that was described in Section 5.6 is sometimes referred to as the ***Knowledge Model*** and has been used in the design of the Expert Advisor System experimental prototype. Schreiber et al describe how the purpose of this model is to explicate in detail the types and structures of the knowledge used in performing a task. The task in this case is to gain the knowledge needed to inform the decisions that enable the ISR Funding Return to be completed in such a way that the accrual of income is optimized.

Studer et al (2000) talk about systems like the Expert Advisor System that are knowledge-based computer systems that deal with complex problems by making use of knowledge. They explain how the knowledge may be acquired from humans or automatically derived from abductive, deductive, and inductive techniques. They say that this knowledge is mainly represented declaratively rather than encoded using complex algorithms and reveal how this representation economizes on the development and maintenance process of these systems and improves their understandability. Studer et al (ibid) continue by describing how control knowledge can be made explicit and be regarded as an important part of the entire knowledge contained in the knowledge-based system and state that this is the rationale that underlies problem-solving methods.

CBR is the *problem solving method* used in the CommonKADS ***Expertise Model*** shown in Figure 5.4. The Expert Systems element of the CBR enables the encapsulation of rules that constrain the responses to the different case questions relating to the provision of the ISR Funding Returns. The natural language interface enables searches for information to be made in English rather than a programming language. These facilities economize on the development and maintenance processes of the Expert Advisor System and increase the users understanding. The *strategic knowledge* used in the Expert Advisor System is gained by retrieving matching or partially matching cases, using weightings to alter the significance of different factors, by providing a 'what-if' projection facility, and through adapting cases that provide partial solutions to become new cases. If no case match exists a new case is developed.

Testing and Evaluation of the Case Adaptation Facility

Details of the testing and evaluation of the facility for adapting cases are provided in Section 8.4.4. The results of the testing demonstrate the fitness for purpose of the facility. In doing so, they also demonstrate that *the CommonKADS Models are well suited to providing a template for the design and documentation of the experimental prototype Decision Support System facility for adapting cases.*

7.6.6 HANDLING CASES AND THE GROWTH IN KNOWLEDGE

In Section 6.1.6 Gallagher Financial Systems (2002) stated that knowledge in the business world was power and that it was the most important asset a business possessed. This was something that the College in this case study was becoming increasingly aware of. Developing the Expert Advisor System experimental prototype and capturing and harnessing knowledge will be explored further in this section.

Mackintosh et al (1999) discuss knowledge in a more general sense than that of the CommonKADS Expertise Model. They say that knowledge exists at different levels of abstraction and its relevance depends on the user. They also make the point that a user's value and acceptability of knowledge varies greatly and that knowledge does not have a fixed quality. It becomes out of date as time elapses. In addition to this, knowledge is intangible and often incomplete, and it is therefore very difficult to describe.

The Expert Advisor System facility for inserting and adapting cases takes account of these issues. The knowledge of users who are involved in completing ISR Funding Returns is captured in cases and is available to others irrespective of people changing their roles within the college, moving to new jobs outside, or retiring. Knowledge relating to different ISR Funding Returns for different periods in time is captured and is available for re-use. The FEFC / LSC funding rules that were valid at the time of each funding bid are made explicit as the rules of the system. Each demand for information in a funding bid that requires a figure to be provided becomes a question in the funding bid case. The ISR funding bid, the information demands within the bid, together with the funding rules that relate to the funding submission form a framework. This framework allows the college to operate within the FEFC / LSC value set and achieve completeness of the content of the funding bids, and accomplish acceptance by the college and by the FEFC / LSC auditors and inspectors

Mackintosh et al (ibid) also wrote about the requirements that occur during the development of a knowledge asset. They identified the need for *acquiring, building, capturing, collecting, compiling, creating, discovering, eliciting, identifying* and *learning* if the knowledge asset was to be achieved. These needs were recognized and played a significant part in the *building* of the Expert Advisor System. The facility for inserting new cases and adapting existing cases enables the knowledge that supports the decision making for ISR funding bids to be *captured* through the *creation* of new cases and the adaptation of existing cases. The *collection* of this knowledge in the casebase enables the college to *discover* how past funding bids were *compiled* and supports the college in the *elicitation* of new knowledge that will assist them in the optimization of the funding achieved. In addition to this the college will make 'what-if' projections and *acquire* new knowledge and *learning* that will enable it to *identify* new opportunities for optimizing funding.

Mackintosh et al also discussed the need for *preserving, conserving, consolidating, holding, retaining, safeguarding, securing, storing* and *pooling* knowledge. The 'Insert and Adapt Cases' facility *stores, holds, preserves, conserves, consolidates* and *retains* knowledge in cases relating to past ISR Funding Returns. In doing this it *secures* and *pools* the knowledge and makes it available to many. It *safeguards* this knowledge against losses that can occur through the changes and the associated people issues that are happening in the FE Sector. Vacancy figures reported by Kingston (2002) provide an indication of the number of people who have left their post in FE and need replacing. Knowledge can be lost through these people leaving. He says:

> 'The AOC survey shows that more than 3,000 teaching vacancies remain unfilled, a 25% increase on the most recent survey a year ago'.

He adds:

> 'The AOC survey shows an even sharper rise in the number of vacancies for support staff and managers. There are almost 5,000 unfilled posts - 44% up on this time last year.'

Mackintosh et al also drew attention to other important considerations when handling knowledge. They acknowledged the necessity for the knowledge to be updated if it were to *evolve, grow, improve, be maintained, modified, refined* and *refreshed*. Use of the Expert Advisor System provision for inserting cases results in new cases being added to the casebase and the casebase *evolves* and *grows*. In addition to this using the case adaptation facility allows cases to be *refined, modified* and *refreshed*. Use of these facilities result in a casebase that is regularly *improved* and *maintained* by its users.

Mackintosh et al continue by discussing how the knowledge can be used for the benefit of the organisation. They describe how knowledge can be *applied, enacted, executed, exploited* and *utilized*. The knowledge which College management acquires through the use of cases is *applied* in the decision making process that underpins the completion of the ISR Funding Returns. The production of the figures for these returns is the *execution, exploitation* and *utilization* of this knowledge, whilst the management process of ratification and endorsement of these figures is the *enactment* of this knowledge. The transferring of knowledge between members of the organisation or between different organisations is described by Mackintosh et al as *disseminating, distributing, exchanging* and *sharing*. In the case of the College the knowledge is *disseminated* to College Managers and governors and *distributed, exchanged* and *shared* with the FEFC / LSC auditors and inspectors.

Mackintosh et al proceed to talk about transforming the knowledge into a 'better' format. They describe this as *compiling, explicating, formalizing* and *standardizing* the knowledge. They also emphasize the need for assessing the knowledge through the processes of *appraisal, evaluation, validation* and *verification*. They then identify the need to perform other functions on the knowledge, these functions being *classification, exploration, location, monitoring, organizing* and *retrieving*. The college DBA team use the case structure described in Section 6.4 to *compile, explicate, formalize* and *standardize* the knowledge. They use the cases relating to other funding returns and the rules relating to the current funding return to *appraise, evaluate, validate* and *verify* the knowledge. The DBA team *classifies* the knowledge by providing a case description that identifies the ISR Funding Return that the case relates to and by providing an identifier for each question within a case. They provide a natural language descriptor to *explore* and search the Casebase until the cases that match or partially match their knowledge requirements are *located* and *retrieved.* They also *organize* system backups and use the BNF report to *monitor* the execution of inferences. The BNF reports are discussed in Section 7.9.

The facilities for inserting and adapting cases not only enable knowledge to be acquired but result in a casebase being built that holds cases relating to many funding returns. These cases can easily be retrieved and compared. In Section 3.9 Critical Success Factors were identified that required *easy extraction of comparative information* and also required *information to be in the right place at the right time*. The development and implementation of these facilities in the Expert Advisor System experimental prototype demonstrates that these Critical Success Factors can be achieved. In addition to this these case facilities can be used with other facilities in the Expert Advisor System that provide access to data that can substantiate the figures used in the ISR Funding Returns and help in the resolution of data anomalies. These are the facilities for *accessing detailed case data* described in Section 7.4, and the facilities for *accessing historical data and charts* described in Section 7.5. When the case and data facilities are both used another Critical Success Factor identified in Section 3.9 is achieved. This Critical Success Factor requests facilities to be provided that will enable college managers *to make informed operational and strategic decisions and be able to substantiate those decisions.*

7.7 ADAPTING DATA QUERIES

In Section 3.3.3 senior managers and the DBA team explained how the tasks that needed to be done to complete the ISR Funding Return were becoming harder to accomplish due to lack of time or lack of knowledge. It was stated that finding ways to prevent duplication of effort or ways to use the technology to capture knowledge, were important if colleges were to provide meaningful funding returns. It was also declared that knowledge and information must be captured by the DBA team to reduce costs, free management time and encourage informed decision making. These statements led me to focus on using the skills of the DBA team in a cost effective way and optimizing the use of their time. I also tried to reduce the level of technical skills that were needed for extracting information, the amount of training that staff would require and the duplication of effort where possible.

At present highly paid staff with specialist technical skills write Ingres SQL queries to extract decision making information directly from the college MIS. Only two staff have the specialist skills that are required to do this and many other demands are made on their time. In addition to this, licensing costs for Unix and Ingres are extremely expensive. Also in Section 6.2 the DBA team said that decision making queries made heavy demands on the MIS and it was not unusual for these demands to impair system performance and response times. The Expert Advisor System architecture has been designed to address these issues.

As shown in Figure 6.2 and Figure 6.7 Microsoft Access is used to extract decision making information from the Data Warehouse instead of from the MIS, and Microsoft Excel is used to provide the graphics. The Data Warehouse also uses a different hardware platform than the MIS in accordance with the CommonKADs Platform Model that was specified in Figure 5.8. This design strategy removes processing away from the operational MIS to the Data Warehousing decision support system, thus reducing the risk of impairing the performance of the MIS and also reducing the licensing costs that would be incurred when the Expert Advisor System was used by many people. A Critical Success Factor that was identified in Section 3.9 requested *an improvement in system performance*. Removing the processing from the operational MIS to the Data Warehouse allows this Critical Success Factor to be achieved.

During discussions on the CommonKADS Organisation Model in Section 5.3 it was stated that analysis of the socio-organisational college environment was extremely important whilst colleges were experiencing rapid change and were having to manage the ensuing people, organisational and technical issues. In addition to this John Harvey-Jones (1988) spoke about managing change from a wider perspective. He discussed the pressures for technological, economic, and social change and described the effect these massive forces for change were having on the individual and how they needed to be managed. Harvey-Jones (ibid) said:

> 'The engine of change is dissatisfaction with the present, and the brakes of change are fear of the unknown and fear of the future. It follows that you cannot go too far against the grain; the grain of the people in one's organisation, and their conscious or unconscious acceptance of the need for change.'

Harvey-Jones' comments reflect on the need to manage and support the people in the change situation at the College. Section 5.3 also mentioned that the College technical and administration staff had identified people, organisational and technical issues that needed to be managed. Consequently, incorporating the Microsoft Access and Microsoft Excel packages into the Expert Advisor System took into account the need to manage these issues. It also met a request made by Senior College Managers in Section 4.3. They requested that the Expert Advisor System prototype should use 'off the shelf' commercial packages to constrain technology and training costs, increase staff acceptance and encourage competent and skilful use. The inclusion of these packages made use of skills which many of the staff already possessed and were confident in using. Consequently introducing the Expert Advisor System as the 'live' decision support system in the College could keep the associated training costs low, encourage the competent and skilful use of existing skills, and make user acceptance of the system easier to achieve.

Belasco (1990) reveals how empowering a new vision consumes time and most staff already have a lot of work waiting to be done. He continues by saying that it is easy to see how staff may regard using the new vision as another task to do, or may think about how they can put off doing the task. Since the 1992 Further and Higher Education Act, college principals and their management teams have been endeavoring to offer visionary leadership that will enable their colleges to move forward and meet new and rapidly changing demands. Staff often respond to demands of this type in a manner similar to that described by Belasco, particularly when new systems are introduced. Interviews that took place with College staff as part of the investigative work for the Expert Advisor System revealed this to be the case. People's attitudes to the task of completing the ISR Funding Return were shown in Table 5.1.

As a result of the learning gained from these interviews, and the need to manage people issues, the Expert Advisor System experimental prototype handles queries in a way that makes it is possible to reduce duplication of programming effort. Through selection of the 'Queries and SQL' menu option facilities are provided for accessing existing queries for extracting case question data. An example is given in Figure 7.19. The 'Queries and SQL' menu option also allows access to existing queries that provide case question totals as shown in Figure 7.20. For the purpose of completeness the data extraction queries and the queries that provide the totals for the other questions in the case are provided in Appendices E.1 - E8 and F.1 - F.8. The Expert Advisor System provides these facilities to enable staff to retrieve and adapt queries with minimal effort, thus creating a new query that extracts data relating to a new or changed question in an adapted case, or a new query that provides new totals. This is more efficient than writing a completely new query every time.

The case adaptation achieved through using the 'Insert or Adapt Cases' procedure given in Section 7.6, together with the 'Queries and SQL' procedure that allows adaptation of existing data extraction or aggregation queries given in this section, allows system adaptation to be performed. This makes it possible to provide an auditable data trail for the figures used in an ISR Funding Returns when a case is adapted. The 'Insert or Adapt Cases' facility reduces duplication of effort by allowing existing queries to be retrieved, adapted and reused.

A typical data extraction query is shown in Figure 7.19. A query that provides totals is shown in Figure 7.20.

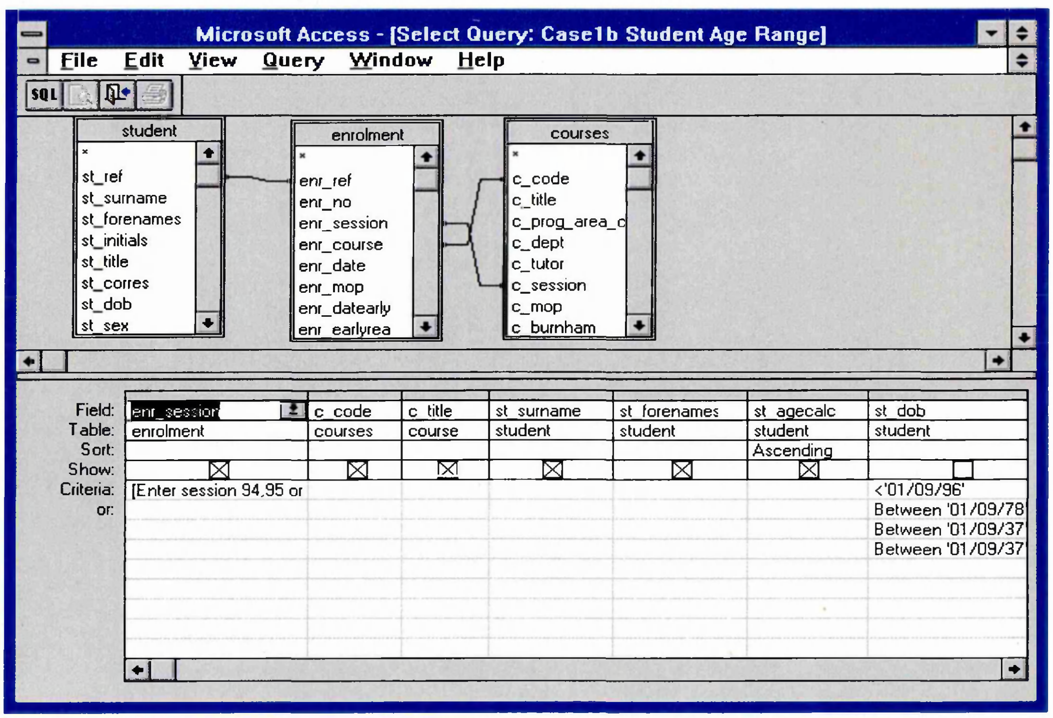


Figure 7.19
Data Extraction Query for 'Which Age Range?' Case Question

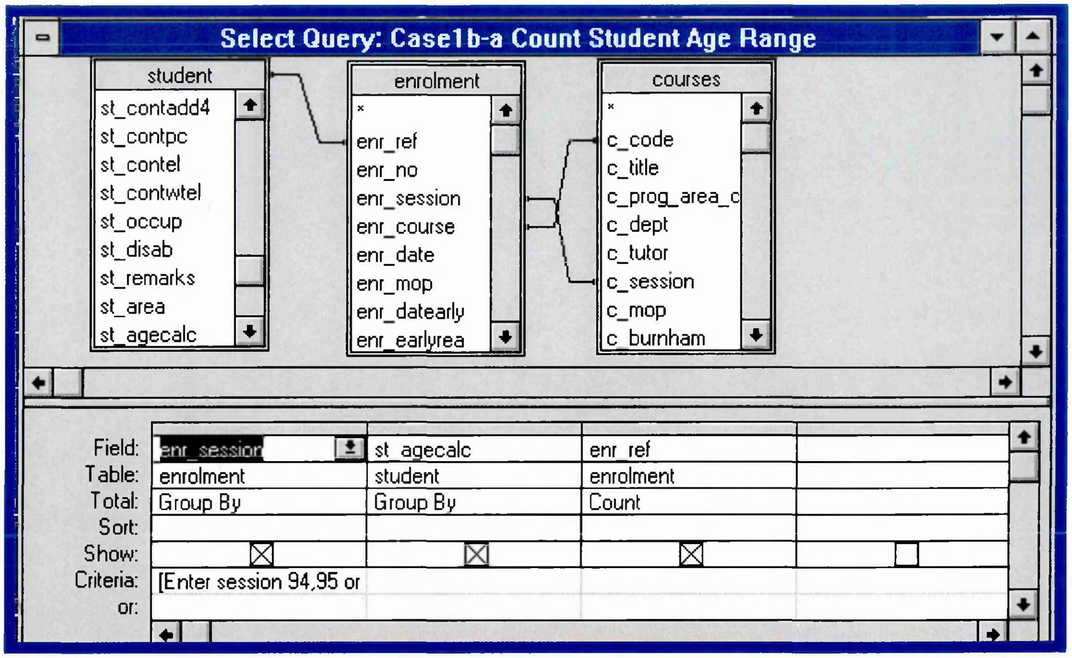


Figure 7.20
Count Query for 'Which Age Range?' Case Question

7.7.1 DEVELOPING ACCESS TO THE QUERIES AND SQL

Form Procedures

Figure 7.21 given shows how the menu icon 'Queries and SQL' is used to access a query. The 'On Activate' and 'Deactivate' properties belonging to the 'Select Query' form I developed are set to activate two other procedures I developed in Access Basic. The 'Sub Form_Activate' procedure hides the standard MS Access toolbar and displays a customized toolbar which allows the Administrator easy access to the SQL and to the query. The 'Sub On_Deactivate' procedure is activated when the query is no longer being used. It hides the customized toolbar and restores the MS Access toolbar. These technical procedures for the 'Select Query' form are shown in Figure 7.21.

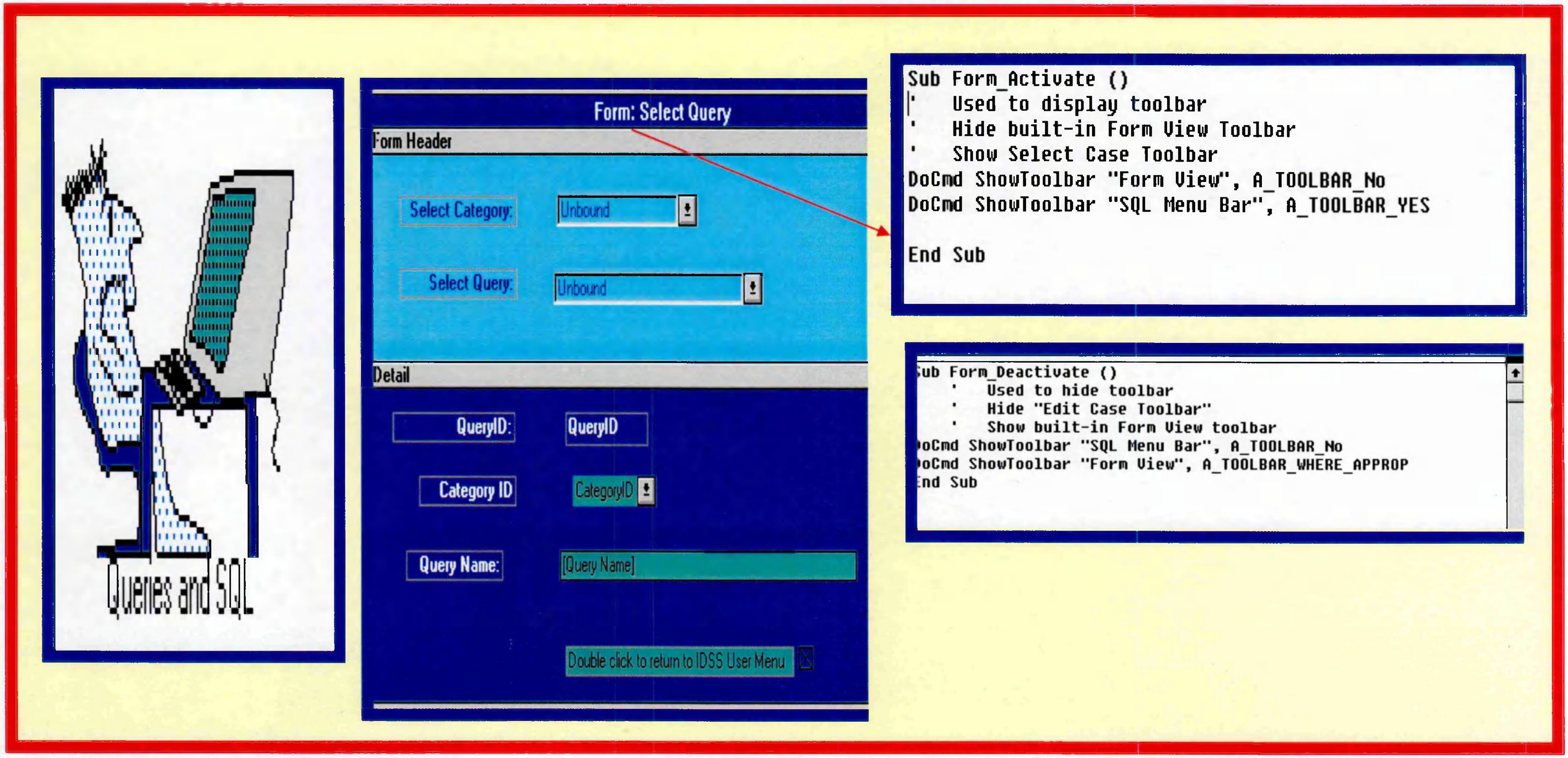


Figure 7.21
Administrator Menu - Displaying Queries and SQL Form Activation Procedure

Field Procedures

Details of some of the technical procedures I have developed and the design of the 'Select Query' Access form are provided in Figure 7.23. The 'Select Category' combo box on this form has the row source property set to activate the 'Case Category List' query that is shown. The query identifies the type of funding return that the case question for which the query was written belongs to. This would be either ISR or DLE in the prototype. A property of the next field on the form, the 'Select Query' combo box is set to activate a 'Case Query List' query. This 'Case Query List' query identifies the query the user has selected from the list displayed in the combo box. Another property I have set for the 'Select Query' combo box is the 'After Update' property. It activates an event driven procedure that I have written in Access Basic. This 'Sub Select_Query_After_Update' procedure finds the query selected by the user, enables the controls in the detail section of the 'Select Query' form and hides the QueryId text box and the Category ID combo box that are in the detail section of the form. It also activates the macro shown in Figure 7.22 that displays the query. The CategoryID box uses the CategoryID already selected from the Select Category combo box list as a control source. A property is set for this box that uses the output from the 'Case Category List' query which extracts the query name. The query name is then displayed on the screen in the Query Name box until the query itself is displayed. It is also used as a control source by the macro that enables the selected query to be displayed.

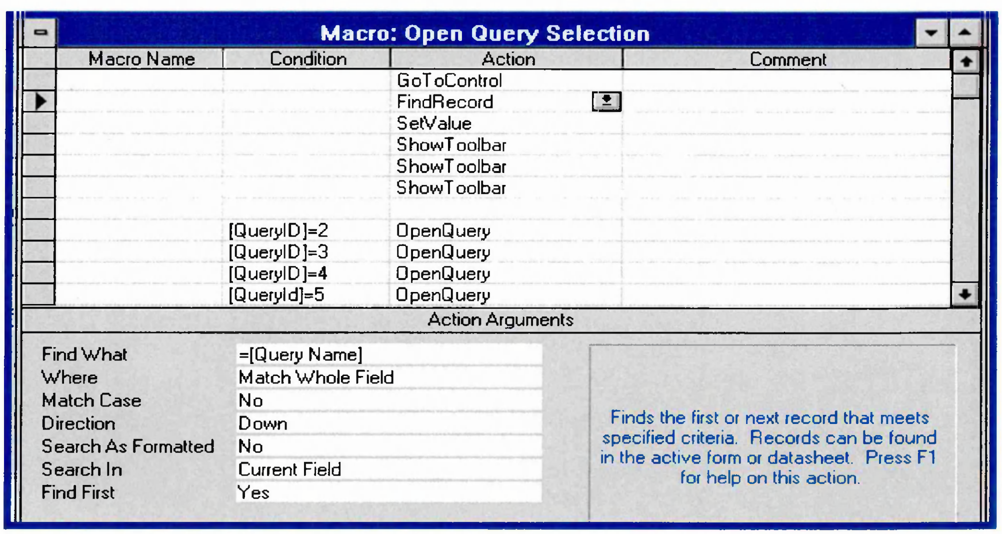


Figure 7.22
The Access Basic Procedure used to activate the Display Query Macro

Data Query Adaptation

The provision of this facility for adapting data queries demonstrates that *other knowledge discovery techniques can be used together with CBR principles to provide useful and adaptive systems*. It contributes to the achievement of hypothesis 2.

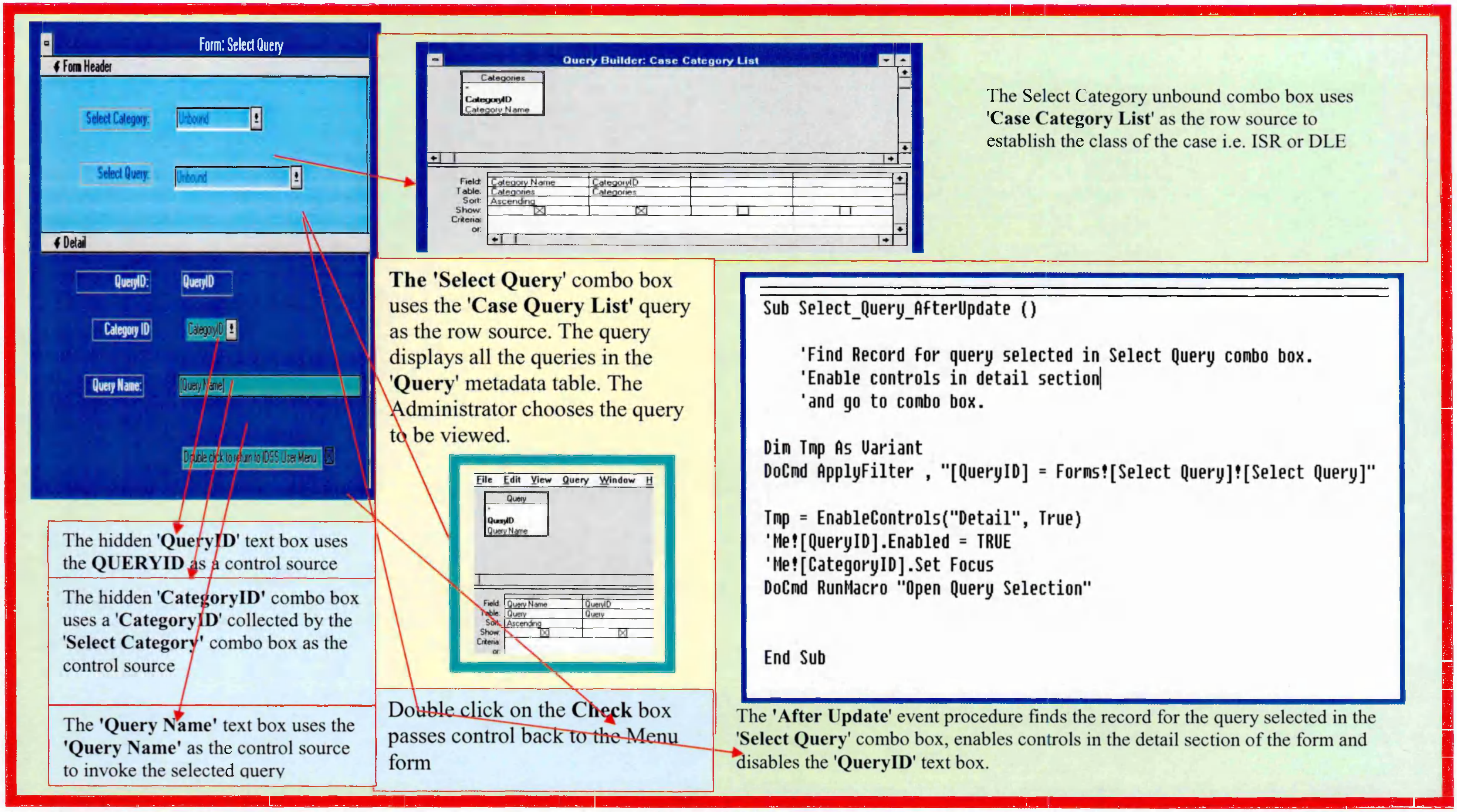


Figure 7.23
Administrator Menu – Displaying Queries and SQL

7.7.2 COMMONKADS AND ADAPTATION OF DATA QUERIES

In Section 2.5 Arsham (2003) draws attention to today's businesses being driven by data. He says that business managers and decision makers are increasingly encouraged to use data to justify their decisions. This is true of colleges now they operate as businesses. Section 5.3.2 explains how the College MIS data is currently interpreted to gain the decision making knowledge needed to inform the completion of ISR Funding Returns. It reveals how figures from completed returns are used to assess patterns that have occurred in the past. It also says that situational knowledge at different points in time cannot be extracted from the MIS because information in the relational database has been overwritten. In addition to this past returns have often been built using information gained from incomplete, inaccurate data.

The Expert Advisor System queries that handle the extraction and aggregation of data avoid these data quality problems by using the Data Warehouse data that has been cleansed, scrubbed and stored for different time periods and is not overwritten. The data extraction and aggregation queries use Microsoft Access which is identified as the *other subsystem* shown in the ***Task Model*** to achieve the *output* of the detailed data and aggregated figures. These are required to substantiate the figures used in the completed ISR Funding Return. The *agents* in the ***Agent Model*** are the DBA team who formulate or adapt the queries and use Excel to produce the bar charts and pie charts, and ensure they are stored as solutions in the Data Warehouse. The Management Team are also *Agents* who acquire knowledge from the data extractions, the totals and the charts. In addition to Microsoft Access, Microsoft Excel is identified as the *other subsystem* in the ***Task Model.*** The figures, data and charts provide situational knowledge relating to different time periods for the managers to assist them in making comparisons and informed decisions.

Microsoft Access and Excel are the *problem solving method* used in the ***Expertise Model.*** They are used to apply the principles of Data Warehousing. This allows complete, accurate, historical, aggregated data to be stored, retrieved and displayed as totals and charts for different time periods. *Strategic knowledge* is acquired through the comparison and assimilation of this information. The aggregated counts and charts that are produced become a *knowledge source* in the *task layer* of the ***Expertise Model.*** In the ***Communication Model*** the DBA team becomes involved in a *transaction enquiry* when they execute a data query or produce a bar chart or pie chart using Access or Excel. They use the *transfer task* function and the Data Warehouse snapshot data to realize the system output that informs management decision making. The output is the detailed data, the aggregated data and the graphs.

Testing and Evaluation of the Adapting Data Queries facility

Details of the testing and evaluation of the facility for adapting data queries are provided in Section 8.4.5. The results of the testing demonstrate the fitness for purpose of the facility. In doing so, they also demonstrate that *the CommonKADS Models are well suited to providing a template for the design and documentation of the experimental prototype Decision Support System facility for adapting data queries.*

Critical Success Factors for the Expert Advisor System were discussed in Section 3.9. It was established that there was *a need for complete, consistent, accurate data to be available, to view detailed data and aggregated data at different points in time, to provide graphical representation of data for quick and easy assimilation,* and *to provide easy extraction of comparative information.* The Data Warehousing facilities covered in Section 6.3 provide facilities for the collection and storage of snapshots of complete, consistent and accurate data for different time periods and address the Critical Success Factor requesting this sort of data. However this data set needs to be used in the decision making process for its value as a business asset to be realized. The DBA team has an important role to play in this context. They develop and adapt queries that use this data set and *provide access to detailed data, aggregated data and graphs relating to different time periods.* These results allow the management team *to view and compare* the contents of past ISR Funding Returns, to learn and gain knowledge from their completion and to make informed decisions that will assist the College in optimizing the funding accrued from new ISR Funding Returns.

Section 7.4 discussed the Expert Advisor System facilities that allow detailed data to be accessed. Section 7.5 discussed the facilities that allow historical data and charts to be accessed. In both these cases the facilities were considered from a user perspective, and not from a technical perspective where the data needs to be extracted and manipulated before the user is provided with what they want. The DBA team inserts and adapts queries that use the Data Warehouse quality data and provide the substantive data for case questions as required by the managers, auditors and inspectors. To enable the DBA team to do this and for the information *to be in the right place at the right time* to meet the demands of the College and the FEFC / LSC, the Expert Advisor System provides facilities for the DBA team *to view existing queries and SQL.* In doing so it meets two other Critical Success Factors. Firstly for the existing queries and *the related SQL to be viewed,* and secondly *for information to be in the right place at the right time.*

7.8 MAINTAINING METADATA TABLES

Using Metadata has been an essential part of developing the Expert Advisor System but determining how the Metadata should be implemented has been hard to decide. Barquin et al (1997) of the Data Warehousing Institute discussed Metadata problems. They stated that difficulties were being experienced with Metadata integration and explained that new tools were appearing on the market so quickly that it was impossible for a single vendor to supply the integration of Metadata that was required. They continued by describing how many tools and databases with their own Metadata stores already existed, and how companies would consider a major retrofit to use a common repository to be prohibitively expensive. They also pointed out that even if such a repository existed, a single vendor would probably own it. They added that vendors of other tools would be reluctant to depend heavily on it, so at best the integration would be optional.

Anahory (1997) described the problem still further. He explained how there currently was no recognized Metadata standard, but new and emerging standards were being specified. MacIver (1999) also said there was a lack of overall Metadata standards but he revealed that two competing standards were emerging in Data Warehousing and Business Intelligence. These standards were:

The **Open Information Model** (OIM) that is the collaborative work of Microsoft and about twenty other vendors and, since 1998, the Meta Data Coalition (MDC). The goal of the coalition is to have their work accepted as the Metadata standard. It is based on COM APIs, uses SQL and the XML interchange format.

The **Common Warehouse Metadata Standard** (CWM) that is the collaborative work of IBM, Unisys, NCR, Hyperion, Oracle and a growing list of other interested parties. It is based on CORBA APIs, uses a subset of UML, adopts XML as the interchange format and the Object Management Group (OMG) play a leading role in its development.

MacIver (ibid) also explained how Platinum had recently undertaken work for converging these standards but their recent acquisition by Computer Associates raised doubts about the future of their work.

Future development of the Expert Advisor System will not only need to consider emerging standards in Data Warehousing but the complete role of Metadata. The Meta Data Coalition (1999) statement provides understanding of why this is necessary. They say:

> 'Metadata is ideally created whenever data is touched, moved, changed or stored differently. Tracking Metadata is relevant and important in any number of circumstances, including Data Warehouses, but also in implementing new enterprise applications, migrating to client / server-based architectures, moving from legacy systems to new platforms, switching over to new database management systems, etc.'

Berson and Smith (1997) also made an important statement about Metadata that needs to be considered. They said:

> 'It is imperative that the same Metadata or its *consistent* replicas be available to all tools selected for the Data Warehouse implementation, thus enforcing the integrity and accuracy of the Warehouse information'

Although these statements confirmed that no common Metadata standard existed they also emphasized the crucial role of Metadata, and the need for a single Metadata repository or consistent replicas. Consequently I decided that, although the College that was used for the case study operated at a number of different sites, with some of the sites using their own small database systems in preference to the MIS, the Expert Advisor System would use a single Metadata repository. Due to the lack of formal agreement on Metadata standards Microsoft Access tables were used to provide Metadata for the prototype. I also recognized that a review of Metadata standards would need to become part of the technology change management process and could result in the development of a 'live' version of the Expert Advisor System complying with a new Metadata standard.

7.8.1 MAINTAINING METADATA TABLES

Through selection of the 'Tables' menu icon a screen is displayed that allows the DBA team to select and display a metadata table. Examples of metadata tables are given in Figure 7.24. This function allows metadata tables to be updated, thus allowing easy navigation of the Expert Advisor System when insertions, additions or deletions are made to tables, cases or categories.

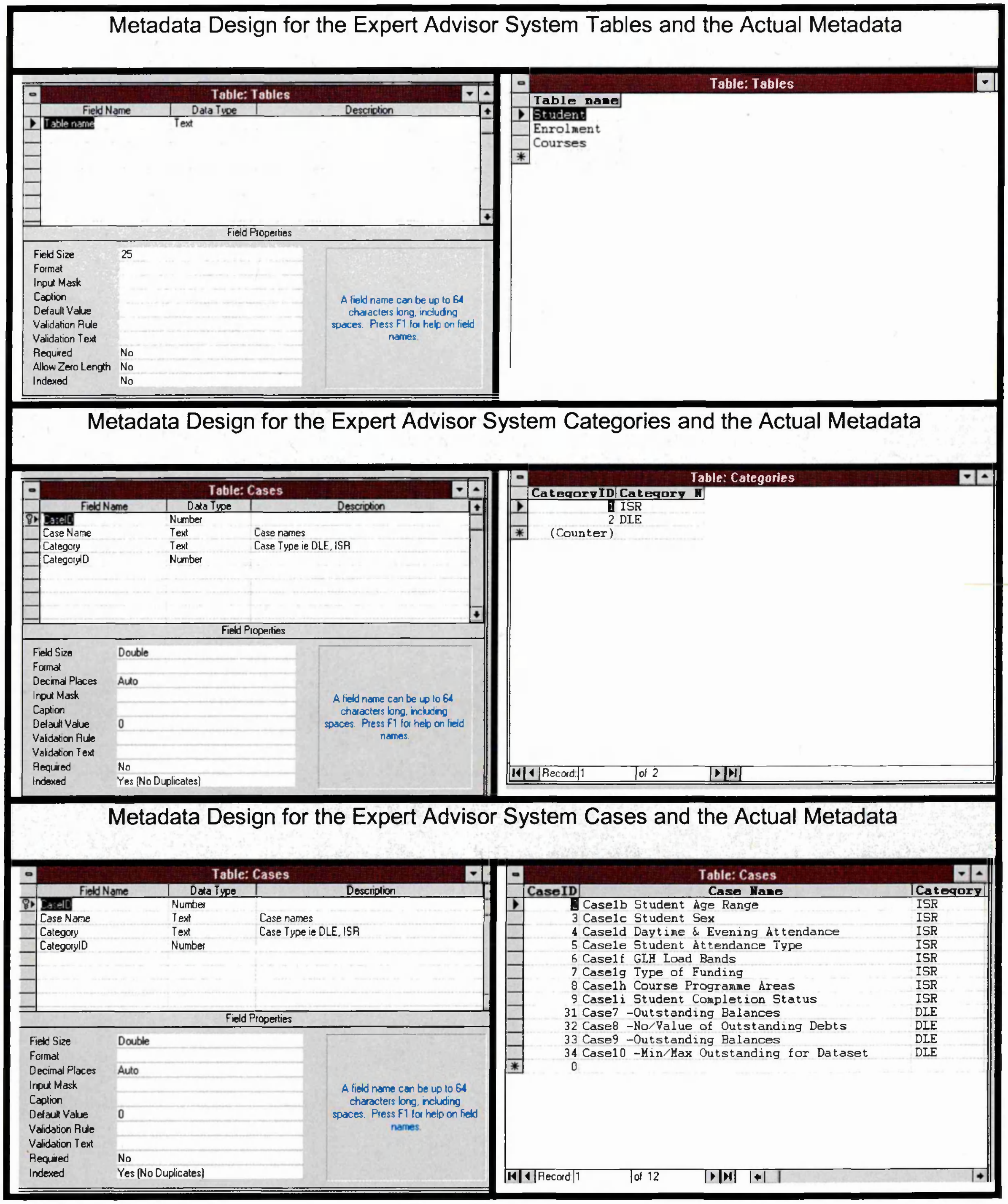


Figure 7.24
Examples of Metadata Tables

7.8.2 DEVELOPING ACCESS TO THE METADATA TABLES

When the 'Tables' menu icon is selected a Microsoft Access form that I developed is displayed. This allows the user to select the Metadata table they wish to view or maintain. An overview of the icons, macros, forms and queries I have developed to provide this function is given in Figure 7.25.

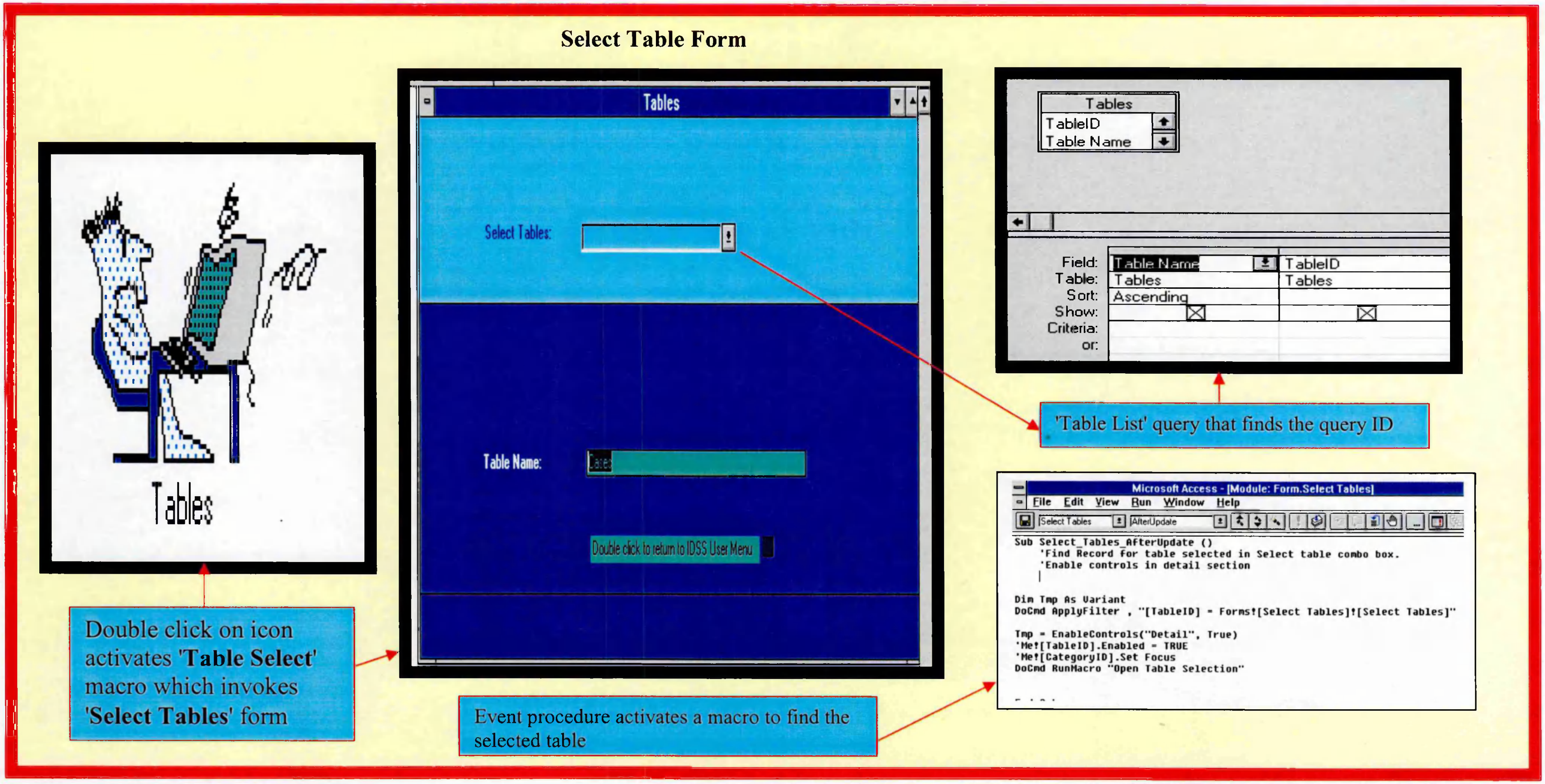


Figure 7.25
Administrator Menu - Displaying Tables Procedure

The Metadata tables in the Expert Advisor System support the facilities that *enable the performance of the system to be improved* and for the data *to be in the right place at the right time.* These two needs were identified as Critical Success Factors in Section 3.9.

7.9 DISPLAYING THE BNF REPORT

When 'BNF Report' is selected from the Administrator Menu the BNF report is displayed. This is a report that is used by the DBA team to identify the sequence of execution of the inferences made by the Expert Advisor System. 'BNF' is a term used in the CBR Express package but it is not an abbreviation for 'Bachus Nauer Form' the database normalization term. An example of part of a BNF report is provided in Figure 7.26.

7.9.1 DEVELOPING ACCESS TO THE BNF REPORTS

Details of the technical procedures that are used to access the BNF report are provided in Figure 7.26. A property is set to activate the 'View Case BNF' macro when the Administrator clicks the mouse on the 'BNF Report' icon on the Expert Advisor System menu. The macro displays the BNF report in Notepad for the Administrator to view. The report is produced by a CBR Express function.

Understanding of the CBR Inferences

The provision of the facility to access BNF reports and gain knowledge of the execution of the inferences that are made when Cases are used demonstrates that *CBR principles can be used together with other knowledge discovery techniques to provide useful systems*. It contributes to the achievement of hypothesis 2.

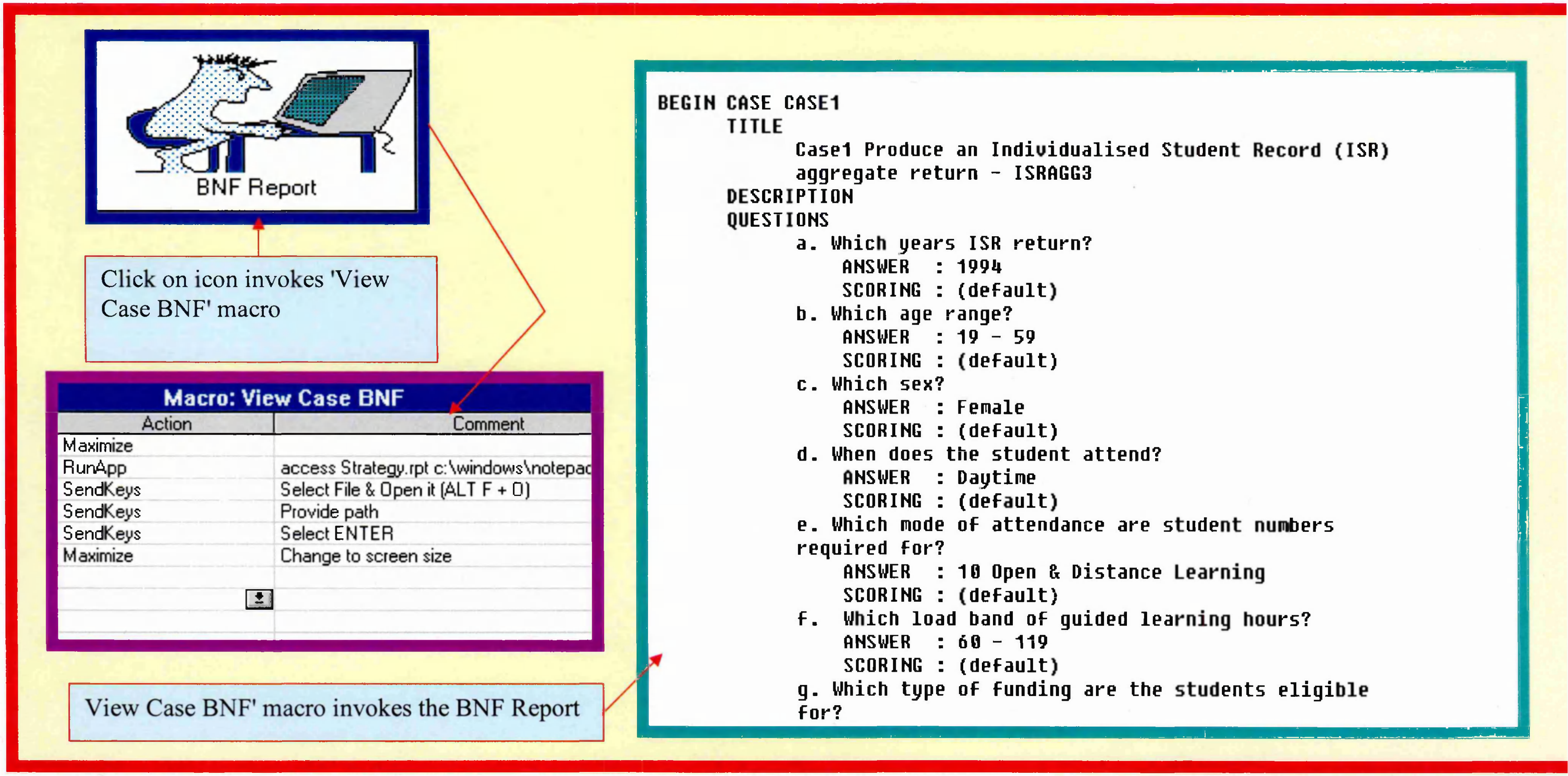


Figure 7.26
Administrator Menu – Displaying the BNF Report Procedure

7.9.2 COMMONKADS AND THE BNF REPORT

The BNF report is an important part of the CommonKADS ***Expertise Model***. The CBR Express package that is used as a component of the Expert Advisor System documents the control it provides over the inference steps that are made and specifies the sequence of execution of these steps for an ISR case in the BNF report. This provides the *task knowledge* in the *Expertise Model.*

```
e. Which mode of attendance are student numbers
required for?
   ANSWER  : 10 Open & Distance Learning
   SCORING : (default)
```

Figure 7.27
An Inference Documented in a BNF Report

In the example provided in Figure 7.27 the inference made by the Expert Advisor System is that student numbers are required for the ‘Open and Distance Learning’ mode of attendance and that the ‘default’ setting was used to calculate the scoring for the case question. If weighting factors had been altered to increase or decrease the scoring for the question ‘default’ would be replaced with details of the adjustment. If this had occurred the importance of the question could have been inferred from the adjustment that had been made.

The inferences that can be made use the knowledge specified in the *domain layer* of the ***Expertise Model***. This knowledge is based on the college problem domain and the FEFC / LSC rules relating to the funding methodology. The rules that constrain the answers to the case questions that are used in the case study are provided in Appendix D.

The *inference layer* provides the theory relating to the use of the domain layer. It states what the potential inferences are that can be made using the domain layer knowledge that is specified. It does not identify which inference actually needs to be made, or the order in which the inferences need to be made. An example of this is given in Figure 7.28. All six modes of attendance are available for use by the Expert Advisor System but the system does not specify which 'mode of attendance' must be used or the order in which the 'modes of attendance' are used.

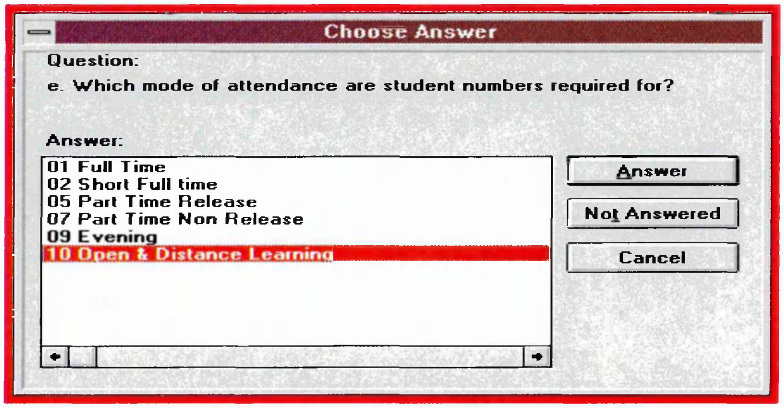


Figure 7.28
Rules for 'Which mode of attendance are student numbers required for?'

The *inference layer* also models inferences as possible knowledge sources. The case question data, aggregated figures and the charts that substantiate the case question are *knowledge sources* in the Expert Advisor System. The aggregated figures and charts that were provided as a solution to the Case question 'Which Mode of Attendance are the number of students enrolments required for?' are shown in Figure 7.29.

Case question 1e) Which Mode of Attendance (MOA) are the number of student enrolments required for?

Detailed information to support these counts and charts are held in sheets Case1e 94, Case1e 95 & Case1e 96.

MOA

1 - Full Time 30 weeks or more	5 - Part Time Released
2 - Full Time 4 - 30 weeks	7 - Part Time Non Released
3 - Sandwich	9 - Evening only
4 - Block Release	10 - Open/Distance Learning

Session	MOA	Enrolments	Session	MOA	Enrolments	Session	MOA	Enrolments
94	1	4	95	1	3	96	1	8
94	5	7	95	5	17	96	5	19
94	7	2	95	7	2	96	9	85
94	9	70	95	9	69			

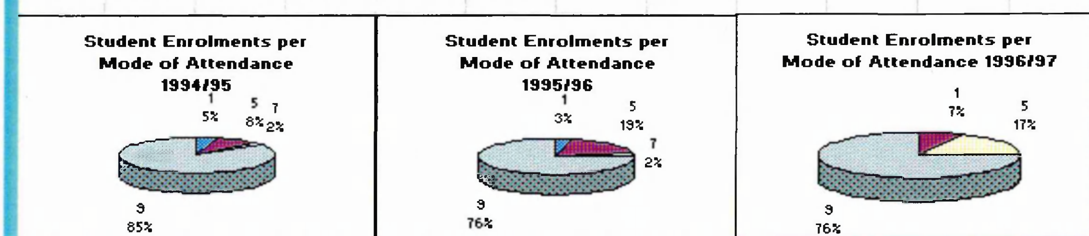


Figure 7.29
Knowledge Sources in the Expert Advisor System

The *inference layer* also models data elements that are produced when the *knowledge source* operates on data elements and produces new data elements. The data elements are modeled as meta-classes. Examples of this are when the Expert Advisor System uses a meta-class input to formulate a new case or to retrieve data relating to a particular category of funding bid. The categories in the prototype are ISR and DLE. DLE is the Demand Led Element FEFC funding.

The term 'category' was used rather than 'class' because it was already in use in the College.

Testing and Evaluation of the Facility for Accessing the BNF Report

Details of the testing and evaluation of the facility for accessing the BNF report are provided in Section 8.4.7. The results of the testing demonstrate the fitness for purpose of the facility. In doing so, they also demonstrate that *the CommonKADS Models are well suited to providing a template for the design and documentation of the experimental prototype Decision Support System facility for accessing the BNF report* and contribute to the achievement of hypothesis 1.

7.10 KNOWLEDGE DISCOVERY

The development and implementation of the experimental prototype described in this chapter enables the Expert Advisor System to become 'a learning system'. As cases are retrieved and adapted for re-use, or new variables added to existing cases, new cases containing situational knowledge are created and the Casebase grows. Future enquiries using the Expert Advisor System compare the current case with the historical cases in the Case Base. The historical cases now include the new cases that were created. The results from the Expert Advisor System incorporate knowledge and learning gained from the additional cases which have been added. The Expert Advisor System experimental prototype is a precedent-based system that uses past experience and provides ***case-based knowledge discovery.***

In addition to this the system provides access to detailed case question data and aggregated data that are used to provide totals and graphs. All of these enable the user to gain knowledge and learning from past ISR funding bids. As cases are adapted to form new cases data extraction queries and data aggregation queries that provide totals are also adapted and new graphs are developed. Each query and graph relates to a specific question in a case and corresponds to the time period covered by the case question. Comparative situational knowledge and learning is gained from each new auditable data trail and its associated graph. The Expert Advisor System experimental prototype is a precedent-based system that uses past data and graphs to provide ***data-based and graph-based knowledge discovery.***

Snapshot data from the Data Warehouse are also used in the Expert Advisor System to allow the user to make 'what-if' projections using quality data and gain knowledge and learning about the future and the impact of funding changes which may happen. Managers use the system to make forecasts to inform their decision making relating to students, courses and their qualifications. The managers need to know the impact of these decisions on the completion of the ISR Funding Returns and Strategic Planning Returns. The Expert Advisor System provides ***projection-based knowledge discovery*** to allow managers to gain knowledge about future threats and opportunities. They use this knowledge to optimize their funding bids.

Case-based knowledge discovery together with data-based knowledge discovery, graph-based knowledge discovery and projection-based knowledge discovery provide system-based knowledge discovery. ***System-based knowledge discovery*** assists the College Managers in making informed decisions and optimizing their funding bids.

Knowledge Warehousing

In addition to this Nemati et al (2002) whilst discussing the need for Data Warehouses to be extended to become Knowledge Warehouses, say there is a need for a new generation of knowledge-enabled systems that provide the infrastructure needed to capture, cleanse, leverage, and disseminate not only data and information but also knowledge. These features of knowledge-enabled systems are features used by Expert Advisor System experimental prototype to provide system-based knowledge discovery. The work in this thesis should add new learning and understanding to the research area of Knowledge Warehousing.

CHAPTER 8 - RESULTS

This chapter considers the 'automation' of the Expert Advisor System then discusses system testing and evaluation. The chapter concludes with an analysis of the results of this work and gives details of the conclusions that can be drawn from it.

8.1 A PARTIAL SYSTEM AUTOMATION FRAMEWORK

Dearden (2001) explains how using a combination of human and automated activities to perform system functions can be described as *partial system automation*. He adopts the following function definition for his work.

> *'A function is a service or benefit required of the completed human-machine system, described in a way that is independent of any particular division of work between humans and machines'*

The Expert Advisor System is a human-machine system that uses partial system automation to provide a decision support function for college managers.

Dearden (ibid) continues by identifying the need for a framework that can be used to communicate design ideas and provide clear guidance during the development of this type of system. He states that the degree of support provided by the framework is known as '*operationality*'. This he defines as focusing on the reading of a representation for a specific purpose, namely imagining and constructing an artefact that matches the specification. The CommonKADS Models that were discussed in Sections 5.3 - 5.8 communicate design ideas and are the specification that provides guidance for the development and implementation of the artefact, this being the Expert Advisor System. The degree of support that the Expert Advisor System provides is evaluated through the use of a survey that is provided in Appendix G. Before completing the survey participants did the exercises that were provided to gain knowledge and understanding of the system and its capabilities. The survey forms the framework for testing the system and the results of the survey are used to assess the decision making support the system offers. These activities demonstrate the *operationality* of the system.

8.2 A TESTING AND EVALUATION SURVEY

Three types of people participated in the Expert Advisor System Survey. Those in the first type were working in the Higher Education Sector in occupations that had similar roles and responsibilities to those of their counterparts in the Further Education Sector. These people possess specialist knowledge of the Education Sector, how it operates, its culture, requirements and expectations. They are able to provide a careful, focused critical evaluation of the Expert Advisor System. The second type consisted of one individual who had worked for a Local Education Authority and who had been actively involved with the transitional work between the LEA and the College used for the case study when the 1992 Further and Higher Education Act became effective. He had detailed knowledge of the Further Education domain and the complexity of the funding mechanism, and was capable of performing a critical evaluation. The third type of people consisted of those who were working in the Commercial Sector and had the required level of technical and management expertise to enable them to undertake the critical evaluation.

The Expert Advisor System was an experimental, throw-way prototype that was developed to evaluate the appropriateness of the chosen methodology, to test the feasibility of integrating the chosen technologies and principles, to help users to see the capability of the system, and to act as a vehicle for communicating ideas, expectations and requirements. Although the small group of people who were chosen to participate in the survey could not provide a comprehensive evaluation of this prototype, their specialist knowledge and skills equipped them to perform an evaluation that would highlight important issues that would need consideration during the development of a 'live' system. The varied backgrounds of the participants also enabled the system to be evaluated from a variety of different, but valuable perspectives.

All participants read short scenarios explaining each task to be performed and undertook an exercise to gain knowledge and understanding of the task. They considered the validity of a statement relating to the task and allocated a score for it, and a score for any corresponding CSFs, then completed a comment box on the 'Expert Advisor System Evaluation Survey' form. A copy of the form is provided in Appendix G.

Simple statements were used in the survey to ensure that each participant understood exactly which part of the system they were allocating a score to. Designing the survey in this way allowed the analysis of the scores to be undertaken without having to return to the participants to gain an understanding of any ambiguities. The participants were also encouraged to make comments relating to the particular function of the prototype that was being evaluated. These comments were valuable because they provided an opportunity for participants to highlight issues that would not be apparent through the scoring system.

The primary aim of the survey was to test the Expert Advisor System experimental prototype from a user perspective and evaluate its fitness for the purpose of supporting decision making that would influence the completion of the ISR Funding Return. The questions in the survey were chosen to enable the main functions of the Expert Advisor System to be tested and evaluated, and to establish how easy the prototype was to use and understand.

8.3 THE SURVEY RESULTS

Chapter 7 explained how the Expert Advisor System experimental prototype was developed and implemented. It considered technical and organisational issues. In contrast to this the emphasis in this chapter will be on system testing and user evaluation.

In addition to the premises in the evaluation survey the Critical Success Factors (CSFs) that were determined for the Expert Advisor System are an important user expectation that needs to be considered whilst testing and evaluating the system. Where the survey task being undertaken corresponds to one of the CSFs that were identified in Section 3.9, the survey participant completes the relevant exercise then considers the CSF before allocating a CSF score.

The Expert Advisor System Survey results showing the participants responses are provided in Tables 8.1.1 - 8.1.5.

The Expert Advisor System Survey Results								
Possible Responses 1 Strongly Agree 2 Agree 3 Neither 4 Disagree 5 Strongly Disagree	**Participant A**	**Participant B**	**Participant C**	**Participant D**	**Participant E**	**Participant F**	**Participant G**	
User Menu - View Questions in Cases Menu option								
Past questions in cases are easy to access	1	1	1	1	1	1	2	
It is simple for a User to answer Case questions	1	1	1	1	1	1	1	
When a new Case is being set up it is easy to find and view similar questions that have already been used	2	2	1	1	1	1	2	**CSF** To provide a natural language interface
The system enables the user to identify similar Cases	2	1	1	1	1	1	1	**CSF** To provide a natural language interface
The Expert Advisor System Facility for finding Cases that nearly match as well as those that match perfectly is a useful facility for informing decision making. It could help many organisations	2	1	1	1	2	1	1	
The ISR Case in the Expert Advisor System consists of questions that represent the FEFC Individualized Student Record (ISR) aggregate return (ISRAGG3 shown in Chapter 2 of the thesis	1	1	1	1	1	1	1	

Table 8.1.1
Survey Results

The Expert Advisor System Survey Results								
Possible Responses 1 Strongly Agree 2 Agree 3 Neither 4 Disagree 5 Strongly Disagree	**Participant A**	**Participant B**	**Participant C**	**Participant D**	**Participant E**	**Participant F**	**Participant G**	
User Menu - Display Case Data Menu Option								
The Expert Advisor System provides a facility for viewing detailed data that has been used to support a funding bid i.e. a Case	1	2	1	1	1	1	1	
User Menu - Display Historical Data and Charts Menu Option								
It would be extremely useful for organisations other than education that have a need for accessing historical data at different points in time to inform their decision making to use the Expert Advisor System	1	1	1	1	1	1	5	**CSF** To view detailed data for different time periods
The Expert Advisor System enables aggregated figures, graphs and detailed data for each question in a Case, for each time period to be viewed. Organisations other than education find anomalies in their data and could use the expert Advisor System to look at this detailed level of data to gain deeper understanding before making decisions	1	1	1	1	1	1	5	**CSF** To view aggregated data for different time periods
	1	1	1	1	1	1	2	**CSF** To provide graphical representation of data for quick and easy assimilation
	1	1	1	1	1	1	3	**CSF** To provide easy extraction of comparative information

Table 8.1.2
Survey Results

The Expert Advisor System Survey Results								
Possible Responses 1 Strongly Agree 2 Agree 3 Neither 4 Disagree 5 Strongly Disagree	**Participant A**	**Participant B**	**Participant C**	**Participant D**	**Participant E**	**Participant F**	**Participant G**	
Administrator Menu - Insert or Adapt Cases Option								
It would be relatively easy for Cases to be set up to help Managers operating in other complex problem domains such as the police force, the health service or local government to assist them in their decision making	1	1	1	1	1	1	2	
Using the Expert Advisor System it is easy to adapt an existing Case and save it as a new Case	1	1	1	1	1	1	2	
The procedure for inserting and adapting Cases is simple to use and does not require specialist technical skills	1	1	1	1	1	1	2	
The rules supporting each of the questions in a Case are easy to set up	1	2	1	1	1	1	2	
It is simple to translate a statistical return into Case questions and answers	1	2	1	1	1	1	2	

Table 8.1.3
Survey Results

The Expert Advisor System Survey Results								
Possible Responses 1 Strongly Agree 2 Agree 3 Neither 4 Disagree 5 Strongly Disagree	**Participant A**	**Participant B**	**Participant C**	**Participant D**	**Participant E**	**Participant F**	**Participant G**	
Administrator Menu - Queries and SQL Option								
The procedure to view queries, view SQL, amend queries and save them as new queries to support new questions in new Cases, or additional questions in existing Cases is simple and easy to use and does not require a very high level of technical understanding. after a short training course staff with a lower level of technical expertise than the DBA could amend queries	2	1	1	1	1	1	**1**	**CSF** To view supporting queries and SQL
Administrator Menu - Tables Option								
The facilities for viewing, amending or adding new entries to the tables that form the metadata used by the Expert Advisor System are useful and easy to use	1	1	1	1	1	1	2	

Table 8.1.4
Survey Results

The Expert Advisor System Survey Results								
Possible Responses 1 Strongly Agree 2 Agree 3 Neither 4 Disagree 5 Strongly Disagree	**Participant A**	**Participant B**	**Participant C**	**Participant D**	**Participant E**	**Participant F**	**Participant G**	
Administrator Menu – BNF Report Option								
The BNF report is a useful technical report that shows the order of execution of the inference steps undertaken by the system whilst gaining knowledge about Cases. it helps staff understand how the Expert Advisor System is working	3	1	1	1	1	1	1	

Table 8.1.5
Survey Results

8.4 ANALYSIS OF THE SURVEY RESULTS

This section explains each task in the survey and summarizes the scores that the participants have allocated for the tasks, and the CSFs where applicable. It also gives examples of the comments that participants wrote on their evaluation forms.

8.4.1 VIEWING QUESTIONS IN CASES

Access to case questions is an important part of the Expert Advisor System. This menu option allows the system to be used to gain decision support knowledge about past funding returns. It also allows checks to be made to ensure the ISR Funding Return requirements have been captured correctly in the cases that represent the funding bids. Table 8.2 shows the number of participants who agreed with each score for the different parts of the 'View Questions in Cases' procedure. All the participants either 'agreed' or 'strongly agreed' with each aspect of the procedure thus lending support to the fitness for purpose of this part of the Expert Advisor System.

VIEW QUESTIONS IN CASES SCORES	*1 Strongly*	*2 Agree*	*3 Neither*	*4 Disagree*	*5 Strongly*
Past questions in cases are easy to access	*6*	*1*	*0*	*0*	*0*
It is simple for a user to answer case questions	*7*	*0*	*0*	*0*	*0*
When a new case is being set up it is easy to find and view similar questions that have already been used	*4*	*3*	*0*	*0*	*0*
The system enables the user to identify similar cases	*6*	*1*	*0*	*0*	*0*
The Expert Advisor System Facility for finding cases that nearly match as well as those that match perfectly is a useful facility for informing decision making. It could help many organisations	*5*	*2*	*0*	*0*	*0*
The ISR Case in the Expert Advisor System consists of questions that represent the FEFC Individualized Student Record (ISR) aggregate return. A sample return is provided in Appendix B.1.	*7*	*0*	*0*	*0*	*0*

Table 8.2
View Questions in Cases Scores

The 'View Questions in Cases' menu option provides access to a valuable procedure that uses the CBR element of the Expert Advisor System. This is a procedure that uses fuzzy logic to find partially matching cases. It also uses a natural language interface where the user can provide the search descriptor. When the participants performed the search they found that through the use of 'fuzzy logic' the system operated in a way that was very similar to the human decision making process. They thought that looking at closely matching cases as well as exactly matching cases would be useful when the ISR Funding Return was being completed. They also felt that it would be preferable to use this facility rather than relational database technology that would only extract information that exactly matched a user's request.

Survey participants 'agreed' or 'strongly agreed' with the following statements in Table 8.2.

> *'when a new case is being set up it is easy to find and view similar questions that have already been used'*
>
> *'the system enables the user to identify similar cases"*

These scores demonstrate that the natural language interface that is used for the search descriptor works effectively and that the CSF *'to provide a natural language interface'* has been addressed.

A sample of the participant's comments about the facility for viewing questions in cases is given in Table 8.3.

SURVEY PARTICIPANTS COMMENTS
Require more than exact matches
A relational database would be limited and would only search for an exact match so a lot of important information would be missed
A relational database would exclude all but the perfect matches and hence be narrow in the information given and limited in its usefulness

Table 8.3
Survey Participants Comments - View Case Questions

8.4.2 DISPLAYING CASE DATA

During interviews with College Managers and technical staff concern was expressed that it was not possible to view ISR data at different points in time when the MIS was used. They said this occurred through data being overwritten, and also through the execution of the queries that extracted decision support information. They explained how the queries made heavy demands on the MIS and said it was not unusual for them to impair the performance of the system and result in poor response times. This often prevented these data that substantiated case questions from being accessed. The Expert Advisor System architecture has been designed to address the performance issues and to make snapshots of historical data available.

In addition to this they explained how the FEFC funding rules, the source of funding for courses, course qualification aims and cost weighting factors frequently changed. They pointed out how this could result in the student enrolment income increasing or decreasing, even if the same number of students were recruited to the same courses. In addition to this they discussed the data anomalies that sometimes occurred.

An example of the problems that can occur with data happened whilst I was Head of Information Systems. The College changed to a new MIS system and new technical and coding procedures were introduced. Some data were incorrectly coded and some data conversion work had errors in it. Both these incidents had an impact on funding and required the detailed data that substantiated an ISR Funding Return to be viewed and the problem investigated and resolved. This could not be done easily for the period in time when the ISR Funding Return was submitted due to the data being overwritten.

This example demonstrates how FEFC funding bids can incorporate data that have been incorrectly coded or contain data conversion errors if no data management procedures are carried out to obtain accurate, complete quality data that are in the correct format. The Data Warehousing cleansing and scrubbing procedures in the Expert Advisor System provide this data management function for the data that substantiate ISR Funding Returns. The 'Display Case Data' menu option provides access to such data for different periods in time. These time periods correspond to the snapshots of data in the Data Warehouse and would correspond to the ISR Funding Return submission dates in a 'live' system. Having access to this substantive data allows the College to check anomalies such as those that can occur through wrong coding, data conversion and changing rules, funding sources, qualification aims, cost weighting factors and so on. It can also help to resolve queries from FEFC auditors and inspectors.

An exercise was undertaken by survey participants to gain knowledge and understanding of the 'Display Case Data' procedures provided by the Expert Advisor System. Table 8.4 shows an analysis of the participant's scores.

DISPLAY CASE DATA SCORES	*1 Strongly*	*2 Agree*	*3 Neither*	*4 Disagree*	*5 Strongly*
The Expert Advisor System provides a facility for viewing detailed data that has been used to support a funding bid i.e. a Case	*6*	*1*	*0*	*0*	*0*

Table 8.4
Viewing Case Data Scores

Six participants in the survey 'strongly agreed' that the 'View Case Data' menu option gave access to the detailed data that had been used to support a funding bid. The other participant 'agreed'. This demonstrates that the Expert Advisor System provides access to the detailed substantive data for funding bids. The comments that were made by the participants are provided in Table 8.5.

SURVEY PARTICIPANTS COMMENTS
Easy to access data for previous years
A useful method of looking at data
Very clear and precise
Easy to view the data

Table 8.5
Survey Participants Comments - Viewing Case Data

8.4.3 DISPLAYING HISTORICAL DATA AND CHARTS

During interviews College Managers questioned why the technical systems in use at the College did not allow access to time slices of historical data. They also questioned why the time slice data could not be used to provide totals derived from aggregations of these data, detailed data to substantiate the totals, and pie charts and bar charts developed from these data. They felt that if the totals and charts were brought together for each time slice comparisons could be made that would inform their decision making, and the detailed data could be used to investigate any anomalies. The College Managers said they thought that many other organisations as well as education colleges would want this facility to inform their decision making.

Table 8.6 shows how after completing the exercises that were provided six of the survey participants 'strongly agreed' that it would be useful for education and other organisations to use this Expert Advisor System facility. They also "strongly agreed' that the system made provision for aggregated figures, charts and detailed data to be viewed. These results help to demonstrate that the Expert Advisor System is suitable for this purpose.

One participant 'strongly disagreed'. He felt that other technologies were now available that could have been incorporated in the Expert Advisor System and would have provided this function. In Section 2.2 during discussions on data quality and data management it was established that although technologies would be integrated to provide the Expert Advisor System experimental prototype there would be a necessity for technology change management. New learning would come from the development of the Expert Advisor System prototype but the learning would be used in future decision support systems that could be developed from new or different technologies with more advanced capabilities. The Expert Advisor System is a step in technology change management in the field of decision support systems. It will provide additional knowledge in an area that is advancing rapidly as it strives to meet the demands of rapid change. Decision Support Systems of the future will need to cope with new requirements and will use new and different technologies as suggested by this participant in the survey.

DISPLAY HISTORICAL DATA & CHARTS SCORES	1 Strongly	2 Agree	3 Neither	4 Disagree	5 Strongly
It would be extremely useful for organisations other than education that have a need for accessing historical data at different points in time to inform their decision making to use the Expert Advisor System	6	0	0	0	1
The Expert Advisor System enables aggregated figures, graphs and detailed data for each question in a Case, for each time period to be viewed. Organisations other than education find anomalies in their data and could use the Expert Advisor System to look at this detailed level of data to gain deeper understanding before making decisions	6	0	0	0	1

Table 8.6
Displaying Historical Data and Charts Scores

The participant's comments about this facility for viewing historical data and charts are provided in Table 8.7. One of these comments talks about possible links to On-Line Analytical Processing (OLAP). OLAP is one of the technologies that Berson and Smith (1997) were discussing when they said:

> *'To improve the information content of the data and to empower knowledge workers of today and tomorrow, the latest 'hot' technologies that have emerged on the client / server arena are focused on filtering unnecessary data and presenting the valuable information in a user-friendly, intuitive, and easy to understand way.'*

Berson and Smith (ibid) identified OLAP as a 'hot' technology in 1997. This is an instance where technologies have advanced and become available and technology change management could lead to an evaluation of OLAP and its inclusion in future versions of the Expert Advisor System.

SURVEY PARTICIPANTS COMMENTS
Looked at the 'graphical information' - useful as one collective point. A reference collaborating in 'one' graphical information source
Easily extracted data to produce effective management information
Allows the user to easily see trends
The use of graphs is essential to management with limited time to make decisions
Historical data and aggregate figures and graphical charts are very helpful
Limited by Excel but could link to OLAP perhaps
Very important

Table 8.7
Survey Participants Comments - Displaying Historical Data and Charts

Whilst survey participants were completing the exercises for displaying historical data and charts they were also testing four of the CSFs that were specified in Section 3.9. These were for the Expert Advisor System to provide facilities to:

- view detailed data for different time periods,
- view aggregated data for different time periods,
- provide graphical representation of data for quick and easy assimilation, and
- provide easy extraction of comparative information.

Six of the seven survey participants 'strongly agreed' with the following statement that was included in Table 8.6.

'the Expert Advisor System enables aggregated figures, graphs and detailed data for each question in a Case, for each time period to be viewed'.

This agreement from the participants demonstrates that the facilities provided by the Expert Advisor System meet the first three CSFs and by virtue of this fact demonstrates that the last CSF has been addressed as well.

8.4.4 INSERTING OR ADAPTING CASES

Mark et al (1996) described experiences with case adaptation in the following terms:

'One of our consistent findings was that automated adaptation of case was not feasible. The required depth of domain understanding consistently forced us into ad hoc approaches that had very limited coverage.... On the other hand, we found in Clavier that users are very willing to participate in the adaptation process'.

Automation of the system adaptation was also a difficult part of the development of the Expert

Advisor System. The Expert Advisor System does provide processes for case adaptation and query adaptation and together these provide system adaptation, but provision of a completely automated system adaptation process was not possible. Case adaptation is a simple user process provided by the CBR package that is a component of the Expert Advisor System. The query adaptation process is one that I developed. As described by Dearden (2001) partial system automation is a combination of human and automated activities. The Expert Advisor System uses partial system automation. It combines human and automated activities to perform case adaptation and query adaptation. Together they result in system adaptation.

Despite adaptation being a difficult area of CBR all the survey participants have used the Expert Advisor System to undertake the exercises that were provided for inserting and adapting cases and setting up rules, and have 'agreed' or 'strongly agreed' with the statements given in Table 8.8. They have found it easy to insert and adapt cases and to set up the rules supporting cases. They have also confirmed that specialist technical skills are not required to undertake these tasks. In addition to completing this exercise for setting up rules the participants completed another exercise that compared an ISR Funding Return with the questions in a case that represented an ISR Funding Return. All users found it simple to translate the ISR Funding Return into case questions and answers and felt it would be relatively easy for cases to be set up to help managers operating in other complex domains. Details of the number of participants who have allocated each score for the different parts of these processes are given in Table 8.8.

INSERT OR ADAPT CASES SCORES	1 Strongly	2 Agree	3 Neither	4 Disagree	5 Strongly
It would be relatively easy for cases to be set up to help managers operating in other complex problem domains such as the police force, the health service or local government to assist them in their decision making	6	1	0	0	0
Using the Expert Advisor System it is easy to adapt an existing case and save it as a new case	6	1	0	0	0
The procedure for inserting and adapting cases is simple to use and does not require specialist technical skills	6	1	0	0	0
The rules supporting each of the questions in a case are easy to set up	5	2	0	0	0
It is simple to translate an ISR Funding Return into case questions and answers	5	2	0	0	0

Table 8.8
Insert or Adapt Cases Scores

A sample of the survey participant's comments for these procedures is provided in Table 8.9.

SURVEY PARTICIPANTS COMMENTS
SETTING UP CASES FOR USE IN OTHER DOMAINS
Very easy to add and remove cases
Very easy to set up
Easy to do
INSERTING AND ADAPTING CASES
A commonsense approach makes this straightforward
Very easy
Would allow use by non-technical staff, or 'expertise' to be cascaded to release the more technical to areas where they were needed most
SETTING UP RULES
Expert systems running invisibly would provide for easy adaptation of existing rules
Very easy to change the rules then to see them in use
This was a straight forward process which was easy to follow
Rules are automatically generated by the system
Simple to use
TRANSLATION OF ISR FUNDING RETURN INTO CASES
It is easy to translate
Very straight forward
Very simple to learn
Found it fairly easy to translate this return

Table 8.9
Survey Participants Comments
Setting Up Cases and Translating the ISR Funding Returns into Cases

8.4.5 QUERIES AND SQL

When a case is adapted using the 'Insert or Adapt Cases' menu option that was discussed in Section 7.6, the data relating to the adapted case needs to be extracted. The 'Queries and SQL' menu option provides the procedure for adapting existing data extraction queries. The case question adaptation procedure plus this query adaptation procedure for extracting data provides system adaptation. This results in data being extracted that match the adapted case question and relate to the same time period. These data would be used to substantiate a question in the ISR funding bid that the adapted case was based on and would meet the FEFC requirement for each funding return to be accompanied by auditable substantive data. In addition to this the 'Queries and SQL' procedure allows existing queries that provide totals to be adapted.

Survey participants completed an exercise to gain an understanding of this data adaptation procedure. Details of the scores are given in Table 8.10.

QUERIES AND SQL SCORES	1 Strongly	2 Agree	3 Neither	4 Disagree	5 Strongly
The procedure to view queries, view SQL, amend queries and save them as new queries to support new questions in new cases, or additional questions in an existing case, is simple and easy to use and does not require a high level of technical understanding. After a short training course staff with a lower level of technical expertise than the DBA could amend queries.	6	1	0	0	0

Table 8.10
Queries and SQL Scores

All the participants 'agreed' or 'strongly agreed' with the statements about the 'Queries and SQL' procedure demonstrating that the Expert Advisor System provides a simple query adaptation process. Details of the comments about the 'Queries and SQL' procedure are given in Table 8.11. The final comment in Table 8.11 does, however, warn that the Expert Advisor System would need to be used by someone with the right level of business knowledge and understanding to avoid serious mistakes occurring.

SURVEY PARTICIPANTS COMMENTS
Easy to use - can combine queries and adapt them easily
Straight forward
Allows users without a great deal of 'programming' or application awareness in SQL to develop the adaptations very quickly
There are often far-reaching consequences in adapting systems. What is done easily could be the wrong thing

Table 8.11
Survey Participants Comments - Queries and SQL

8.4.6 METADATA TABLES

The metadata tables are essential to the efficient operation of the Expert Advisor System and all participants in the survey either 'agreed' or 'strongly agreed' that the procedure for viewing, amending or adding new entries to the metadata tables was useful and easy to use. Details of the number of participants who allocated each score for this procedure are provided in Table 8.12.

TABLES SCORES	1 Strongly	2 Agree	3 Neither	4 Disagree	5 Strongly
The facility for viewing, amending or adding new entries to the tables that form the Metadata are useful and easy to use	6	1	0	0	0

Table 8.12
Metadata Table Scores

The comments in the table 8.13 demonstrate the adequacy of this procedure.

SURVEY PARTICIPANTS COMMENTS
Very easy to adapt the metadata
Simple to add new entries
No problems
Very simple to input
Its very easy to alter the metadata

Table 8.13
Survey Participants Comments – Metadata Tables

8.4.7 BNF REPORTS

Six of the survey participants 'strongly agreed' that the BNF report was a useful technical report. One participant neither agreed nor disagreed. He made the point that it was a technical report that he might not be interested in. The BNF report is a report produced for the technical people working with the Expert Advisor System. However, all the participants in the survey, whether they were technical or not, were asked to complete all parts of the survey to establish how easy the system was to use and understand. The following table shows the number of participants who allocated each score for this procedure.

BNF REPORT SCORES	1 Strongly	2 Agree	3 Neither	4 Disagree	5 Strongly
The BNF report is a useful technical report that shows the order of execution of the inference steps undertaken by the system whilst gaining knowledge about cases. It helps staff understand how the Expert Advisor System is working.	6	0	1	0	0

Table 8.14
BNF Report Scores

The sample of the participant's comments given in Table 8.15 demonstrates the adequacy of the BNF reporting procedure.

SURVEY PARTICIPANTS COMMENTS
Very clear to see the inferences
Easy to view
Very useful and clear to use
Can be used to edit the report and alter the execution
Very useful
A technical facility that I would (might) not be interested in.

Table 8.15
Survey Participants Comments - BNF Reports

8.5 THE GENERAL RESPONSE TO THE SURVEY

In addition to completing the activities that have been discussed in Sections 8.4.1 - 8.4.7 each participant was asked to answer some general questions about the system and allocate scores and / or make comments. Details of the scores and comments are provided in Table 8.16 and Table 8.17.

Survey participants were asked to write the appropriate score in the response box and / or complete the comment box.

General Questions		
Scores: 1 Strongly Agree, 2 Agree, 3 Neither, 4 Disagree, 5 Strongly Disagree		
Occupation	Score	The Expert Adviser System menu is clear and easy to follow
Head of Quality		I'd probably change the graphics. Where to click and point could be clearer (buttons).
Head of Undergraduate Studies (HE)		In most cases clear
Lecturer (HE)		Yes the system menu is easy to follow.
IT Technical Support Advisor (HE) & School Governor	1	
Ex LEA Employee	1	Clear graphics and text layout
Commercial Consultant		Yes. It was intuitive.
Technical Director		User interface design looks very dated, and would need some serious revision before going commercial.
Occupation	Score	The menu options meet the needs of a business user and a technical administrator
Head of Quality		Yes
Head of Undergraduate Studies (HE)		Yes - OK
Lecturer (HE)		Yes, it meets the needs of a business
IT Technical Support Advisor (HE) & School Governor	1	
Ex LEA Employee	1	
Commercial Consultant		Yes. I can see no real problems.
Technical Director		Yes, but again the mixture of menus with buttons needs some further thought.

Table 8.16
Survey Participants Scores and Comments for the General Questions

Occupation	Score	Cases can be used to inform management decision making
Head of Quality		Yes
Head of Undergraduate Studies (HE)		Yes
Lecturer (HE)		Yes it is very informative
IT Technical Support Advisor (HE) & School Governor	1	
Ex LEA Employee	1	
Commercial Consultant		Of course.
Technical Director		

Occupation	Any Other Comments
Head of Quality	From a cursory look at the system it would seem to have applicability in many different domains. With training users should be able to use the system with ease and to good effect. With upgrade to e.g. Windows 2000 this would be a very powerful tool to complement the user's expertise. Tool can be used by a range of workers (strategic, operational and knowledge). There is a lot going on behind the scenes in the system.
Head of Undergraduate Studies (HE)	I found the tool very easy and useful to use
Lecturer (HE)	It is an excellent and clear decision making tool, that is much required in the industry.
IT Technical Support Advisor (HE) & School Governor	Although the system uses antiquated technologies, it is quite apparent the 'system' would be a very useful tool in today's HE / FE environment. The technologies today are far superior, however, the underlying principles still apply.
Ex LEA Employee	Coming from an LEA background, it is easy to see how the system could be used to ensure the accuracy of reports / returns and contribute to decision-making. It could provide a valuable resource for managers and admin staff.
Commercial Consultant	Since this was a prototype it held up very well.
Technical Director	As a prototype started using mid-90s technology this is good. I think that some rethinking would need to be carried out to turn this into a commercial product. Furthermore, there has recently been a spate of software released that would make market entry difficult.

Table 8.17
Survey Participants Scores and Comments for the General Questions

The participant's responses to the statement *'The Expert Adviser System menu is clear and easy to follow'* were favourable. The Head of Quality did say, however, that he would have preferred a change in the graphics and a click and point approach using buttons, to be adopted for the menu, and the Technical Director said that the user interface design was very dated, and would need some serious revision before going commercial. In Section 2.2 the need for technology change management was acknowledged. The comments from both of these participants indicated that they recognized this need and felt more advanced technologies should be used for the design of the menu for a 'live' system.

All the participants in the survey also agreed with the statement *'The menu options meet the needs of a business user and a technical administrator'.* The Technical Director did however, point out that further thought needed to be given to the use of buttons on the menus. This again reinforces the need for technology change management.

Six of the seven survey participants also agreed with the statement *'Cases can be used to inform management decision making'.* The Technical Director did not respond to this statement. The final part of the survey was to request comments from the participants about the complete system. All of the participants made positive comments, although the comments from the Head of Quality, the IT Technical Support Advisor (HE) & School Governor, and the Technical Director again indicated that they recognized the need for technology change management and that a 'live' system would have to be developed from technologies with more advanced technical capabilities. The Technical Director also recognized mid-90s technologies were in use when the development of the Expert Advisor System began and said the prototype was good and the Commercial Consultant said that as a prototype the system held up well. Other positive comments were made about the system being easy to use, being suitable for use by strategic, operational and knowledge workers, about it contributing to decision making and about its applicability in different domains.

These general comments demonstrate that participants in the survey responded well to the experimental prototype, and that it received a positive report on its capabilities, although a 'live' system would need to be developed using more advanced technologies. It is however realized that more extensive testing and evaluation work with a larger group of people from within the college could provide additional valuable, more detailed feedback. The high level of scores where participants 'strongly agree' or 'agree' with the statements in the survey is very significant. It lends weight to the conclusion that the experimental prototype is fit for the purpose of assisting College managers in making informed decisions.

8.6 SURVEY CONCLUSIONS

Section 8.1 explains how the Expert Advisor System is a human-machine system and how its operationality can be assessed through the results of the evaluation survey. Dearden et al (1998) explains how the goal for allocation of functions in such systems is to design a system for which the performance is high, the activities of the operator are achievable and appropriate to the operator's role and the development of the system is technically and economically feasible. In addition to this, Dearden et al (2000) explains that in designing the system, the organisation seeks to provide the best possible system for a competitive price. All these factors will be considered as features of *operationality.*

All the processes that support the menu options in the Expert Advisor System received good scores in the evaluation survey and were reported to be simple and easy to use. The prototype was developed to operate on a separate platform from the MIS operational system using the architecture design specified in Section 5.8. This design reduces the problem of system impairment that was arising when queries to extract decision support information were executed on the operational MIS system. It also results in quicker responses being achievable to requests for decision support information. The prototype did not suffer from performance problems such as those mentioned in Section 8.4.2, whilst working with the sample data set. More detailed trials with a larger volume of data would need to be undertaken, before progression from the experimental prototype to the live working system was undertaken.

All the administrator menu options were reported to be simple and easy to use by technical and non-technical staff. This could result in tasks that had been done by highly paid staff with specialist skills, like DBAs, being done by staff with lower levels of technical skills initially, and eventually being done on the desktop by people with business knowledge. These changing job roles could result in reduced expenditure and greater staffing flexibility.

Reduced training and purchasing costs could be achieved as the Microsoft Access and Excel packages were already in use in the College used for this case study and staff already had the skills and confidence with these packages. The CBR package that was incorporated in the prototype was an 'off the shelf' package that was used with minimal training for the purpose of the evaluation survey. The results from the survey indicated that the Expert Advisor System was technically and economically feasible if the design was implemented using up to date versions of the software. It also provided evidence that funding bids can be translated into cases relatively easily which in turn means that facilities have been provided that could be used to help optimize funding. It also demonstrates that the learning achieved through this case study could be of value in other domains. These findings show the operationality of the prototype.

CHAPTER 9 - THE ACHIEVEMENT OF CRITICAL SUCCESS FACTORS

TFPL (2003), a pharmaceutical company, discuss how the excellent management of information provides a strong, workable platform for the innovation necessary for growth. They talk about the use of Information and Communications technology raising the stakes in the business sectors and consider the importance of Critical Success Factors (CSFs) in new and changing market conditions. They say:

> 'The Critical Success Factors for pharmaceutical companies in a technology driven environment will be based on the ability to harness this technology, create and sustain an effective knowledge strategy flexible enough to re-align its focus quickly enough to new and changing market conditions.'

The College managers and DBA team saw the benefit of using technology to acquire knowledge and substantive data to assist in the completion of the ISR Funding Returns. They too had to respond to new and changing market conditions. It was this need that led to the development and implementation of the Expert Advisor System prototype and the identification of CSFs to ensure that the system met their decision support needs. The CSFs were identified in Section 3.9. This section will evaluate the achievement of the CSFs.

9.1 CRITICAL SUCCESS FACTOR 1

To use a development methodology that is flexible enough to cope with rapid change and unclear requirements during the early stages of development.

The CommonKADs methodology has been used to develop the models provided in Sections 5.3.2, 5.4.2, 5.5.2, 5.6.2, 5.7.2 and 5.8.2, and each of these models has supported the development of the Expert Advisor System prototype as described in Sections 7.3.2, 7.4.3, 7.5.2, 7.6.5, 7.7.2 and 7.9.2.

Section 5.9 confirmed the value of the CommonKADS methodology through its use in the analysis and design of the Expert Advisor System. It did however, identify a significant constraint in the *Organisation Model*. It was found that the *Structure* element of the *Organisation Model* could not be accurately represented and assumptions had to be made. As stated in Section 5.3, due to the fast rate of change and frequent restructuring, the College used in the case study failed to define how their functional units related to each other and what their responsibilities were. This resulted in assumptions being made relating to the *Structure* element of the *Organisation Model*. Although this constraint was identified, the methodology was effective in producing the models that supported the design of the Expert Advisor System.

Tansley and Hayball (1993) whilst discussing the KADS methodology being used for the development of a KBS say:

> *'The bottom line is that KADS is an approach which finally makes practical the commercial development of advanced knowledge-based technology - at the very least, by being a proven effective development framework.'*

The Expert Advisor System prototype was a KBS, and in Section 7.6.6 criteria specified by Mackintosh et al (1999), were related to the Expert Advisor System and used to explore the capabilities of the KBS. This activity will be considered here as a method for demonstrating the effectiveness of the CommonKADS development framework. The criteria are:

- **developing the knowledge asset:** acquiring, building, capturing, collecting, compiling, creating, discovering, eliciting, identifying, importing, learning;
- **preserving the knowledge asset:** conserving, consolidating, holding, retaining, safeguarding, securing, storing, pooling;
- **updating the knowledge asset:** evolving, growing, improving, maintaining, modifying, refining, refreshing;
- **using the knowledge asset within or for the benefit of the organisation:** applying, enacting, executing, exploiting, utilising;
- **transferring the knowledge asset between members of the organisation, or between organisations:** disseminating, distributing, exchanging, sharing;
- **transforming the knowledge asset into a 'better' format:** compiling, explicating, formalising, standardising;
- **assessing the knowledge asset:** appraising, evaluating, validating, verifying;
- **performing other functions on the knowledge asset:** classifying, exploring, locating, monitoring, organising, and retrieving.

The explanation of the Expert Advisor System facilities for each of the criteria given in Section 7.6.6 demonstrated that a knowledge asset had been developed, and that knowledge could be preserved and updated, and used within and for the benefit of the College, and that the knowledge could be transferred between College staff, or between the College and the FEFC / LSC. It also showed that the knowledge could be transformed into a 'better' format, could be assessed, and other functions such as classifying, exploring, locating, monitoring, organising and retrieving knowledge could be performed. Section 7.6.6 provides evidence that the Expert

Advisor System KBS, based on the models that were developed using the CommonKADS methodology, has been developed and that CommonKADS has provided *an effective development framework that has been flexible enough to cope with rapid change and unclear requirements during the early stages of development.*

In addition to these findings, the survey that evaluated and tested the Expert Advisor System not only considered specific system facilities but included a general section where it was possible to measure the response of the survey participants to the complete system. This section was analysed and discussed in Section 8.5. The participants responded well to the experimental prototype and it received a positive report on its capabilities, although it was made clear that more advanced technologies would need to be used in the development of a 'live' system.

The outcomes from the CommonKADS methodology findings in Section 5.9, the KBS evaluation in Section 7.6.6 and the results from the Expert Advisor System testing and evaluation survey in Section 8.6 all confirm that the Expert Advisor System prototype meets the expectations of the College, and in doing so they demonstrate that the *CommonKADS development methodology is flexible enough to cope with rapid change and unclear requirements during the early stages of development.*

9.2 CRITICAL SUCCESS FACTOR 2

To provide a natural language interface.

Section 7.3.1 explains how the Expert Advisor System search option that uses 'fuzzy logic' was requested as a CSF because the College managers were aware of their own lack of technical skills and wanted a simple to use facility for searching for information. Participants in the Expert Advisor Survey undertook exercises to gain an understanding of the 'Viewing Questions in Cases' function that uses the natural language interface to capture a search descriptor, and to test this function. The findings from the survey, given in Section 8.4.1, show that all survey participants 'agreed' or 'strongly agreed' with the following statements:

> *'when a new case is being set up it is easy to find and view similar questions that have already been used'*
>
> *'the system enables the user to identify similar cases"*

These findings demonstrate that the natural language interface that is used for the search descriptor works effectively and that the second CSF *'to provide a natural language interface'* has been achieved.

9.3 CRITICAL SUCCESS FACTORS 3 AND 4

To facilitate the use of data from different sites, different systems and different platforms.
For consistent, accurate data to be available.

Section 7.5.2 explains how the Expert Advisor System uses Microsoft Access drivers to provide facilities that allow data to be collected from different sources in various formats. In addition to this, the system uses procedures for populating its Data Warehouse and cleansing and scrubbing its data. These are explained in Section 6.3.1. These procedures not only facilitate the collection of data from *different sites, different systems and different platforms* but ensure the consistency of the data and its format, thus providing *consistent, accurate data* for use in substantiating the decision making that informs the completion of ISR Funding Returns. The Expert Advisor System thus makes provision for the achievement of the third and fourth CSFs.

9.4 CRITICAL SUCCESS FACTORS 5, 6, 7 AND 8

To view detailed data for different time periods.
To view aggregated data for different time periods.
To provide graphical representation of data for quick and easy assimilation.
To provide easy extraction of comparative information.

The Data Warehousing procedures that are used by the Expert Advisor System to capture and store *snapshots of data relating to different points in time* are described in Section 6.3.3. Snapshot data are decision support data that are used by queries for the extraction of detailed data, aggregated data and to provide totals. These data are also used to produce bar charts or pie charts, thus providing *graphical representation of data for quick and easy assimilation.* Appendices E and F provide examples of queries and Section 7.7 explains the Expert Advisor System query adaptation process.

Data outputs from the queries and the charts are stored in the Data Warehouse as case question solutions. The solutions to each of the questions in the case used in this thesis are provided in Appendix C. These solutions each provide *comparative* information for 1994, 1995 and 1996. These years are the points in time for the snapshot data that was available for use with the Expert Advisor System prototype. The information that is available in each solution is the set of totals derived from the *aggregated data, charts and detailed data for each of the years*. The detailed data are provided to help the user understand any substantial differences in the totals for the different time periods. The rules in the case question, that the solution substantiates, can also help the user gain further understanding of any differences. The rules are given in Appendix D.

Section 8.4.3 explained how participants in the Expert Advisor System survey completed exercises to gain an understanding of the provision for displaying historical data and charts, and to test and evaluate it. In doing so they tested the CSFs 5, 6, 7 and 8. Six of the seven participants 'strongly agreed' with the following statement:

> *'the Expert Advisor System enables aggregated figures, graphs and detailed data for each question in a case, for each time period to be viewed'.*

The other participant would have preferred a different, newer technology to have been incorporated in the system. This agreement from the majority of the participants demonstrates that the facilities provided by the Expert Advisor System address the fifth, sixth and seventh CSF and together they provide the comparative information that enables the eighth CSF to be met.

9.5 CRITICAL SUCCESS FACTOR 9

To view existing queries and SQL.

Examples of queries that are used by the Expert Advisor System to extract detailed data, and to aggregate data and produce totals, are given in Appendices E1-E8 and F1-F8. The corresponding SQL is provided for each query. Section 7.8 explains how access to the queries and SQL is provided to allow query adaptation to be performed and to ensure data trails are available for adapted case questions.

Section 8.4.5 explained how participants in the Expert Advisor System survey completed an exercise that was provided to gain an understanding of the facility for viewing queries and SQL, to test it and comment on it. All participants 'agreed' or 'strongly agreed' with the following statement:

> *'The procedure to view queries, view SQL, amend queries and save them as new queries to support new questions in new cases, or additional questions in an existing case, is simple and easy to use and does not require a high level of technical understanding. After a short training course staff with a lower level of technical expertise than the DBA could amend queries'.*

The agreement from all the survey participants demonstrates that the ninth CSF has been achieved.

9.6 CRITICAL SUCCESS FACTOR 10

To provide facilities to enable Senior Managers to make informed operational and strategic decisions and substantiate those decisions.

Section 7.10 explains how case-based knowledge discovery together with data-based knowledge discovery, graphic-based knowledge discovery and projection-based knowledge discovery provide system-based knowledge discovery. System-based knowledge discovery assists the College managers in making informed decisions to help optimize their funding bids and in doing so it *enables Senior Managers to make informed operational and strategic decisions and substantiate those decisions*.

9.7 CRITICAL SUCCESS FACTOR 11

For decision making information to be in the right place at the right time.

Section 7.8.1 explains how the Expert Advisor System makes provision for metadata tables to be updated, thus allowing easy navigation of the system when insertions, additions or deletions are made to tables, cases or categories. All survey participants completed exercises and either 'agreed' or 'strongly agreed' that the procedure for viewing, amending or adding new entries to the metadata tables was useful and easy to use. This is discussed in more depth in Section 8.4.6.

The metadata provision enables easy navigation of the system, whilst the Data Warehousing provision that was discussed in Section 9.3 facilitates the use of data from different sites, different systems and different platforms, and provides consistent, accurate data. The queries that were discussed in Section 9.5 use these facilities whilst extracting detailed data, aggregating data and providing totals for different time periods. These facilities are also used when pie charts and bar charts are produced. Together these allow *decision making information to be in the right place at the right time*. Appendix C contains solutions to case questions. Each solution is an example of comparative information being in the right place at the right time.

9.8 CRITICAL SUCCESS FACTOR 12

To achieve improved system performance.

Section 6.3.1 explains how data from the operational MIS are cleansed and scrubbed to produce quality data to populate the Data Warehouse. As a consequence of this, complex decision support queries that originally used the MIS now use the Data Warehouse. Removing the execution of these complex queries from the MIS results in an improvement in its performance.

9.9 CRITICAL SUCCESS FACTORS CONCLUSION

The evidence provided in this chapter demonstrates that all the CSFs for the Expert Advisor System prototype have been addressed in its design and implementation, and are achieved in its operation.

CHAPTER 10 - EVALUATION OF THE RESEARCH HYPOTHESES

This chapter will consider the two research hypotheses that were identified in Section 1.2 and demonstrate how these hypotheses have been achieved.

10.1 HYPOTHESIS 1

The first hypothesis was:

> *CommonKADS Models are well suited to providing a template for the design and documentation of Decision Support Systems that need to operate in rapidly changing domains*

This section will discuss how each of the models in the CommonKADS methodology have been used in the development of the Expert Advisor System, and how the experimental prototype has been designed to operate in an environment where rapid changes are taking place. These changes are common to all colleges in the FE Sector and are synonymous to changes that are happening in the Public Sector. This section will explain how the models might be used in the Public Sector to develop useful, comparable Expert Advisor Systems, and will use this to demonstrate that the hypothesis has been achieved.

The Organisation Model

The CommonKADS ***Organisation Model*** provides an analysis of the socio-organizational College environment. This is extremely important whilst the College is experiencing rapid change and having to manage the ensuing people, organisational and technical issues. Details of the Organisational Model are provided in Section 5.3. Socio-organisational issues such as financial constraints, frequent management restructuring, resourcing difficulties, people having inadequate skills and a lack of commercial 'know how', and value for money issues are identified. It is also realized that staff performance could be reduced during the transition period resulting from incorporation. Fear, insecurity, lack of knowledge and resistance could alter people's attitudes. The experimental prototype has been designed, developed and implemented within the environment where these socio-organisational factors exist and where rapid change is taking place.

The Task Model

The ***Task Model***, presented in Section 5.4, provided a simple schematic that was used to communicate with College managers and to help them understand how the task of achieving informed decision making to assist in the completion of the ISR Funding Return would be performed.

The Agent Model

The *Agent Model,* presented in Section 5.5, provided an understanding of how the managers and the DBA team would perform the decision making task that was needed to complete the ISR Funding Return.

The Expertise Model

The ***Expertise Model,*** given in Section 5.6, shows the problem solving behaviour the Expert Advisor System is required to perform. It also shows how the input into the model is the problem solving performed by the human 'expert'. In addition to this the model encompasses the *strategic knowledge* that is used to decide which goals are needed to solve a problem.

The *strategic knowledge* is acquired by retrieving matching or partially matching cases and possibly by adapting a partial case solution to become a new case. The process for discovering knowledge through the use of cases is ***case-based knowledge discovery***. *Strategic knowledge* is also acquired through the retrieval of current or historic data, totals derived from aggregations of these data, and graphics such as bar charts or pie charts relating to the data extractions. These are used together to provide comparative information as solutions to case questions. Examples of case question solutions are provided in Appendix C. The knowledge that is discovered is ***data-based knowledge discovery*** and ***graphics-based knowledge discovery***. *Strategic knowledge* is also used to suggest new approaches, or to introduce assumptions when a partial solution is arrived at because information is not available, or because contradictory information is present. This is accomplished by using the snapshots of data from the Data Warehouse to perform 'what-if' projections. This offers ***projection-based knowledge discovery***. Section 7.10 explains how case-based knowledge discovery, data-based knowledge discovery, graphics-based knowledge discovery and projection-based knowledge-discovery are all different aspects of ***system-based knowledge discovery,*** that are available to assist the user in making informed decisions.

The different types of *strategic knowledge* that have just been explained are used by the *agents* in the Agent Model to perform the *task* that was identified as the *current problem* in the Organisation Model. In other words the Managers and DBA team use the knowledge discovered through the use of the Expert Advisor System to inform the decision making needed to complete the ISR Funding Return.

The Communication Model

The ***Communication Model***, given in Section 5.7, was used to show the integration or co-operation of the Expert Advisor System with the user, other agents or other system components.

This model considers how computer programs and users of the system work together and specifies the environment in which the knowledge-based system must work.

The Design Model

The Design models given in Section 5.8, are the ***Application Design Model***, the ***Architecture Design Model*** and the ***Platform Design Model***. The ***Application Design Model*** shows the decomposition of the Expert Advisor System into the MIS, CBR, Access and Excel. The implementation of this design is described in depth in Section 6.3. The ***Architecture Design Model*** shows the application specification and how it is realized in the architecture. The ***Platform Design*** specifies the target language and the hardware and software platforms.

Using and Evaluating the Models

In addition to these explanations of the CommonKADS models, a deeper understanding of how they were used to support the development of the experimental prototype is given in Chapter 7. Evidence is also provided in Section 9.1 to show that CommonKADS is a development methodology that is flexible enough to cope with change and unclear requirements during the early stages of system development. Through the achievement of this CSF it was also shown that *CommonKADS Models can be used to support the design and documentation of an Intelligent Decision Support System that is suitable for use in the rapidly changing domain of FE.*

Similar Changes in the FE Sector and the Public Sector

This section will explain how changes that are happening in the FE Sector are similar to the changes that are happening in the Public Sector departments dealing with health, transport and crime. A lot of the change in the FE Sector has happened as a result of the 1992 Further and Higher Education. The 1999 Local Government Act and the 2000 Local Government Act, for example, are leading to comparable changes in the Public Sector.

Government Change in the Public Sector

In Section 2.3 changes that are being imposed by the Government and will affect the Public Sector were discussed. It was explained how the Government:

- expect local financial accountability to be improved so that it reflects the importance of local accountability, and also the strong interests of Central Government
- will act when excessive increases in council budgets occur. This will be because an increase is particularly large or because a council is not performing to the standards of efficiency and economy that people rightly expect of it

- will take tough action where councils and services are failing
- will stretch targets and rewards to achieve improvements in service
- will promote sound financial management
- will design new grant formulae
- will undertake comprehensive performance assessments and inspections
- will expect the potential of new technologies to be exploited to restructure services and speed up transactions

Local Financial Accountability

The ***local financial accountability*** that the Government expects of the Public Sector was also expected of the FE Sector. In Section 3.2 Coopers and Lybrand Deloitte explained how colleges would be required to submit the ISR Funding Return and supporting data to the FEFC. This was the FEFC mechanism that was used to achieve local financial accountability. Like the Public Sector the FE Sector also had to meet ***the strong interests of central Government.*** Section 3.3.1 explains how the FEFC (1994b) state that supporting ISR data is required to enable policies to be formulated, information about the sector to be published, performance indicators to be calculated, trends to be analyzed, the distribution of funds to be accounted for, and to inform responsible Government ministers about the sector and to allow the performance of colleges to be monitored against their strategic plans. The Public Sector and the FE Sector both need informed decision making to assist them in meeting the changing requirements imposed by local accountability.

Government Action when Standards are not met

In Section 2.9.8 it was reported that the FEFC said they would be uncompromising in their efforts to raise college standards. It also said that the Lifelong Learning Minister declared that colleges who were the worst offenders in not meeting standards were guilty of gross negligence with public money. The Minister said 30 colleges had exam success rates below 50% and he cited unacceptable retention rates and poor standards of governance and management. He announced that options other than closure for failing colleges would include the sacking of governors and the intervention by neighbouring colleges with proven records of excellence. These statements show that the FEFC will act when their standards are not met and public money is being used.

The Government also said they would take action in the Public Sector when their standards were not met. They said they ***will act when excessive increases in council budgets occur. This will be because an increase is particularly large or because a council is not performing to the standards of efficiency and economy that people rightly expect of it.*** The FE Sector and the

Public Sector both have to meet standards or the Government will intervene and act. Decision making has an important role to play in enabling the sectors to meet these externally imposed standards and to help them avoid the tough Government action. In the FE Sector the tough action is the sacking of Governors and the intervention of neighbouring colleges. In the Public Sector the tough action is taken by the Government ***where councils and services are failing.***

Targets to Achieve Improvements

Section 2.9.5 explains how performance indicators reveal if a college has achieved its funding target, student numbers, retention and qualification targets, its contribution to National Education and Training Targets (NTETs), and value for money targets. The Government also say they ***will stretch targets and rewards to achieve improvements in the public service.*** The introduction of targets is a change that is common to the FE Sector and the Public Sector.

New Grant Formulae

Section 2.8 discusses college strategic planning returns and explains how a college block grant for funding is calculated. The block grant and the formula it is based upon have been introduced since incorporation. The Government also state that they ***will design new grant formulae*** for the Public Sector. The purpose of introducing new grant formulae into both these sectors is to ***promote sound financial management.***

Comprehensive Performance Assessments and Inspections

Section 3.3.4 and Section 3.3.5 explain the role the FEFC auditors and inspectors play in undertaking comprehensive assessments of a college's performance. The Government say they will ***undertake comprehensive performance assessments and inspections*** in the Public Sector. Performance assessments and inspections will be significant drivers for change in both sectors.

Exploiting the Potential of New Technologies

Section 4.3 stated that the performance of the college MIS OLTP system was often degraded when complex SQL queries were being executed to obtain decision making information. Pass (1996) confirms that system degradation is often experienced when SQL is used in this way. Section 6.3.1 explains how data from the operational MIS is cleansed and scrubbed to produce quality data that is used to populate the Data Warehouse. As a consequence of this, complex decision support queries that originally used the MIS data now use the Data Warehouse data. Removing the execution of these complex queries from the MIS OLTP system results in an improvement in its performance and faster processing of operational transactions. In other words, restructuring in this way results in a more responsive MIS transaction processing system and provides a separate system specifically designed to support the execution of complex decision support queries. Technology has been used to support this change in a college in the FE Sector. The Government also expects technology to be used to achieve innovative change in the Public Sector. They stated that they expect ***the potential of new technologies to be exploited to restructure services and speed up transactions.***

These examples show that the changes that are happening in the Public Sector are comparable to those that are occurring in the FE Sector. In addition to this the evidence of the use and evaluation of the CommonKADS models, referred to earlier in this section, established that they can be used to support the design and documentation of an Intelligent Decision Support System that is suitable for use in the rapidly changing domain of FE. These facts together demonstrate that the *CommonKADS Models are well suited to providing a template for the design and documentation of Decision Support Systems that need to operate in rapidly changing domains.* They also demonstrate that the models might be used in the Public Sector to develop useful, comparable Expert Advisor Systems.

10.2 HYPOTHESIS 2

The second hypothesis introduced in Section 1.2 was:

> *CBR principles can be used together with other knowledge discovery techniques to provide useful and adaptive systems*

This hypothesis recognizes the need for auditable data trails to support today's decisions. It addresses how Intelligent Decision Support Systems using CBR together with the principles of Data Warehousing can provide system adaptation. When CBR is used, case adaptation is applied when an enquiry is received for information to support decision making and a case search fails to find a match with other cases. If the search solution is not adequate, or there are some variations in the parameters since the most appropriate case was last used, the case that is the nearest match to the requirements is adapted to form a new case. When the principles of Data Warehousing are used snapshots of data relating to different time periods are held in a Data Warehouse. Data from the Data Warehouse are used to enable informed decisions to be made.

When case adaptation occurs data retrieval routines also need to be adapted to ensure the decision support data that is extracted corresponds to the adapted case. Case adaptation, together with data adaptation is described as system adaptation in this thesis. System adaptation enables an audit trail of detailed data, totals derived from aggregations of the data and charts to be produced for adapted cases. These can be provided for different periods in time. This section will evaluate how the development and implementation of the Expert Advisor System demonstrates that this research hypothesis has been achieved.

Case Adaptation

Section 7.6.1 explains how structural adaptation is performed when new questions are added, existing questions are changed or inappropriate questions are removed from a case and the case is saved as a new case. Section 7.6.1 also explains how derivational adaptation is performed when a case search is executed and a case question is left unanswered. Section 8.4.4 provides an analysis of the results of testing and evaluating the case adaptation procedures. All participants in this process either 'strongly agreed' or 'agreed' that it was easy to adapt an existing case and save it as a new case and that the procedure for adapting cases was simple to use and did not require specialist skills.

Query Adaptation

Section 6.3.1 explains the procedures for populating the Data Warehouse with snapshots of data from the MIS system that have been cleansed and scrubbed to provide accurate, consistent decision support data in the correct format. Queries use the snapshots in the Data Warehouse to extract historical data or to aggregate these data and provide totals. The results from these queries, together with bar charts or pie charts form the solution to a case question. Appendix C shows examples of these solutions that provide comparative information for different periods in time for individual questions in a case. When case adaptation takes place it is necessary to adapt the query that extracted or aggregated the historical data and provided totals to substantiate the original case question. The query adaptation procedure is explained in Section 7.7. Section 8.4.5 provides an analysis of the results of testing and evaluating the query adaptation procedures. All participants in this process either 'strongly agreed' or 'agreed' that the procedure to amend queries and save them as new queries was simple and easy to use and did not require a high level of technical understanding.

The testing and evaluation of the case adaptation and the query adaptation procedures was successful. Together these procedures provide system adaptation and demonstrate that *CBR principles can be used together with Data Warehousing principles to provide system adaptation.* They also demonstrate that these adaptation procedures could be adopted for use in the development of other Expert Advisor Systems that need to operate in rapidly changing domains.

The work undertaken to achieve these hypotheses also addresses the research aims and objectives that were identified in Section 1.2 and Section 1.3. The changes in the Public Sector are comparable with the changes in the FE Sector. These changes lead to local financial accountability, adherence to Government standards, the need to achieve targets and improve performance, the introduction of new grant formulae, comprehensive performance assessments and inspections. They also result in ***changing decision support requirements*** and the need for an Intelligent Decision Support System that can operate in domains where financial, technological and cultural change has occurred. The Expert Advisor System is a ***Decision Support System*** that has been developed to operate in this type of domain. It has been tested and evaluated and received favourable responses. The knowledge and understanding gained from the design, development, implementation, testing and evaluation of this prototype could have wide applicability in other organisations. Soft Systems Methodologies, Hard Systems Methodologies and a KBS methodology were evaluated in Section 5. 2 and the CommonKADS Methodology was selected as the ***methodology to be used for the design of the Intelligent Decision Support System,*** known as the ***Expert Advisor System.***

CHAPTER 11 – CONCLUSIONS

In response to the research aims set down in Section 1.2 this thesis has explored the economic, political, legal and technological changes that have an impact on decision support requirements in many organizations. In Sections 2.3 and 2.4 organisational and technological changes in the Public Sector were explored, and in Section 2.5 changing decision support requirements were discussed. In Sections 2.6 - 2.8 the focus moved to the FE Sector and changes were investigated. Section 2.9 brought together the experience and views of people within the sector and identified the need for an Intelligent Decision Support System - the development of which has been a central feature of the research undertaken

To guide the design of the system Critical Success Factors were identified and are given in Section 3.9. These had a strong influence on the choice of methodologies and technologies to explore and research. In Section 5.2 Hard Systems Methodologies, Soft Systems Methodologies and a Knowledge-Based Systems (KBS) methodology were explored and evaluated, and justification provided for the selection of the CommonKADS methodology for the analysis and design of a Knowledge-Based Decision Support System (KB-DSS). Whilst producing the CommonKADS Models it is worth noting that a constraint was identified in the Organisation Model. Section 5.3.2 identifies how due to a fast rate of change and frequent restructuring in the organisation (the FE College), it failed to define how its functional units related to each other and what their responsibilities were. This resulted in *assumptions* having to be made concerning the *Structural* element of the Organisation Model.

In Chapter 4 the rationale for considering Case-Based Reasoning, Rule-Based Systems, Artificial Neural Networks as possible candidate technologies was given and their use and capabilities for incorporation in the prototype explored. The selection of a CBR 'off the shelf' package that incorporates a Rule-Based component was justified. Data Warehousing and Data Mining principles were also explored, and justification for their selection was given.

The experimental prototype Intelligent Decision Support System developed has been designed to assist Senior Managers at FE Colleges in the decision making process that is used to complete their ISR Funding Returns. The system gives access to historic data, provides auditable data trails to substantiate decisions and facilitates 'what-if' projections. Case-based knowledge discovery, data-based knowledge discovery, graph-based knowledge discovery and projection-based knowledge discovery have been achieved through the use of the system. The analysis, design and development of the system were strongly influenced by the Critical Success Factors identified to ensure that the system met the Colleges decision support needs. It's worth noting that as part of the development process cases were adapted, and queries that extracted and aggregated data were also adapted to provide system adaptation. As noted in Section 7.6 adaptation is acknowledged to be a difficult part of CBR. This extension of the adaptation process to cover adaptation of the substantiating case data that relates to the case question and produces an auditable data trail provides a significant contribution to knowledge in the research areas of Intelligent Decision Support Systems, CBR and Knowledge Warehousing.

Chapter 8 documents how testing and evaluation of the prototype was undertaken. In this Chapter the analysis of the results and user feedback has shown the responses to be favourable. Although testing and evaluation only involved a small group of people it is important to note that each was a specialist and arguably their opinions carried weight. Also, the very high occurrence of scores indicating 'agreement' or 'strong agreement' was again arguably significant. Clearly, wider testing would be desirable before the development of a 'live' system.

In carrying out the research needed to develop the experimental prototype Intelligent Decision Support System two research hypotheses were identified at the beginning of Chapter 1. The achievement of these is specifically considered in Chapter 10. Section 10.1 demonstrates that the hypothesis, *CommonKADS Models are well suited to providing a template for the design and documentation of Decision Support Systems that need to operate in rapidly changing environments* has been achieved, although a constraint in the Organisation Model has been identified. Section 10.2 demonstrates that the second hypothesis, *CBR principles can be used together with other knowledge discovery techniques to provide useful and adaptive systems,* has been achieved and that the knowledge and understanding gained from the design, development, implementation, testing and evaluation of this prototype could have wide applicability in other organisations.

Throughout this research a rich source of materials including academic literature, Government white papers, Acts of parliament and commercial technical reviews and articles has been used. The Further Education Funding Council (FEFC) circulars, guidance notes, support manuals, press releases and seminars have provided a detailed understanding of the complex Individualised Student Record funding methodology and the associated funding software. Meetings with the FEFC auditors and inspectors provided an insight into their expectations and an awareness of the difficulties the FE colleges are experiencing. The views and experiences of college principals, senior managers and academic, technical and administrative staff provided an FE perception of the funding situation and highlighted the socio-organisational factors that are occurring in the FE Sector.

In addition to the above, a whole spectrum of information gathering activities has been undertaken. Companies have demonstrated their software and allowed me to perform in depth evaluations to aid the research. Participation in courses, seminars and User Group meetings has increased my knowledge and understanding of the MIS software, the FEFC software and the complex funding methodology. They have made me very aware of the changes that are rapidly taking place. Attendance at conferences, and exhibitions, and involvement in an international collaborative venture has provided an opportunity to exchange views, knowledge and experiences with other researchers. Specialists such as Marie Gustaffson, who participated in the CommonKADS Espirit project have provided me with valuable information. The many sources of information and the large number of people who have helped me in this research have provided me with the knowledge and understanding needed to design, develop, implement and test the experimental prototype Intelligent Decision Support System.

The knowledge and understanding gained from this research work will contribute to future work. The Expert Advisor System experimental prototype has the capacity and flexibility to be extended to provide a 'live' system that incorporates the newer, more advanced technologies and meet the changing expectations that are emerging for knowledge-based decision support systems. During this research significant changes have taken place whilst the experimental prototype was being developed. Existing technologies have advanced and new technologies have become available. On-Line Analytical Processing (OLAP) is widely used. Intelligent Agents have a role to play in the development of applications. The importance of digital technologies is being recognised. New notations such as UML have been introduced. Proposals are being made for the web to be extended and become the Semantic Web and be a universal medium for the exchange of data. A Resource Description Framework is being specified that will fit the principle technologies to be used into a set of layers. New standards, such as those from the Dublin Core Metadata Initiative that focus on developing interoperable metadata standards are emerging. Many of these could be incorporated in later versions of the prototype system.

In particular, the strengths and weaknesses of existing and emerging technologies could be evaluated and their place in the Resource Description Framework could be considered. A web-enabled 'live' version of the Expert Advisor System could be developed. The new and advancing standards that are becoming available could also be evaluated and adopted in the development of the 'live' system if appropriate, and the Semantic Web could be used to support the distribution of decision support data.

Finally, as indicated at the beginning of this thesis, the principal research aim was to evaluate new approaches for meeting the present day decision support needs in many organisations.

Although the Expert Advisor System was developed specifically for use in FE, the way it was developed is key to the achievement of this aim. Through the use of the CommonKADS methodology and its wide applicability, the understanding of the integration of technologies and the use of the principles of Data Warehousing, knowledge and understanding has been achieved that can contribute to the development of future KB-DSS for many other organisations.

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http://203.162.7.73/ieee/htmls/disk_80/3030/8623/292_298_Beyond%rule%based%reasoni.htm
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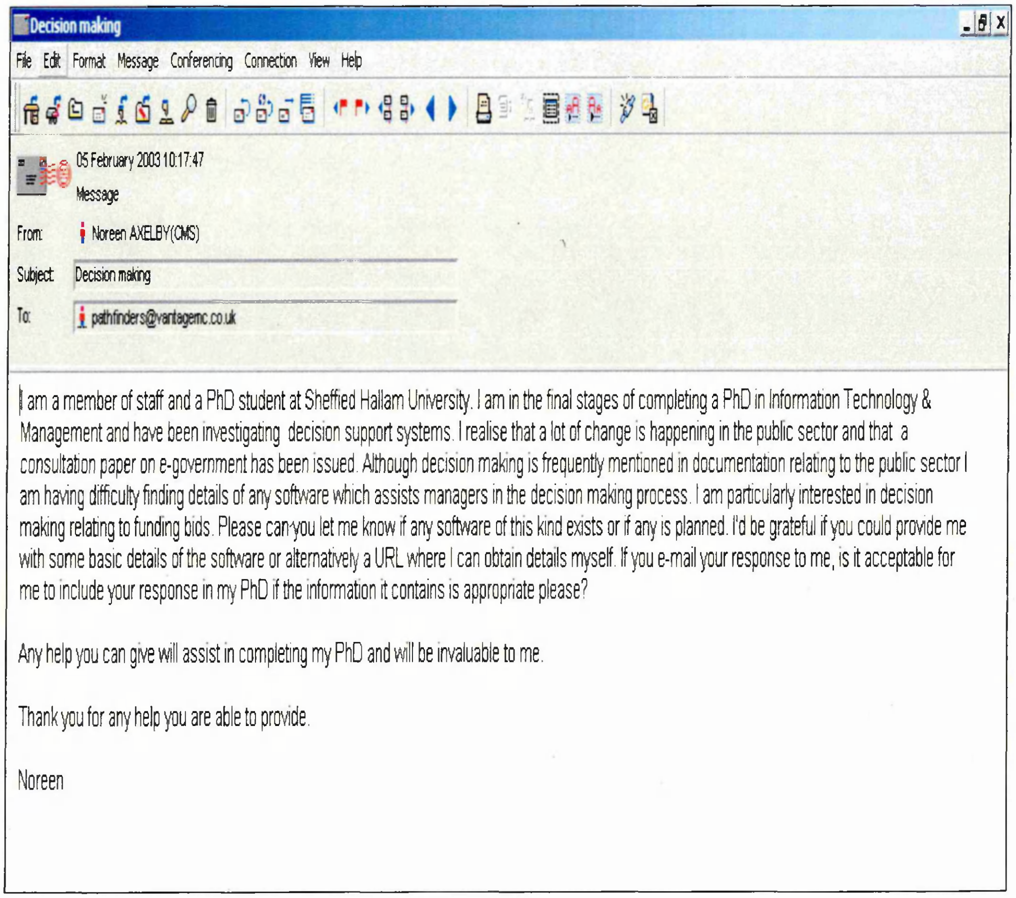
APPENDIX A.1 - AN EMAIL TO CHECK SYSTEM AVAILABILITY



Decision making

File Edit Format Message Conferencing Connection View Help

05 February 2003 10:17:47

Message

From: Noreen AXELBY(CMS)

Subject: Decision making

To: pathfinders@vantagemc.co.uk

I am a member of staff and a PhD student at Sheffied Hallam University. I am in the final stages of completing a PhD in Information Technology & Management and have been investigating decision support systems. I realise that a lot of change is happening in the public sector and that a consultation paper on e-government has been issued. Although decision making is frequently mentioned in documentation relating to the public sector I am having difficulty finding details of any software which assists managers in the decision making process. I am particularly interested in decision making relating to funding bids. Please can you let me know if any software of this kind exists or if any is planned. I'd be grateful if you could provide me with some basic details of the software or alternatively a URL where I can obtain details myself. If you e-mail your response to me, is it acceptable for me to include your response in my PhD if the information it contains is appropriate please?

Any help you can give will assist in completing my PhD and will be invaluable to me.

Thank you for any help you are able to provide.

Noreen

Figure A.1.1
An Email to 'pathfinders@dvantagems.co.uk'

APPENDIX B.1 - A SAMPLE FEFC INDIVIDUALISED STUDENT RECORD AGGREGATE RETURN

FORM ISRAGG3

INDIVIDUALISED STUDENT RECORD (ISR) - AGGREGATE RETURN

Please photocopy, complete and return this form with the ISR to the data collection team, research and statistics, at the Councils Coventry office

FURTHER EDUCATION FUNDING COUNCIL

Cheylesmore House
Quinton Road
Coventry CV1 2WT

Telephone 01203 863000
Fax 01203 863100

Institution name ______ Institution code ______

Contact name (*please print*) ______ Telephone ______

Collection reference date ______

Age	No. of students	Sex		No. of full-time students	No. of part-time guided learning hours/year			Eligible for FEFC funding	Eligible for HEFC funding	Not eligible for FEFC or HEFC funding	Programme area										Completion status		
		F	M		<60	60-119	120-449				1	2	3	4	5	6	7	8	9	10	1	2	3
Daytime																							
Under 16																							
16 - 18																							
19 - 59																							
60 and over																							
Unknown																							
Evening																							
Under 16																							
16 - 18																							
19 - 59																							
60 and over																							

Signature ______ **Position** ______ **Date __/__/__**

Figure B.1.1
An Individualised Student Record Funding Return

APPENDIX B.2 - A SUMMARY OF THE REQUESTED STRATEGIC PLANNING INFORMATION

Annex A

SUMMARY OF INFORMATION REQUESTED

	Colleges	*HE institutions*	*External institutions*
By 31 July 1998*			
Strategic plan textual update	***only*** if significant changes or notified by regional director	***only*** if significant changes or notified by regional director	full plan required
Projected student numbers	***only*** if revised from February 1998 return	***only*** if revised from February 1998 return	***only*** if revised from February 1998 return
Withdrawal of provision information	***only*** if revised from February 1998 return	***only*** if revised from February 1998 return	***only*** if revised from February 1998 return
TEC approval	***only*** if textual update provided as a result of significant changes	n/a	n/a
Financial forecast	required	n/a	n/a
Beyond July 1998			
Finance mid-year update	required by February 1999, but ***only*** if notified by regional finance director	n/a	n/a
Finance record and audited accounts	required by 31 December 1998' to be sent to the Council's central finance team	n/a	n/a
Accommodation strategy information	further details to be provided in a summer circular	n/a	n/a

*** *information requested by 31 July 1998 should be sent to Louise Butcher at the Council's Coventry office***

*' provided proposed changes to financial memorandum (which colleges will be consulted on) are agreed***

Figure B.1.2
A Strategic Planning Summary

APPENDIX B.3 - A COVER SHEET FOR THE RETURN OF THE STRATEGIC PLANNING AND FINANCIAL FORECAST INFORMATION

Annex B

COVER SHEET FOR RETURN OF STRATEGIC PLANNING AND FINANCIAL FORECAST INFORMATION: JULY 1998

THE FURTHER EDUCATION FUNDING COUNCIL

(Reference Circular 98/16)

This cover sheet must be completed by all institutions. Please photocopy, complete and return to Louise Butcher at the Council's Coventry office by 31 July 1998.

Cheylesmore House
Quinton Road
Coventry CV1 2WT

Telephone 01203 863000
Fax 01203 863100

Name of institution *(please print)*

Sponsoring college *(external institutions only)*

FEFC code

Contact for strategic plan queries

Telephone

Returns Enclosed *(please tick)*

All institutions

1	Strategic plan	full plan (external institutions – 2 copies)				❑
		update (colleges/HE institutions – 3 copies)				❑
		nil return				❑
2	Projected student numbers (2 copies from external institutions; 3 copies from other institutions)					
	SP98 NUM (JUL): FE	paper	❑	or	nil return	❑
	SP98 NUM (JUL): HE	paper	❑	or	nil return	❑
3	Collaborative provision (2 copies from external institutions; 3 copies from other institutions)					
	SP98 CP (JUL)	paper	❑	or	nil return	❑
4	Planned withdrawals (2 copies from external institutions; 3 copies from other institutions)					
	SP98 CHG (JUL)	paper	❑	or	nil return	❑

Colleges only

5	Evidence of TEC approval of strategic plan update (3 copies)					❑
6	Financial forecasts (1 copy of each)	three-year forecast	❑		disk	❑
		principal's certificate	❑		commentary	❑

DECLARATION **I confirm that the figures provided on the accompanying SP forms are correct.**

Signature

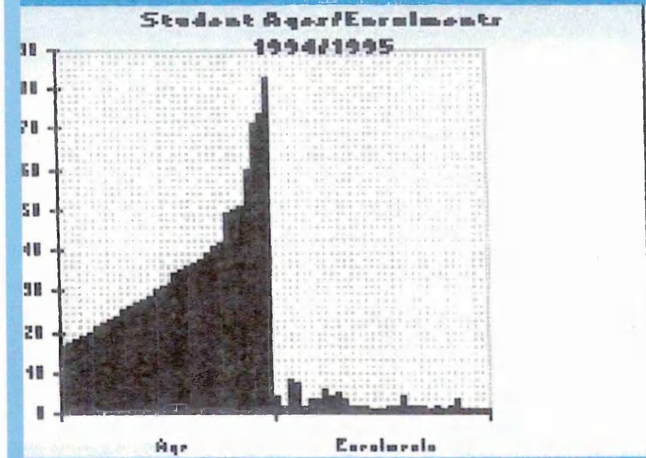
Principal/head of institution

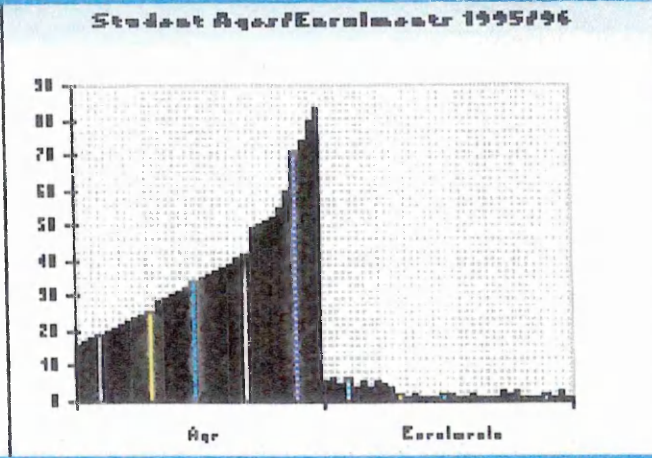
Name *(please print)*

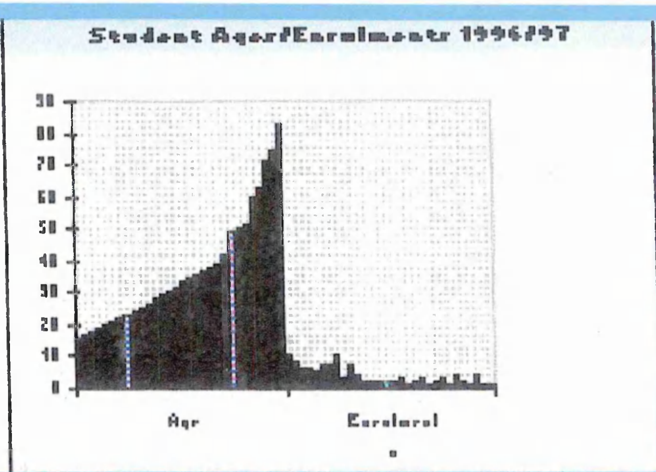
Date

Figure B.1.3
Strategic Planning and Financial Forecast Information

APPENDIX C.1 - AGE RANGE SOLUTION (QUESTION 1B)







Case question 1b) Which age range?

Detailed information to support these counts and charts is held in sheets Case1b 94, Case1b 95 & Case1b 96.

Nb. To produce charts use columns,&,rows.

Session	Age	Enrolments
94	16	4
94	17	2
94	18	8
94	19	7
94	20	2
94	21	3
94	22	3
94	23	6

Session	Age	Enrolments
95	16	6
95	17	7
95	18	5
95	19	7
95	20	4
95	21	6
95	22	4
95	23	6

Session	Age	Enrolments
96	16	10
96	17	8
96	18	6
96	19	6
96	20	5
96	21	7
96	22	7
96	23	10

Figure C.1.1
Solution to Case Question 1B

APPENDIX C.2 - GENDER SOLUTION (QUESTION 1C)

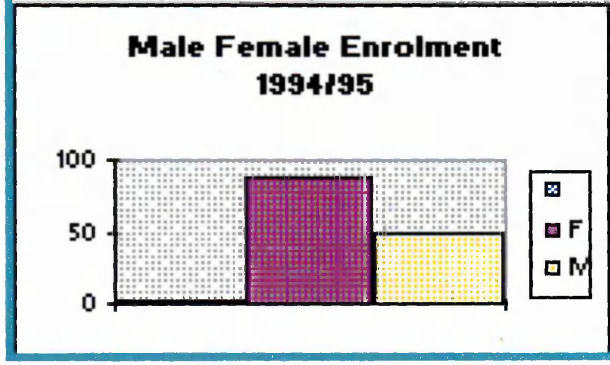
Case quesion 1c) Which sex?

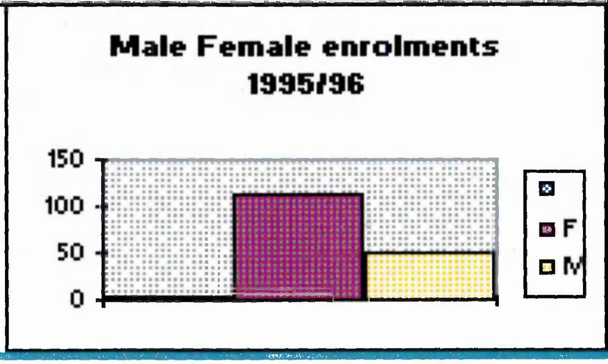
Detailed information to support these charts and sheets is held in sheets Case1c 94, Case1c 95, Case1c 96.

Session	Sex	Enrolments
94		3
94	F	88
94	M	48

Session	Sex	Enrolments
95		3
95	F	112
95	M	50

Session	Sex	Enrolments
96		4
96	F	125
96	M	67





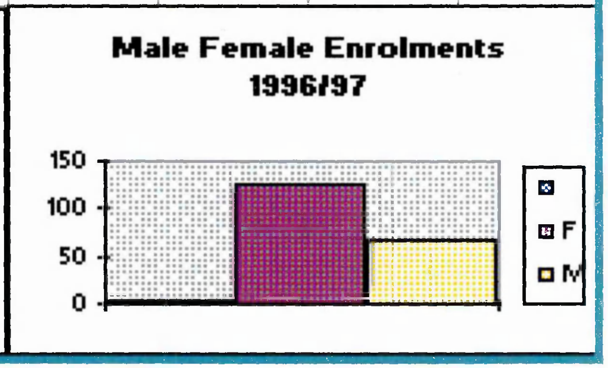


Figure C.1.2
Solution to Case Question 1c

APPENDIX C.3 - TIME OF ATTENDANCE SOLUTION (QUESTION 1D)

Case question 1d) When does the student attend - daytime or evening?

Detailed information to support these counts and charts is held in sheets Case1d94, Case1d95 & Case1d96.

Daytime Modes of Attendance (MOA) are 01,02,05,07,09,10.
Evening Mode of Attendance is 09.

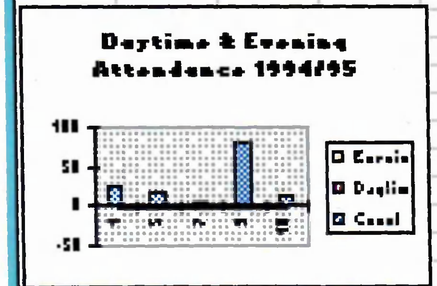
Modes of Attendance

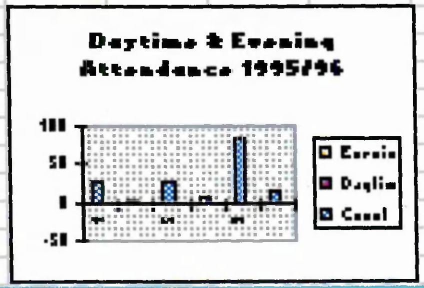
1 Full Time 30 weeks or more	5 Part Time Released
2 Full Time 4-30 weeks	7 Part Time Non Released
3 Sandwich	9 Evening only
4 Block Release	10 Open/Distance Learning

Yr	MOA	Daytim	Evenin	Count
94	1	-1	0	24
94	5	-1	0	19
94	7	-1	0	6
94	9	0	-1	79
94	10	-1	0	12

Yr	MOA	Daytim	Evenin	Count
95	1	-1	0	29
95	2	-1	0	4
95	5	-1	0	28
95	7	-1	0	8
95	9	0	-1	83
95	10	-1	0	14

Yr	MOA	Daytim	Evenin	Count
96	1	-1	0	43
96	2	-1	0	3
96	5	-1	0	27
96	7	-1	0	7
96	9	0	-1	98
96	10	-1	0	19





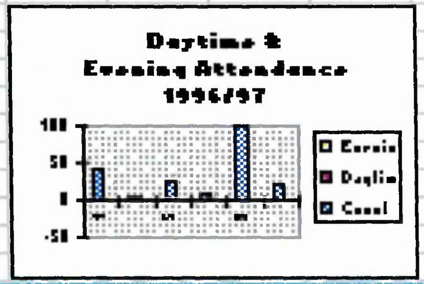


Figure C.1.3
Solution to Case Question 1d

APPENDIX C.4 - MODE OF ATTENDANCE SOLUTION (QUESTION 1E)

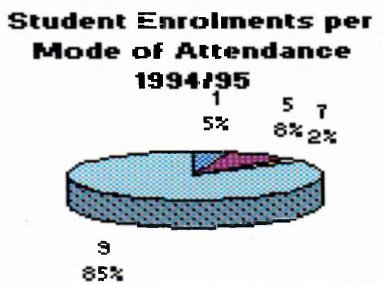
Case question 1e) Which Mode of Attendance (MOA) are the number of student enrolments required for?

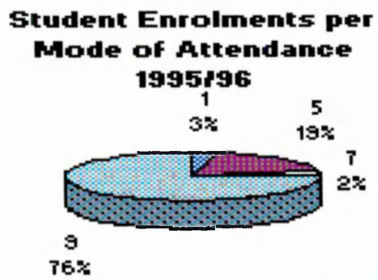
Detailed information to support these counts and charts are held in sheets Case1e 94, Case1e 95 & Case1e 96.

MOA

1 - Full Time 30 weeks or more	5 - Part Time Released
2 - Full Time 4 - 30 weeks	7 - Part Time Non Released
3 - Sandwich	9 - Evening only
4 - Block Release	10 - Open/Distance Learning

Session	MOA	Enrolments	Session	MOA	Enrolments	Session	MOA	Enrolments
94	1	4	95	1	3	96	1	8
94	5	7	95	5	17	96	5	19
94	7	2	95	7	2	96	9	85
94	9	70	95	9	69			





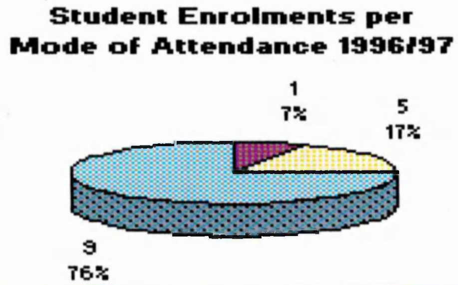


Figure C.1.4
Solution to Case Question 1e

APPENDIX C.5 - GUIDED LEARNING HOURS LOAD BAND SOLUTION (QUESTION 1F)

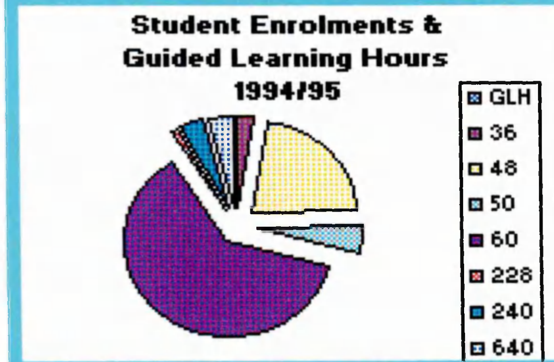
Case question 1f) Which load band of Guided Learning Hours (GLH)?

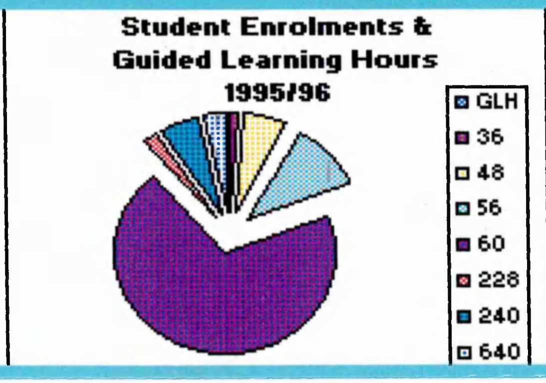
Detailed information to support these counts and charts are held in sheets Case1f 94, Case1f 95 & Case1f 96.

Load Bands
1 9-59 hours
2 60 - 119 hours
3 120 -209 hours
4 210 - 329 hours
5 330 - 449 hours
6 at least 450 hours

Nb. To produce graphs use Pie,4,col 1,row 0,Legend

Session	GLH	Enrolments	Session	GLH	Enrolments	Session	GLH	Enrolments
94	36	2	95	36	1	96	36	4
94	48	17	95	48	6	96	48	21
94	50	4	95	56	10	96	60	67





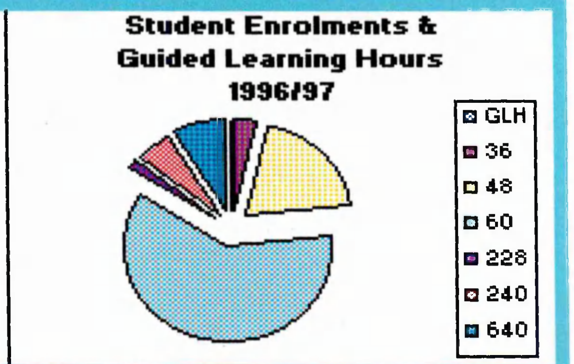


Figure C.1.5
Solution to Case Question 1f

APPENDIX C.6 - SOURCE OF FUNDING SOLUTION (QUESTION 1G)

Case question 1g) Which type of funding are the students eligible for?

Detailed information to support these counts and charts are held in sheets Case1g 94, Case1g 95 & Case1g 96.

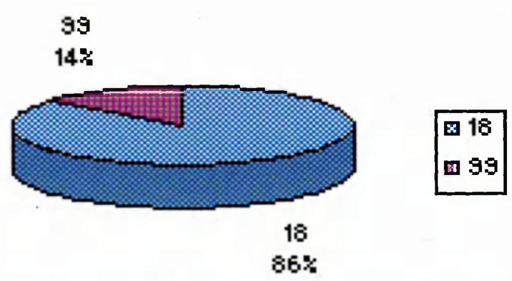
Funding Types

18 - Local education Authority Funding (LEA)

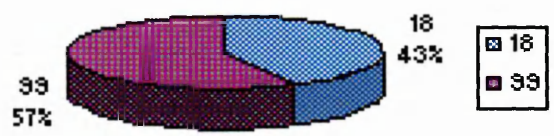
99 - Further Education Funding Council (FEFC)

Year	Funding	Enrolments	Year	Funding	Enrolments	Year	Funding	Enrolments
94	18	67	95	18	38	96	18	27
94	99	11	95	99	51	96	99	82

Student Funding 1994/95



Student Funding 1995/96



Student Funding 1996/97

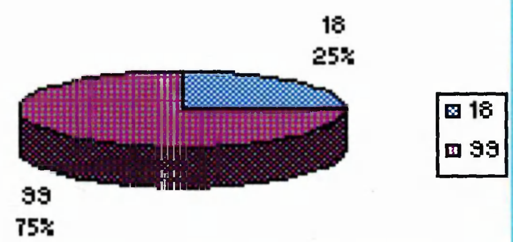
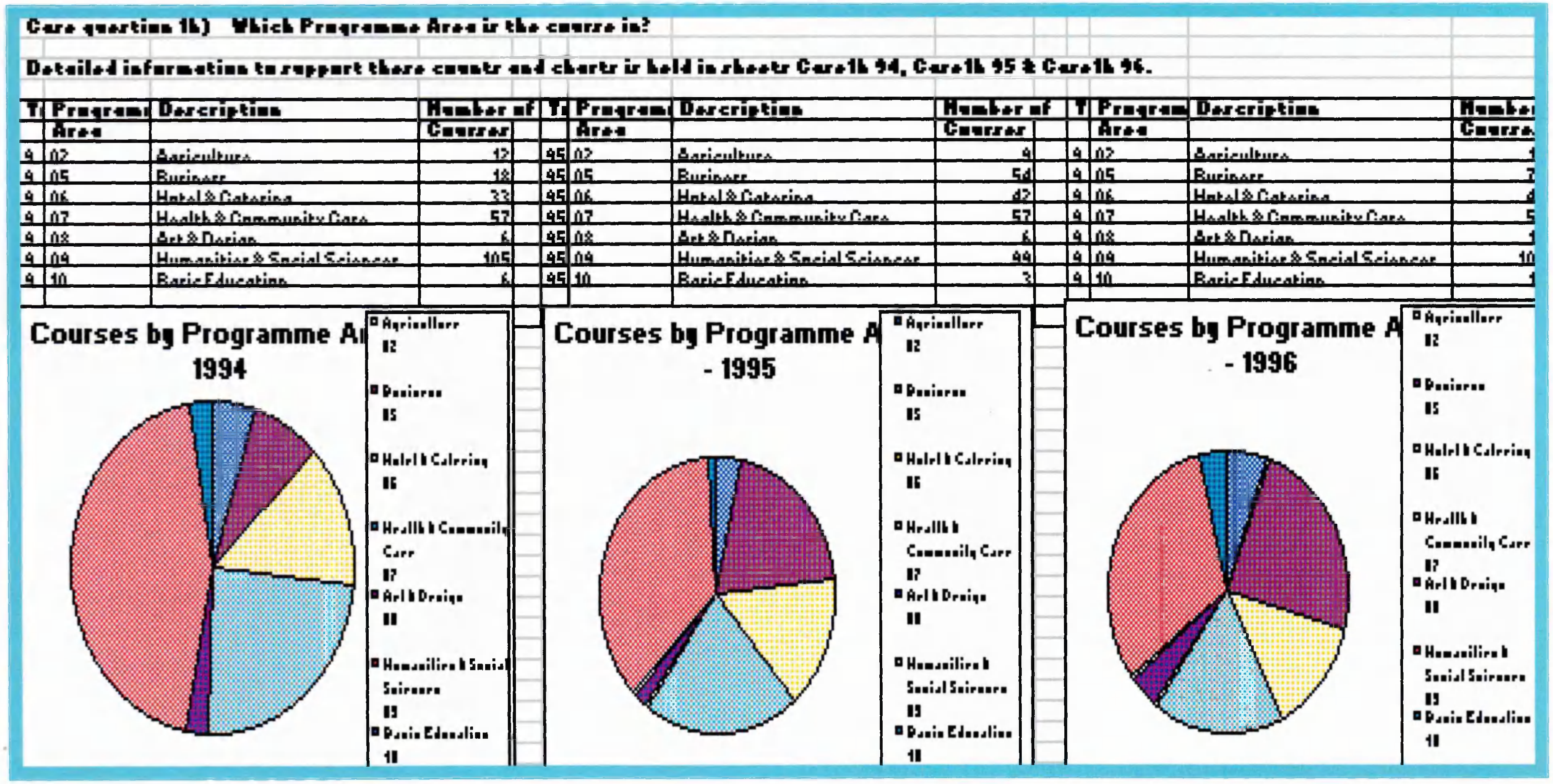


Figure C.1.6
Solution to Case Question 1g

APPENDIX C.7 - COURSE PROGRAMME AREA SOLUTION (QUESTION 1H)



Y	Programme Area	Description	Number of Courses
9	02	Agriculture	12
9	05	Business	18
9	06	Hotel & Catering	33
9	07	Health & Community Care	57
9	08	Art & Design	6
9	09	Humanities & Social Sciences	105
9	10	Basic Education	6

Y	Programme Area	Description	Number of Courses
95	02	Agriculture	9
95	05	Business	54
95	06	Hotel & Catering	42
95	07	Health & Community Care	57
95	08	Art & Design	6
95	09	Humanities & Social Sciences	99
95	10	Basic Education	3

Y	Programme Area	Description	Number of Courses
9	02	Agriculture	1
9	05	Business	7
9	06	Hotel & Catering	4
9	07	Health & Community Care	5
9	08	Art & Design	1
9	09	Humanities & Social Sciences	10
9	10	Basic Education	1

Figure C.1.7
Solution to Case Question 1h

APPENDIX C.8 - COMPLETION STATUS SOLUTION (QUESTION 1I)

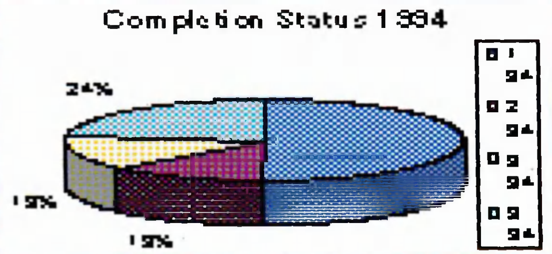
Case Question 1i) Which student completion status?

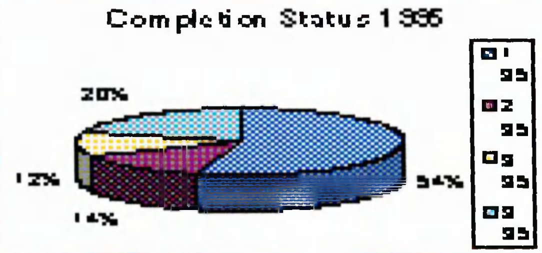
Detailed information to support these counts and charts is held in sheets
Case1i 94, Case1i 95 and Case 1i 96

Completion Status Codes

1 Qualification aim achieved
2 Qualification aim partially achieved
3 Withdrawn from course
9 Continuing study

Year	Completion Status	Count	Year	Completion Status	Count	Year	Completion Status	Count
94	1	70	95	1	90	96	1	107
94	2	18	95	2	23	96	2	23
94	3	18	95	3	19	96	3	22
94	9	33	95	9	33	96	9	44





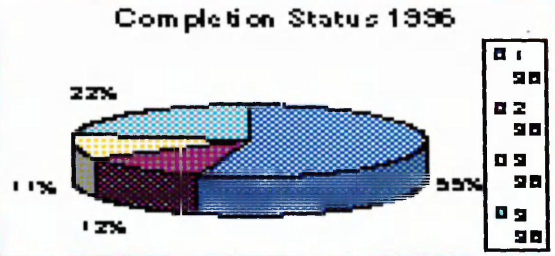


Figure C.1.8
Solution to Case Question 1I

APPENDIX D.1 - RULES CONSTRAINING THE ANSWERS TO CASE QUESTIONS 1B - 1I

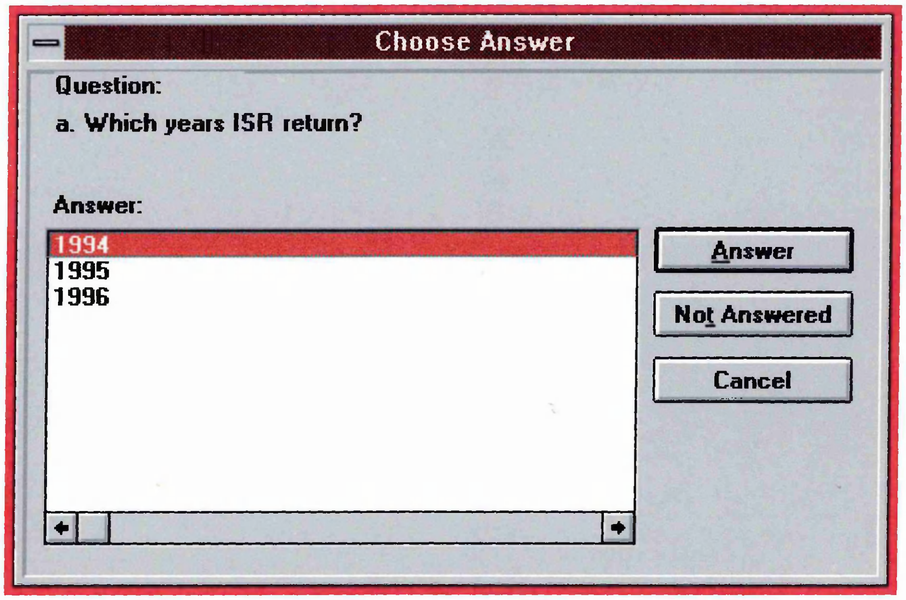


Figure D.1.1
Rules for 'Which years ISR Return? (Question 1a)

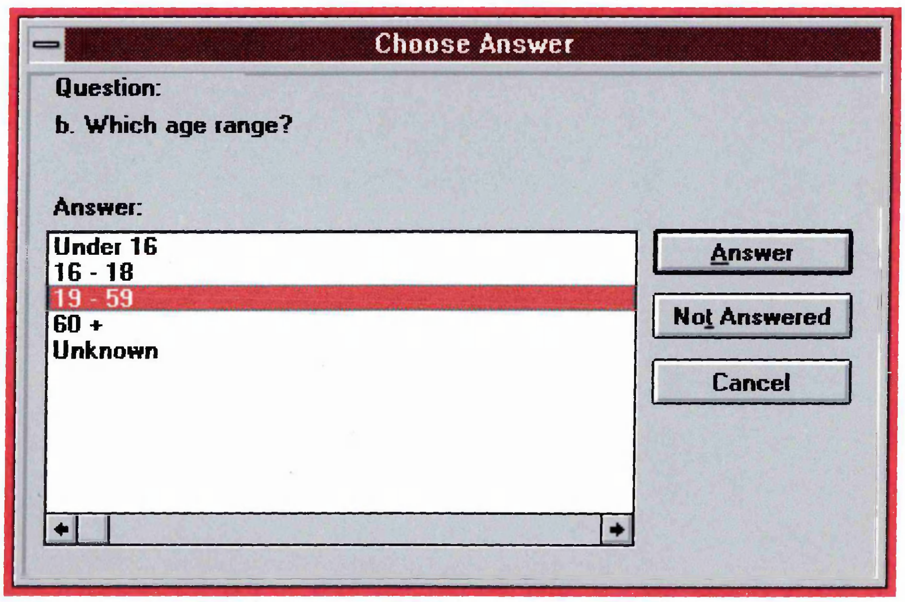


Figure D.1.2
Rules for 'Which age range?' (Question 1b)

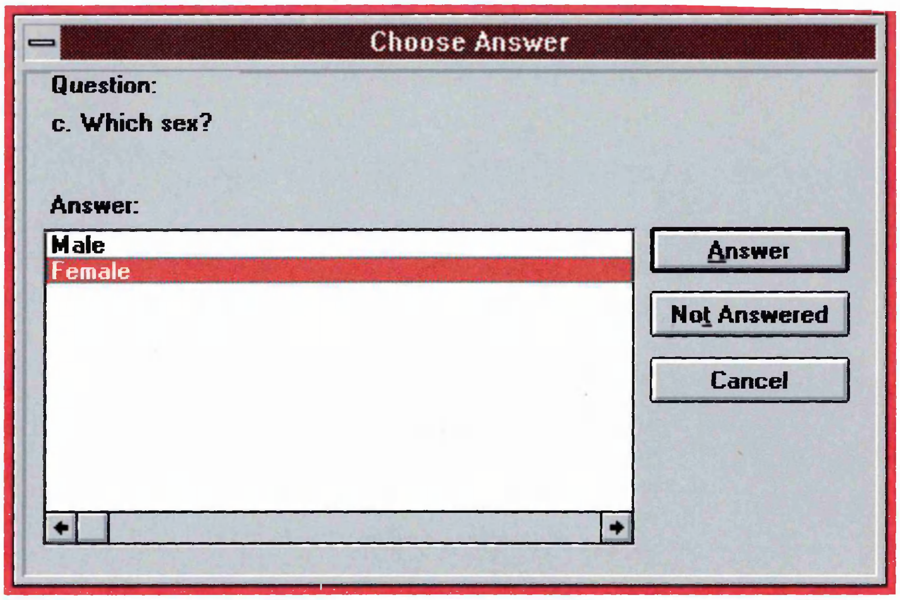


Figure D.1.3
Rules for ‘Which sex?’ (Question 1c)

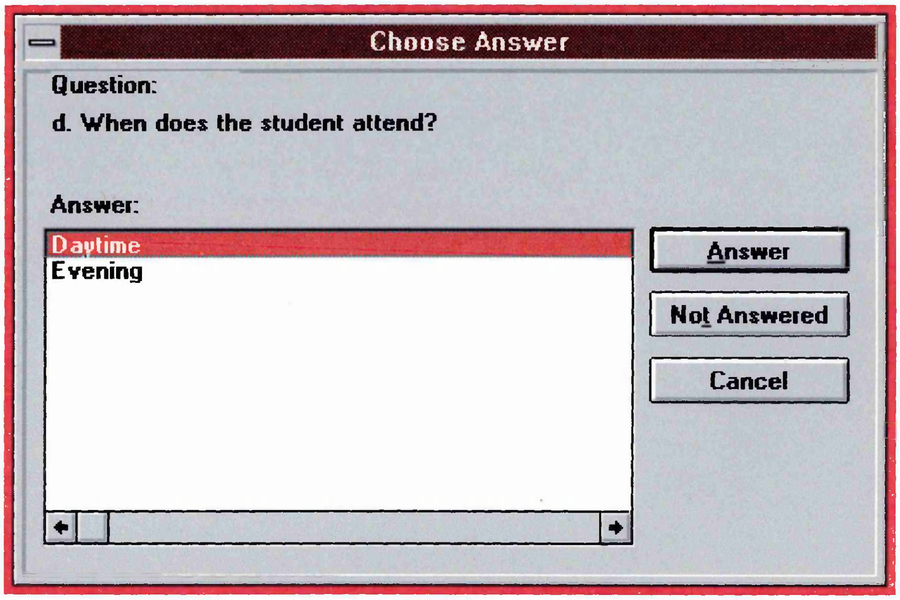


Figure D.1.4
Rules for ‘When does the student attend?’(Question 1d)

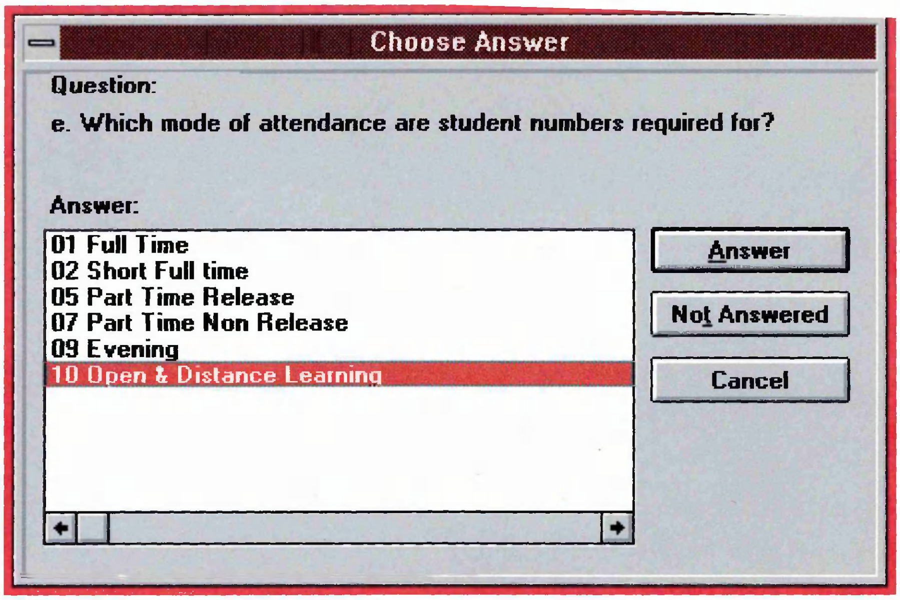


Figure D.1.5
Rules for 'Which mode of attendance are student numbers required for?' (Question 1e)

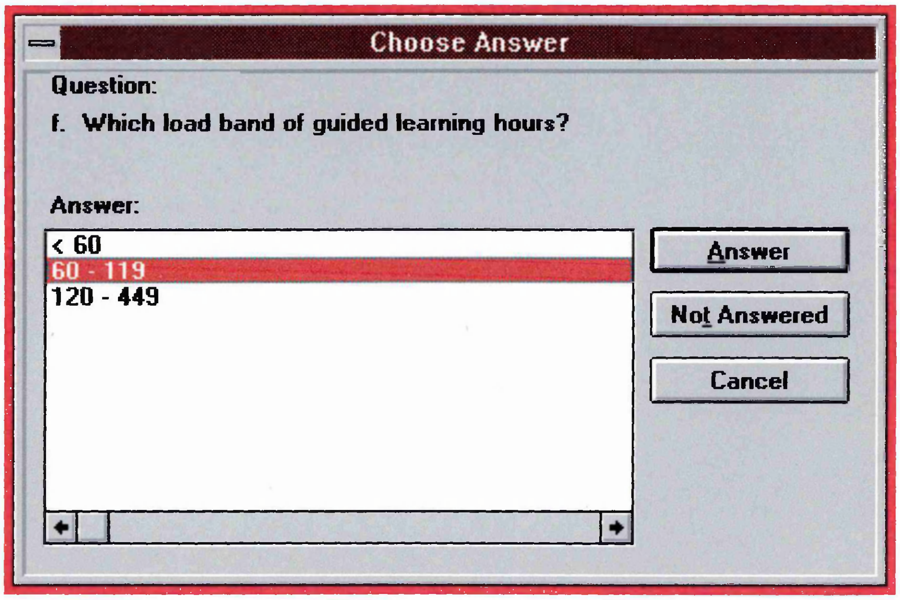


Figure D.1.6
Rules for 'Which load band of guided learning hours?' (Question 1f)

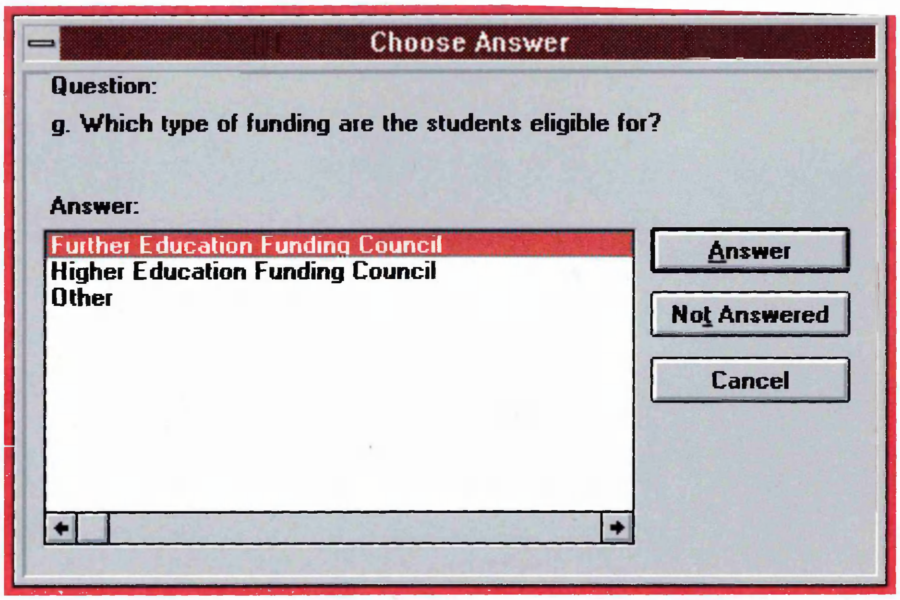


Figure D.1.7
Rules for 'Which type of funding are the students eligible for?' (Question 1g)

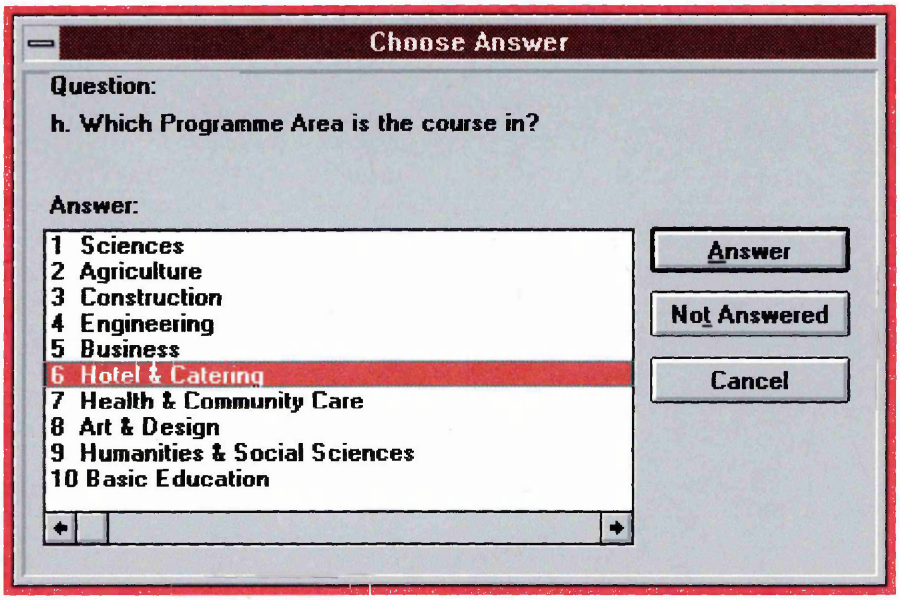


Figure D.1.8
Rules for 'Which programme area is the course in?' (Question 1h)

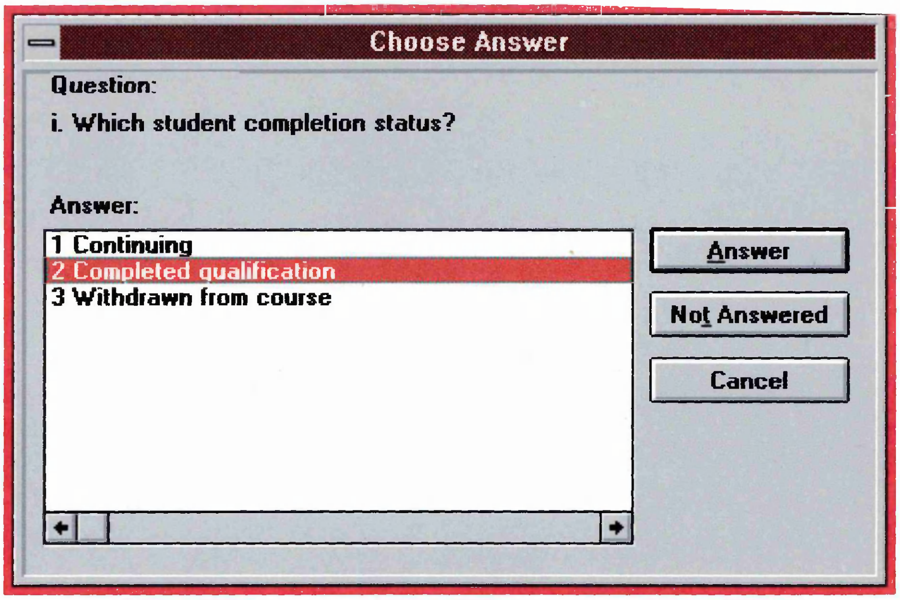


Figure D.1.9
Rules for 'Which student completion status?' (Question 1i)

APPENDIX E.1 - AGE RANGE COUNT QUERY (QUESTION 1B)

Which age range?

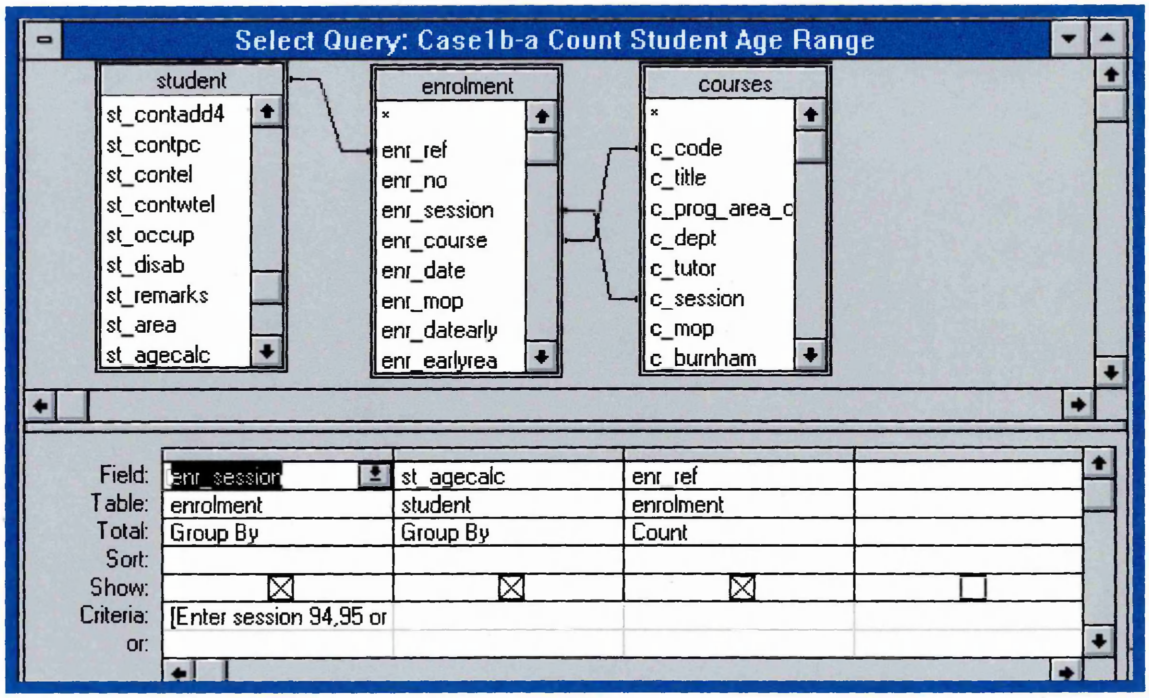


Figure E.1.1
Count Query for 'Which age range?'

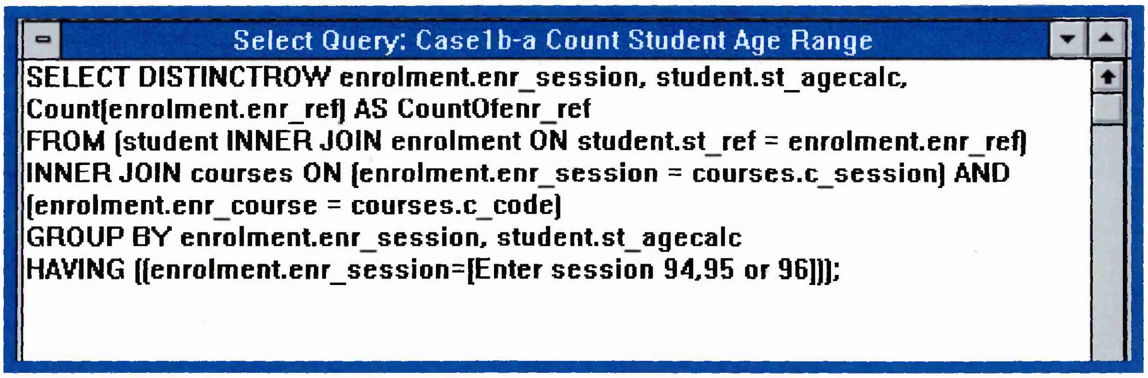


Figure E.1.2
Count Query SQL (Question 1b)

APPENDIX E.2 - GENDER COUNT QUERY (QUESTION 1C)

Which sex?

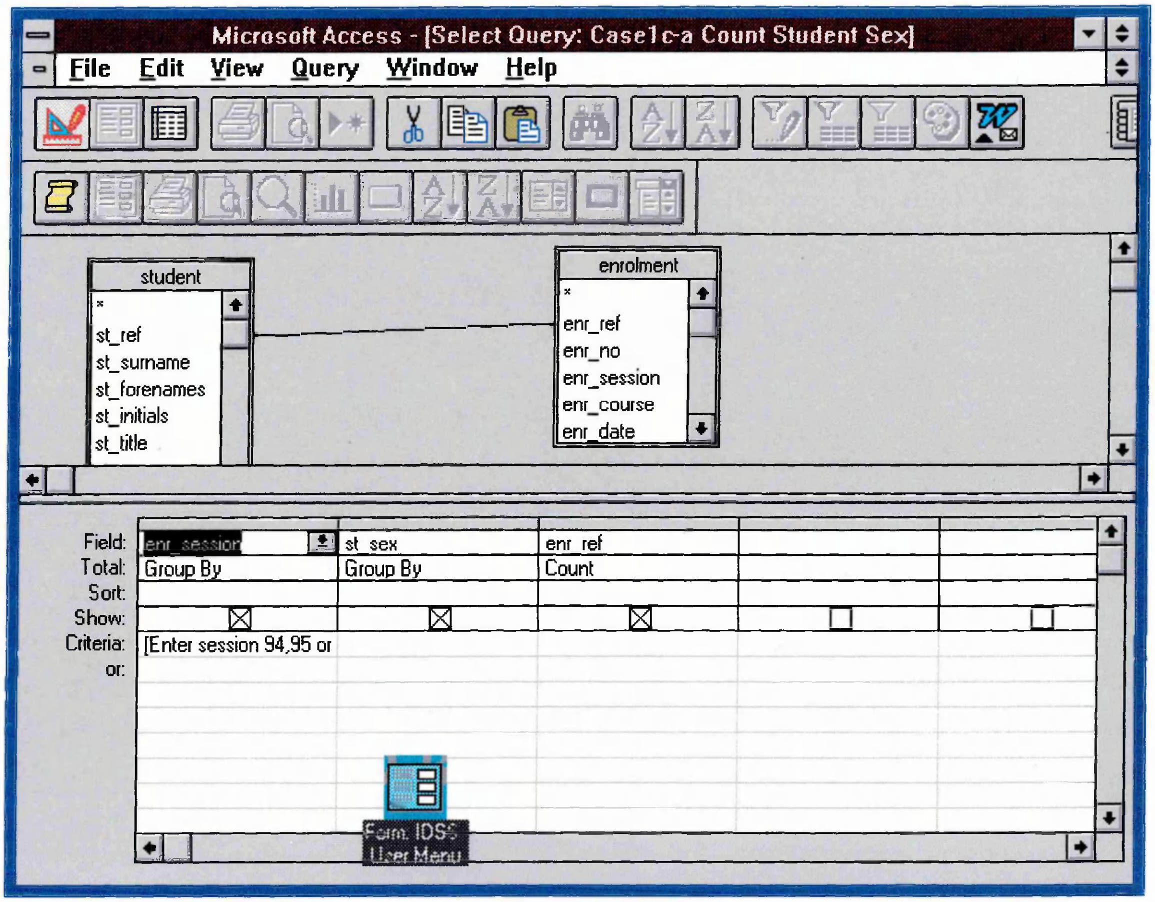


Figure E.2.1
Count Query for 'Which sex?'

```
SELECT DISTINCTROW enrolment.enr_session, student.st_sex, Count(enrolment.enr_ref) AS
CountOfenr_ref
FROM student INNER JOIN enrolment ON student.st_ref = enrolment.enr_ref
GROUP BY enrolment.enr_session, student.st_sex
HAVING ((enrolment.enr_session=[Enter session 94,95 or 96]));
```

Figure E.2.2
Count Query SQL (Question 1c)

APPENDIX E.3 - TIME OF ATTENDANCE COUNT QUERY (QUESTION 1D)

When does the student attend?

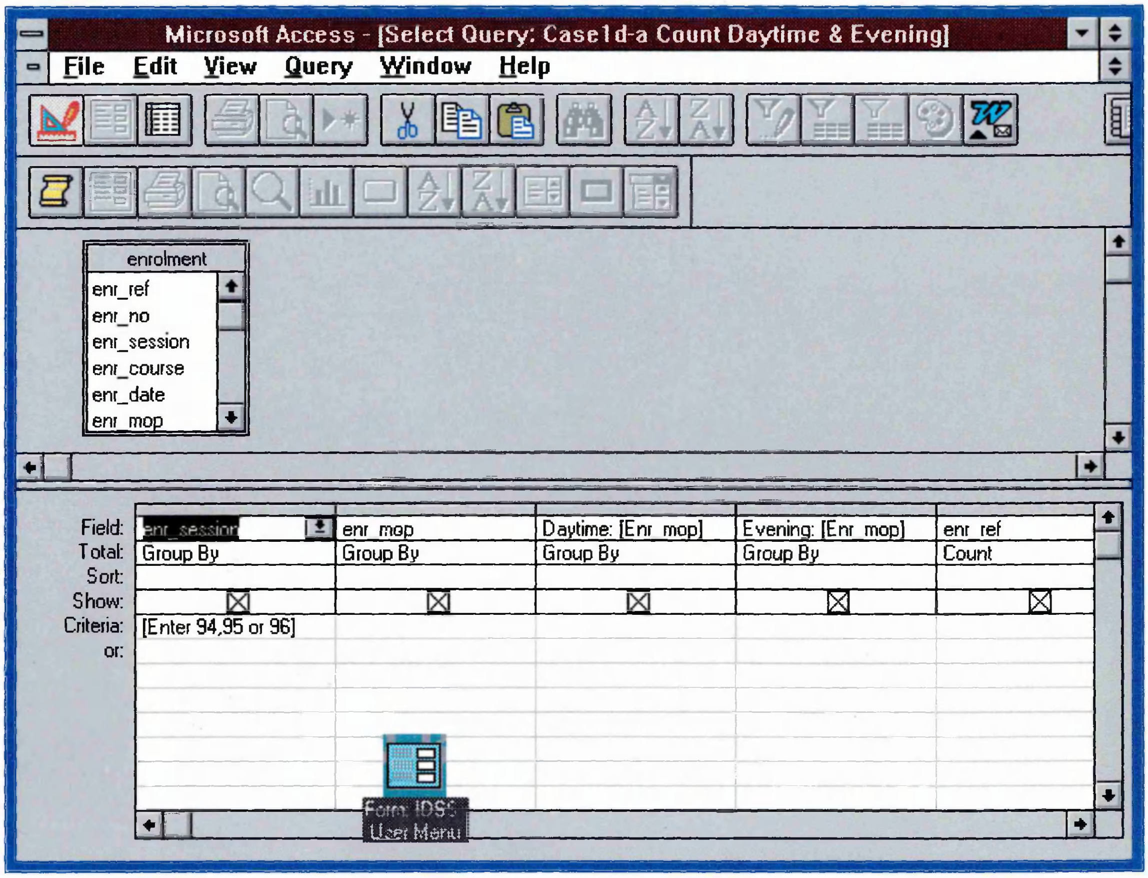


Figure E.3.1
Count Query for 'When does the student attend?'

```
SELECT DISTINCTROW enrolment.enr_session, enrolment.enr_mop, [Enr_mop] In
("01","02","05","07","10") AS Daytime, [Enr_mop]="09" AS Evening, Count(enrolment.enr_ref)
AS CountOfenr_ref
FROM enrolment
GROUP BY enrolment.enr_session, enrolment.enr_mop, [Enr_mop] In
("01","02","05","07","10"), [Enr_mop]="09"
HAVING ((enrolment.enr_session=[Enter 94,95 or 96]));
```

Figure E.3.2
Count Query SQL (Question 1d)

APPENDIX E.4 - MODE OF ATTENDANCE COUNT QUERY (QUESTION 1E)

Which mode of attendance are student numbers required for?

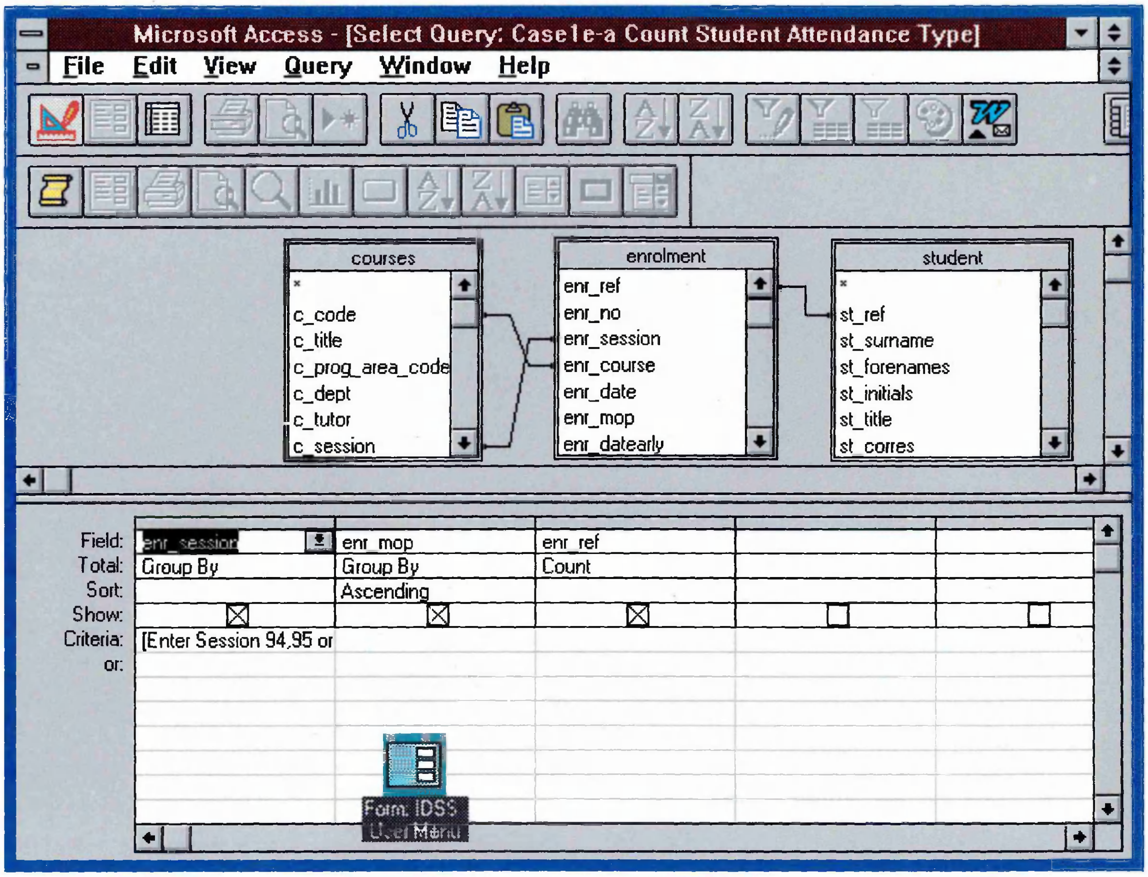


Figure E.4.1

Count Query for 'Which mode of attendance are student numbers required for?

```
SELECT DISTINCTROW enrolment.enr_session, enrolment.enr_mop, Count(enrolment.enr_ref)
AS CountOfenr_ref
FROM courses INNER JOIN (enrolment INNER JOIN student ON enrolment.enr_ref =
student.st_ref) ON (courses.c_session = enrolment.enr_session) AND (courses.c_code =
enrolment.enr_course)
GROUP BY enrolment.enr_session, enrolment.enr_mop
HAVING ((enrolment.enr_session=[Enter Session 94,95 or 96]))
ORDER BY enrolment.enr_mop;
```

Figure E.4.2

Count Query SQL (Question 1e)

APPENDIX E.5 - LOAD BAND OF GUIDED LEARNING HOURS COUNT QUERY (QUESTION 1F)

Which load band of guided learning hours?

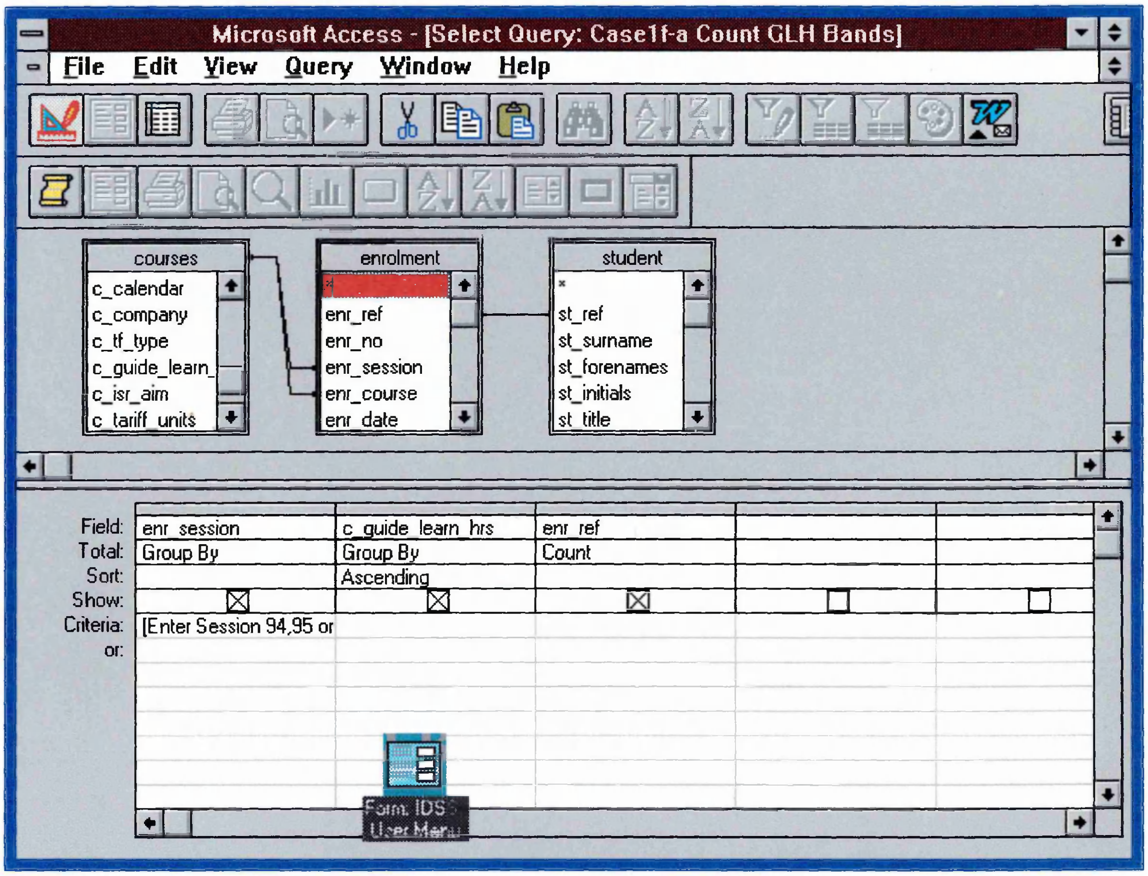


Figure E.5.1

Count Query for 'Which load band of guided learning hours?'

```
SELECT DISTINCTROW enrolment.enr_session, courses.c_guide_learn_hrs,
Count(enrolment.enr_ref) AS CountOfenr_ref
FROM courses INNER JOIN (enrolment INNER JOIN student ON enrolment.enr_ref =
student.st_ref) ON (courses.c_code = enrolment.enr_course) AND (courses.c_session =
enrolment.enr_session)
GROUP BY enrolment.enr_session, courses.c_guide_learn_hrs
HAVING ((enrolment.enr_session=[Enter Session 94,95 or 96]))
ORDER BY courses.c_guide_learn_hrs;
```

Figure E.5.2

Count Query SQL (Question 1f)

APPENDIX E.6 - SOURCE OF FUNDING COUNT QUERY (QUESTION 1G)

Which type of funding are the students eligible for?

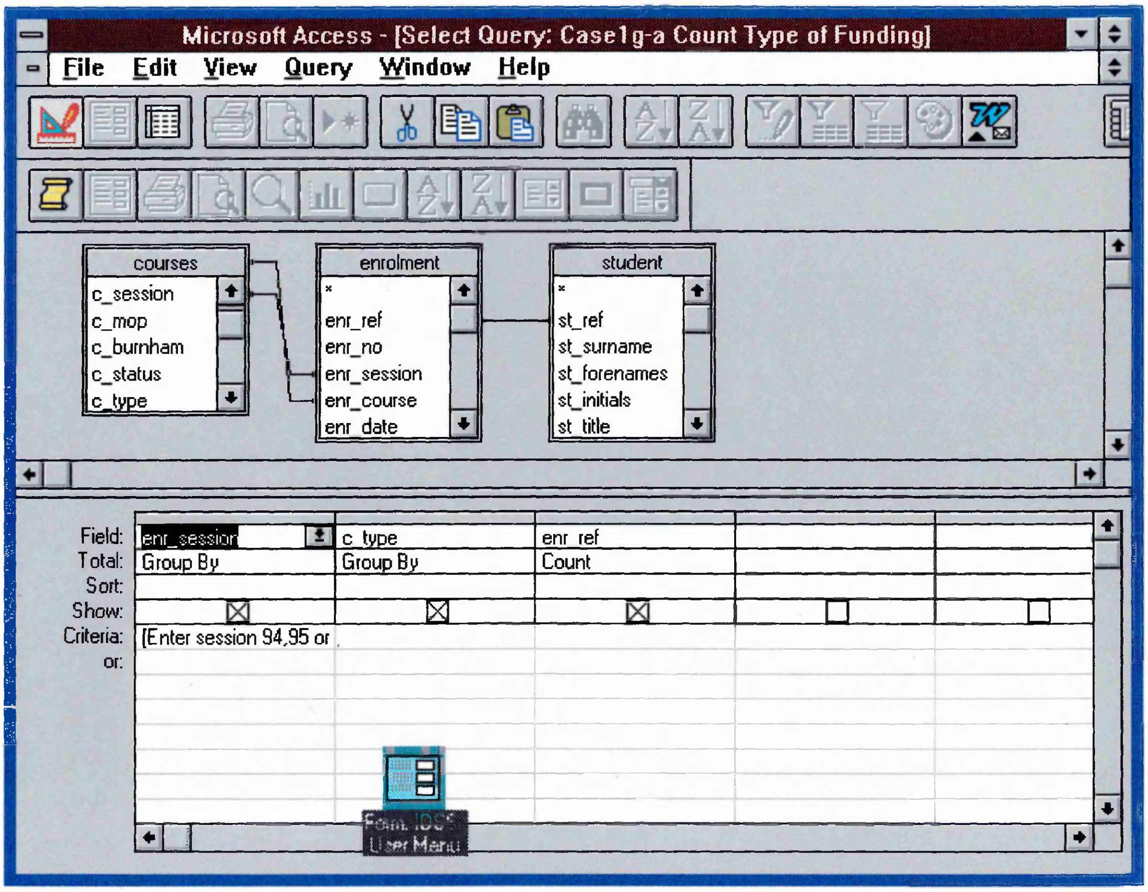


Figure E.6.1
Count Query for 'Which type of funding are the students eligible for?'

```
SELECT DISTINCTROW enrolment.enr_session, courses.c_type, Count(enrolment.enr_ref) AS
CountOfenr_ref
FROM courses INNER JOIN (enrolment INNER JOIN student ON enrolment.enr_ref =
student.st_ref) ON (courses.c_code = enrolment.enr_course) AND (courses.c_session =
enrolment.enr_session)
GROUP BY enrolment.enr_session, courses.c_type
HAVING ((enrolment.enr_session=[Enter session 94,95 or 96]));
```

Figure E.6.2
Count Query SQL (Question 1g)

APPENDIX E.7 - PROGRAMME AREA COUNT QUERY (QUESTION 1H)

Which Programme Area is the course in?

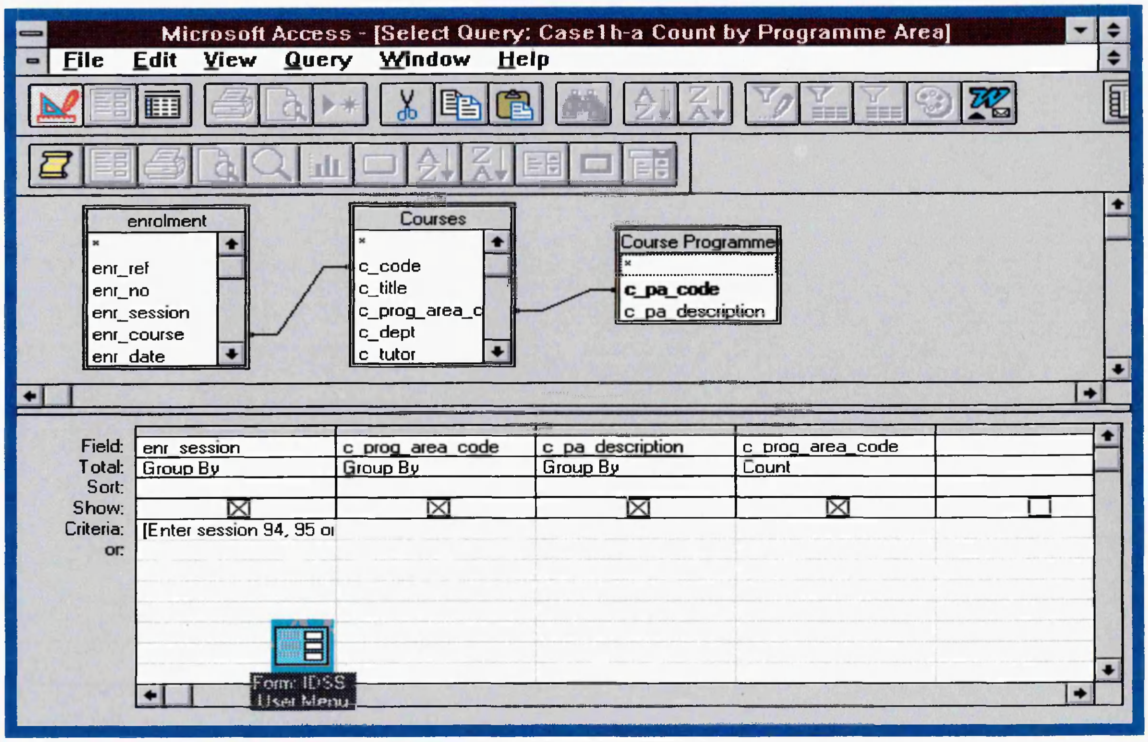
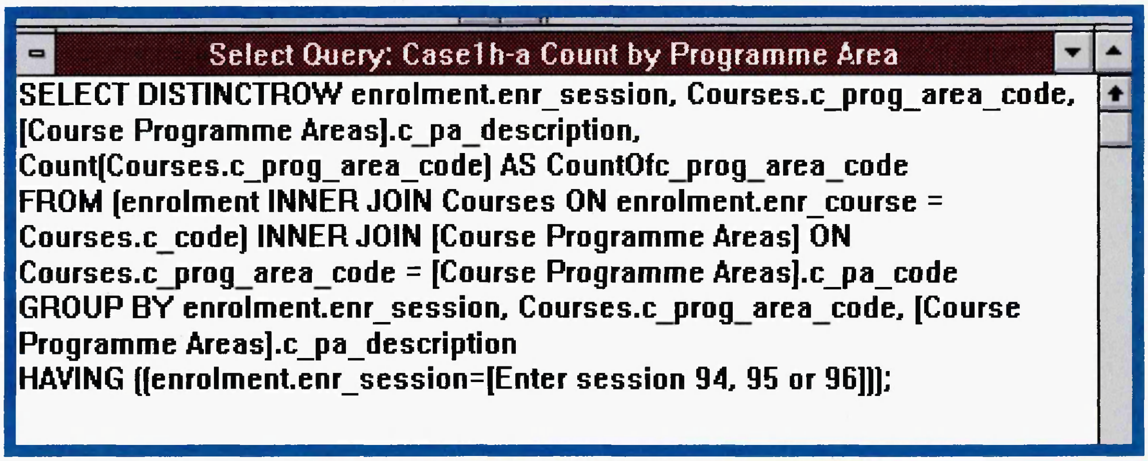


Figure E.7.1

Count Query for 'Which programme area is the course in?'



Select Query: Case1h-a Count by Programme Area

```
SELECT DISTINCTROW enrolment.enr_session, Courses.c_prog_area_code,
[Course Programme Areas].c_pa_description,
Count(Courses.c_prog_area_code) AS CountOfc_prog_area_code
FROM (enrolment INNER JOIN Courses ON enrolment.enr_course =
Courses.c_code) INNER JOIN [Course Programme Areas] ON
Courses.c_prog_area_code = [Course Programme Areas].c_pa_code
GROUP BY enrolment.enr_session, Courses.c_prog_area_code, [Course
Programme Areas].c_pa_description
HAVING ((enrolment.enr_session=[Enter session 94, 95 or 96]));
```

Figure E.7.2

Count Query SQL (Question 1h)

APPENDIX E.8 - COMPLETION STATUS COUNT QUERY (QUESTION 1I)

Which student completion status?

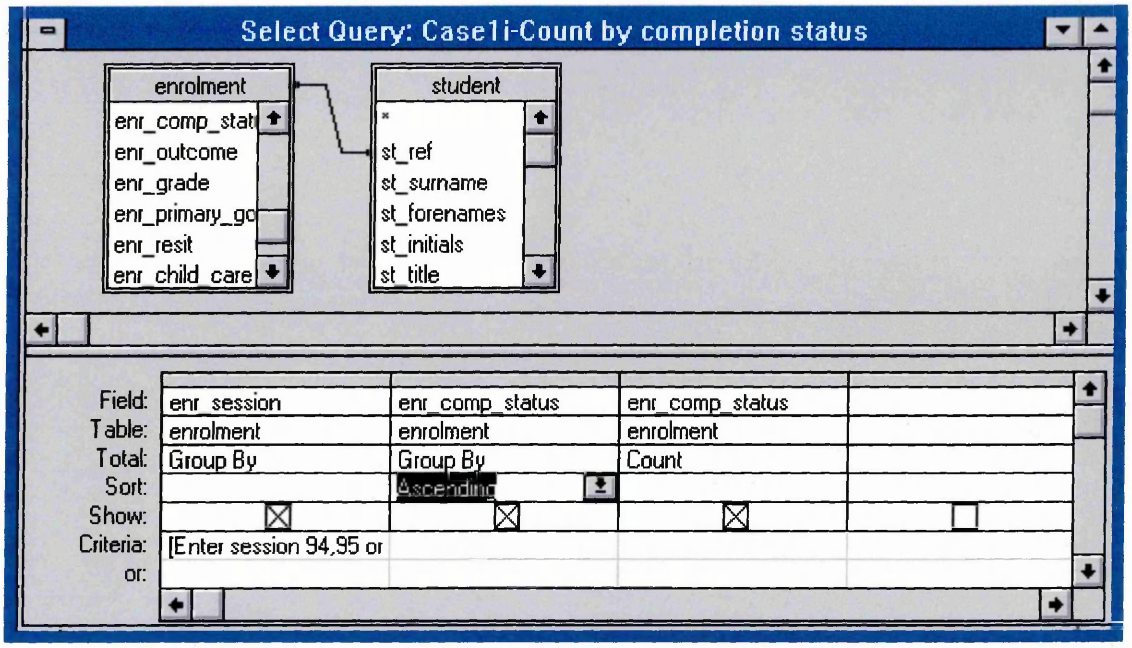
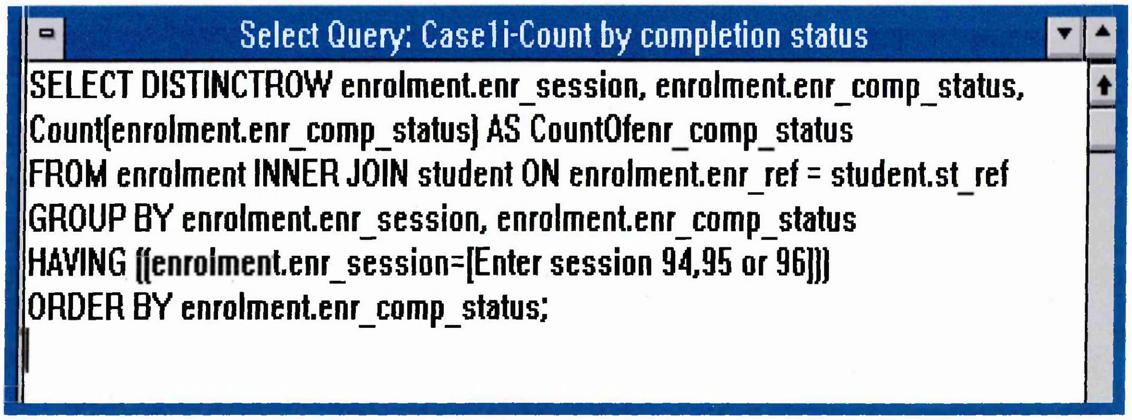


Figure E.8.1
Count Query for 'Which student completion status?'




```
SELECT DISTINCTROW enrolment.enr_session, enrolment.enr_comp_status,
Count(enrolment.enr_comp_status) AS CountOfenr_comp_status
FROM enrolment INNER JOIN student ON enrolment.enr_ref = student.st_ref
GROUP BY enrolment.enr_session, enrolment.enr_comp_status
HAVING ((enrolment.enr_session=[Enter session 94,95 or 96]))
ORDER BY enrolment.enr_comp_status;
```

Figure E.8.2
Count Query SQL (Question 1i)

APPENDIX F.1 - AGE RANGE DATA QUERY (QUESTION 1B)
Which age range?

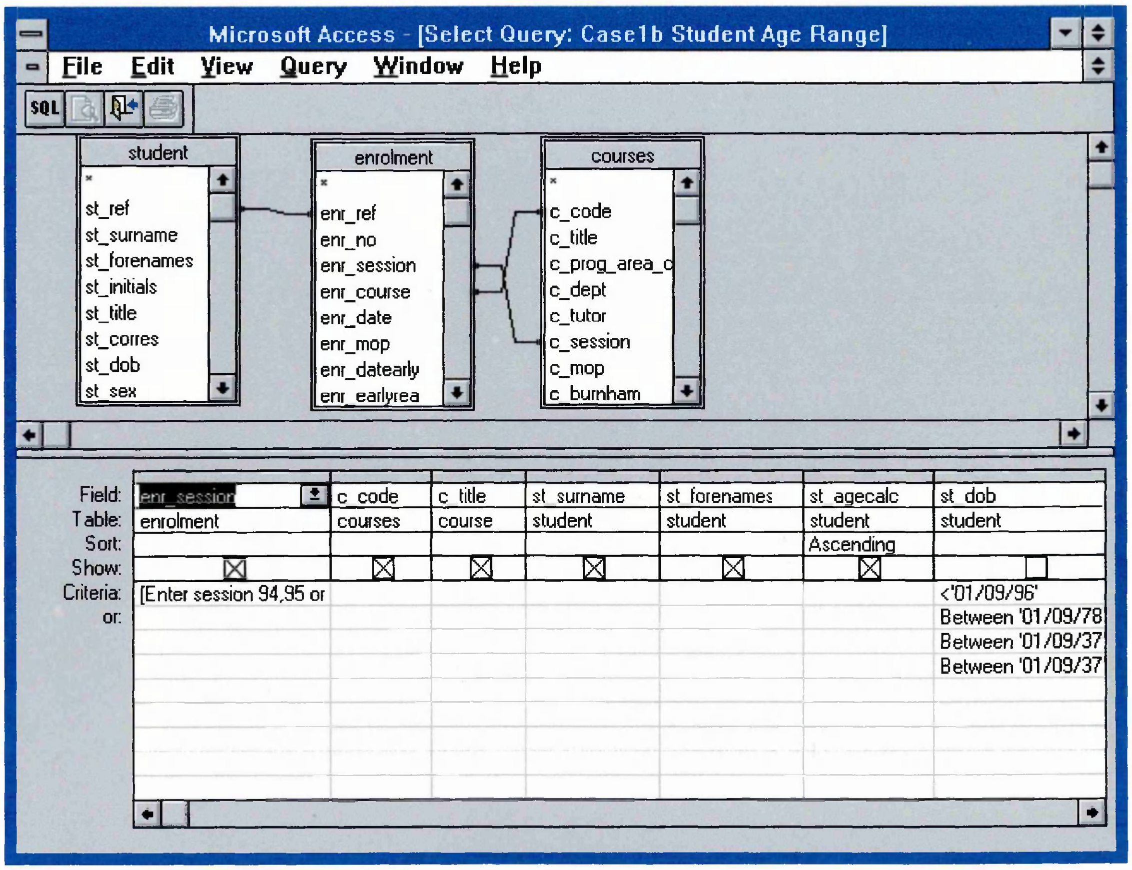


Figure F.1.1
Data Query for 'Which age range?'

APPENDIX F.2 - GENDER DATA QUERY (QUESTION 1C)
Which sex?

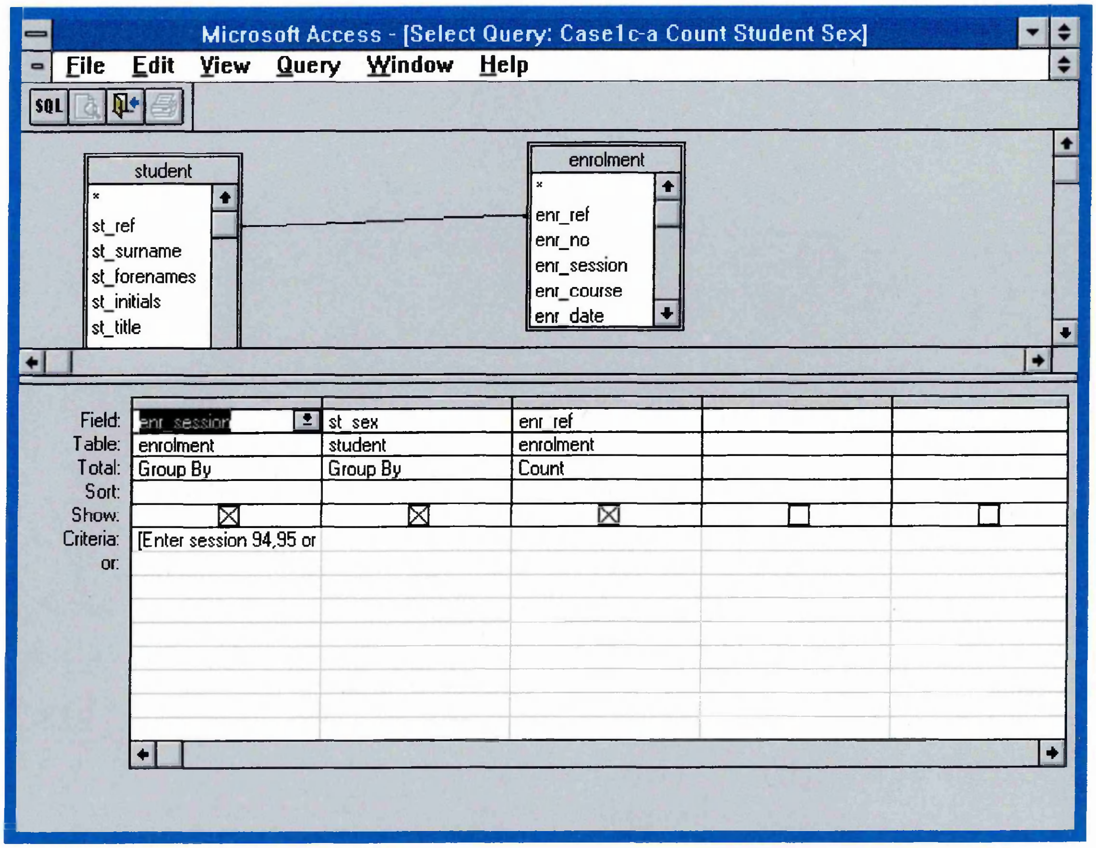


Figure F.1.2
Data Query for 'Which sex?'

APPENDIX F.3 - TIME OFATTENDANCE DATA QUERY (QUESTION 1D)

When does the student attend?

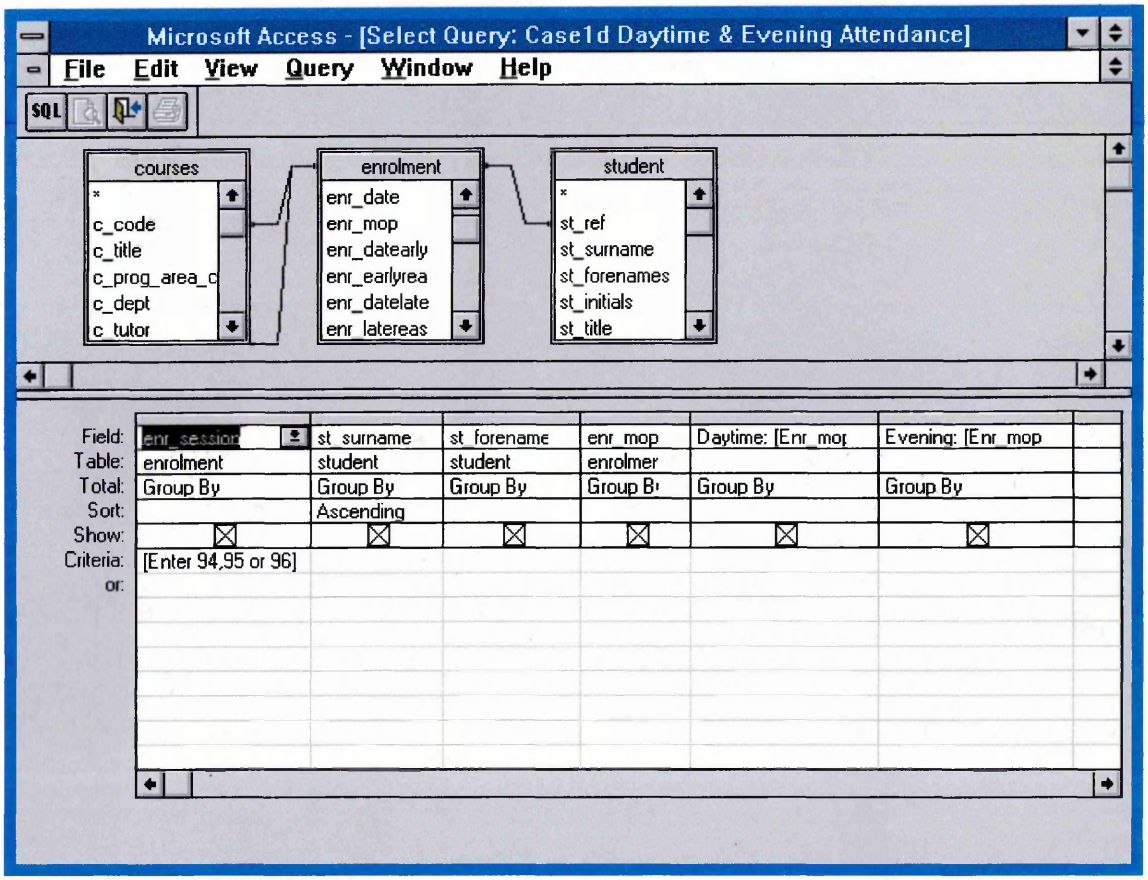


Figure F.1.3

Data Query for 'When does the student attend?'

APPENDIX F.4 - MODE OF ATTENDANCE DATA QUERY (QUESTION 1E)

Which mode of attendance are student numbers required for?

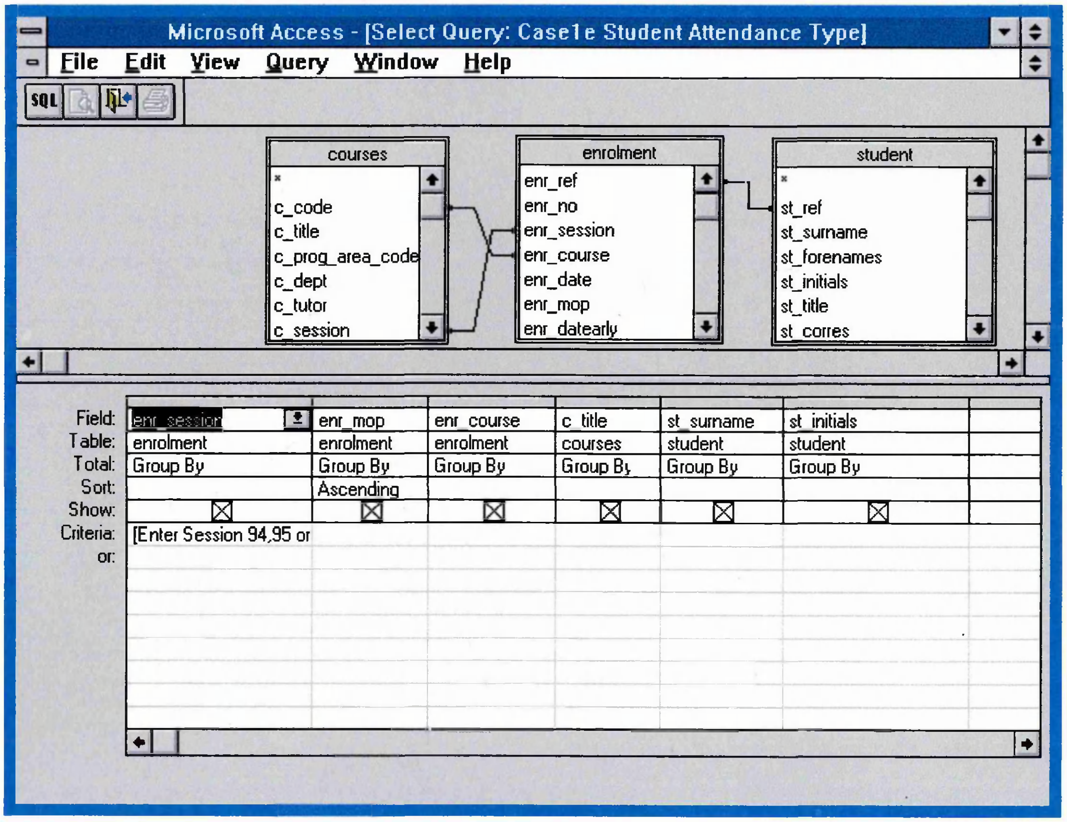


Figure F.1.4
Data Query for 'Which mode of attendance are student numbers required for?'

APPENDIX F.5 - LOAD BAND OF GUIDED LEARNING HOURS DATA QUERY (QUESTION 1F)

Which load band of guided learning hours?

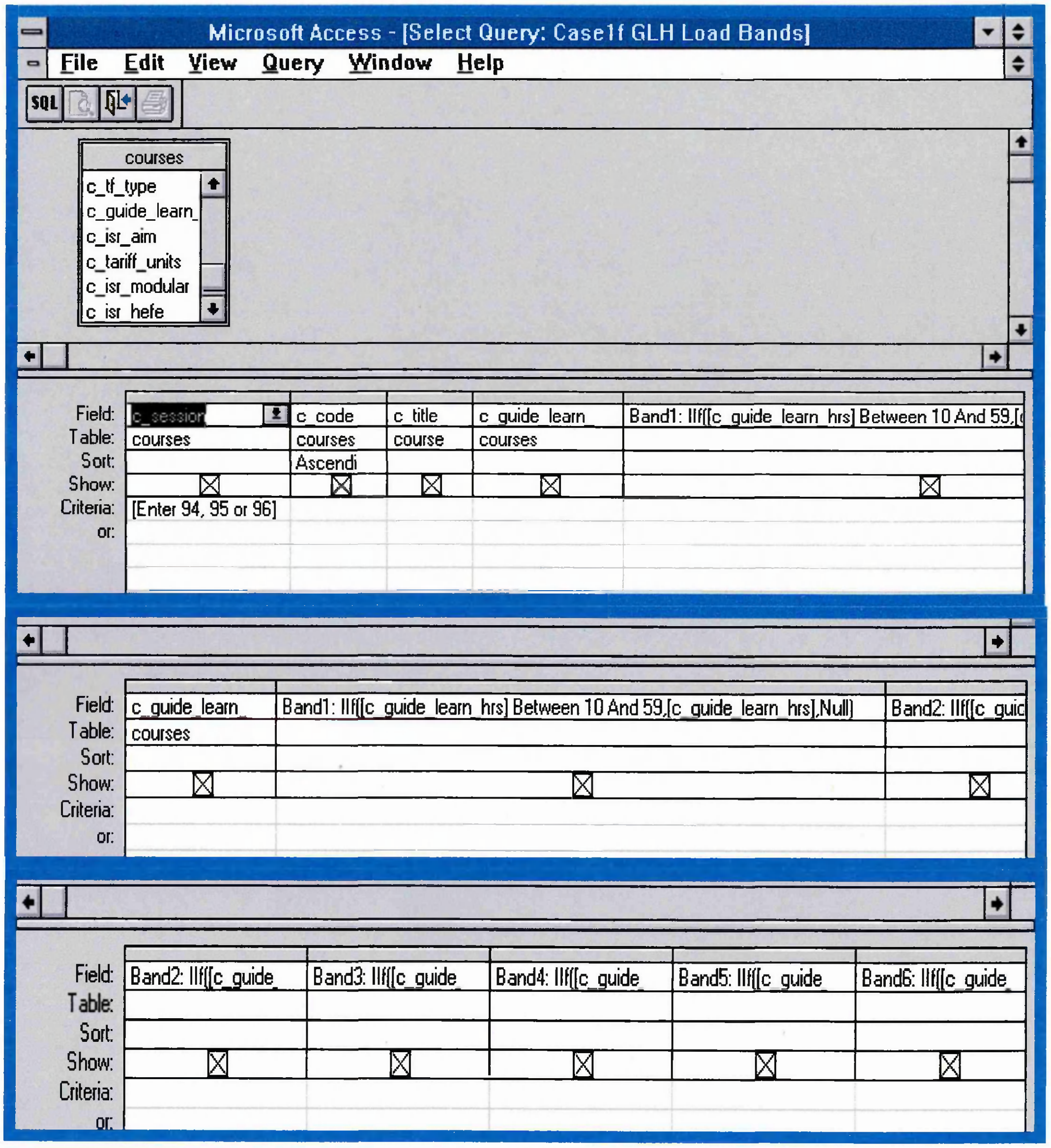


Figure F.1.5

Data Query for 'Which load band of guided learning hours?'

APPENDIX F.6 - SOURCE OF FUNDING DATA QUERY (QUESTION 1G)

Which type of funding are the students eligible for?

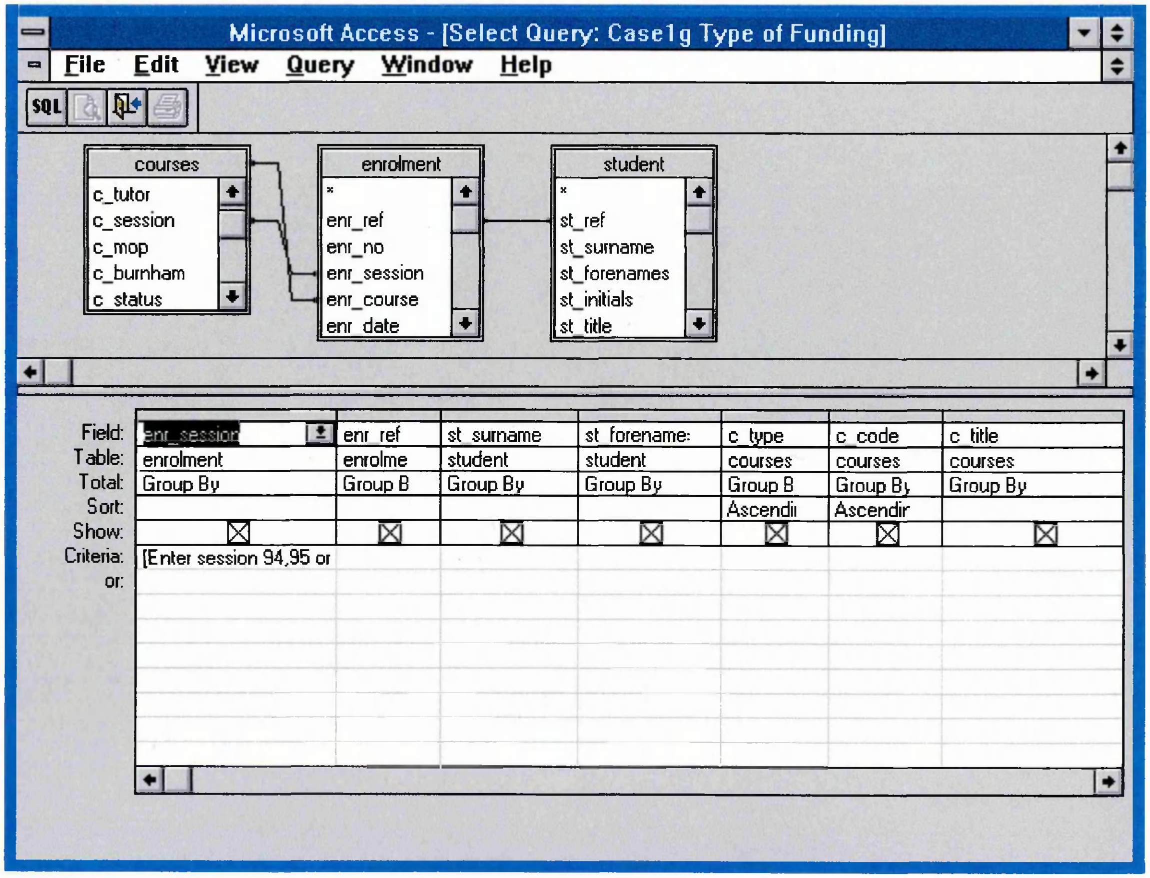


Figure F.1.6

Data Query for 'Which type of funding are the students eligible for?'

APPENDIX F.7 - PROGRAMME AREA DATA QUERY (QUESTION 1H)
Which Programme Area is the course in?

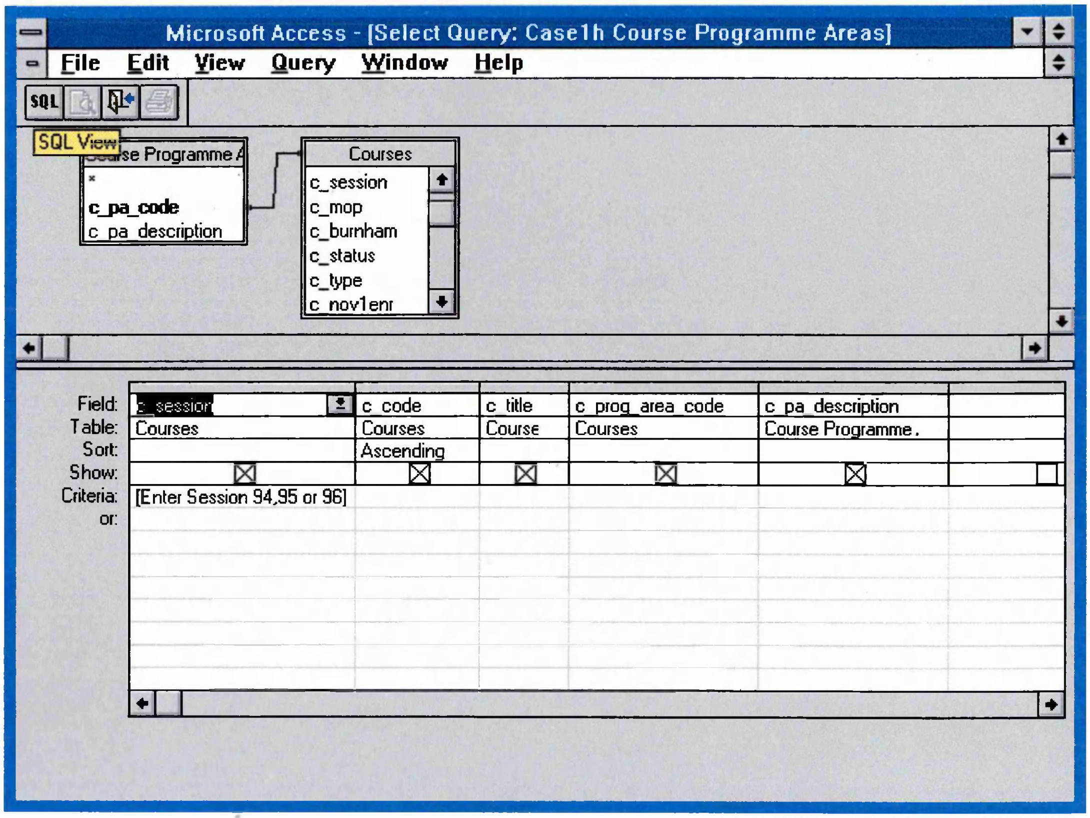


Figure F.1.7
Data Query for 'Which programme area is the course in?'

APPENDIX F.8 - COMPLETION STATUS DATA QUERY (QUESTION 1I)

Which student completion status?

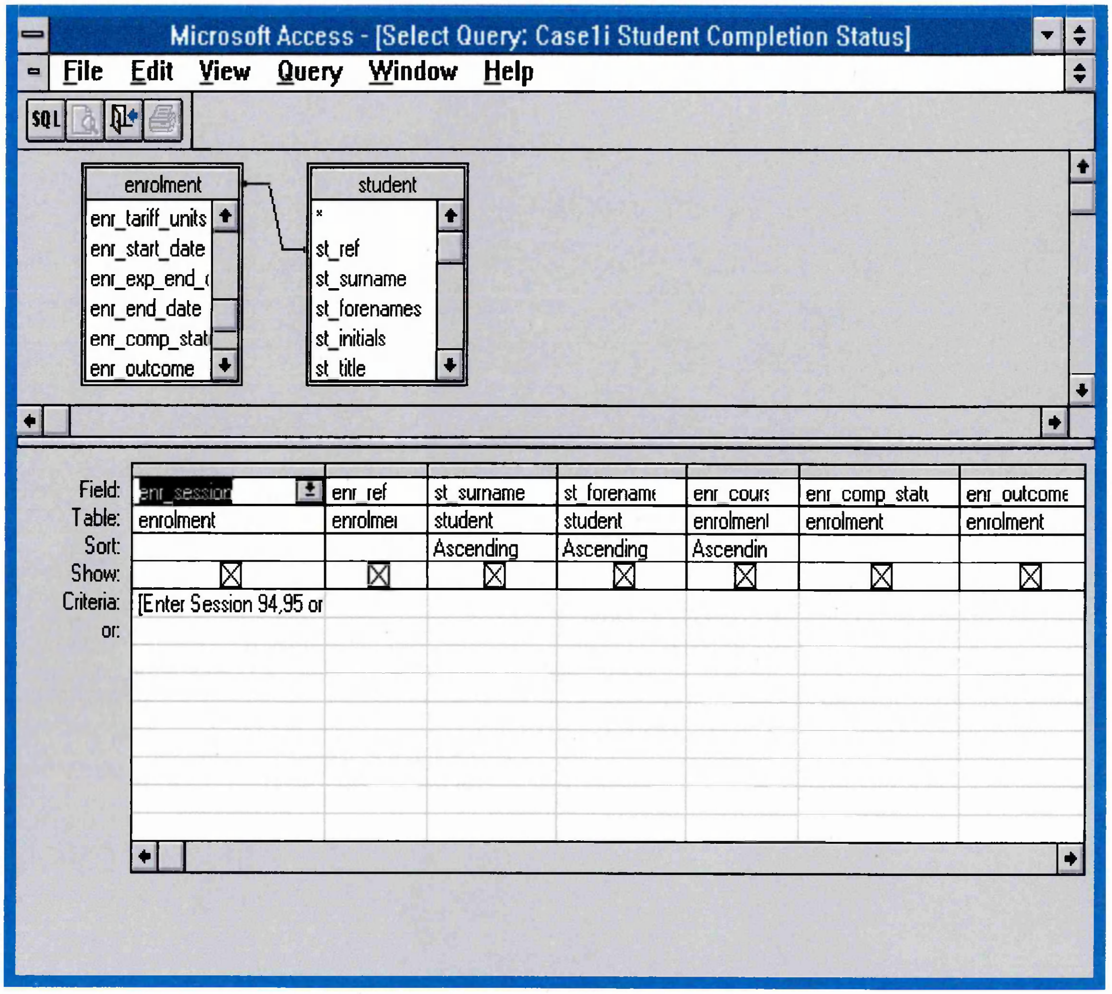


Figure F.1.8

Data Query 'Which student completion status?'

APPENDIX G - THE EXPERT ADVISOR SYSTEM EVALUATION SURVEY

Expert Advisor System Evaluation Exercise

Name: ....

Position: ....

Organization: ....

Statement	**Response**	**Menu Option**	**Comment - please use a continuation sheet if required**
Please read the following scenarios and statements, do the exercises, consider the validity of the statements, write the appropriate number in the response box and complete the comment box. *Statements are in italics.*	1 Strongly Agree 2 Agree 3 Neither 4 Disagree 5 Strongly Disagree	Navigation paths through the Expert Advisor System	Critical Success Factors (CSF) for the Expert Advisor System were identified through consultation with College Managers, The Further Education Funding Council (FEFC), Auditors and Inspectors and the Database Administrators (DBA) team. Please consider whether the CSFs have been met when making your comments
Senior Managers making decisions frequently want to view past questions which may influence the way they wish to handle decision making in the current situation. *Past questions stored in Cases are easy to access and view.*		User Menu View Questions in Cases Case Panel	1. User Exercise - View Case Questions

Figure G.1.1
Exercise 1 (View Case Questions)

Statement	**Response**	**Menu Option**	**Comment - please use a continuation sheet if required**
Please read the following scenarios and statements, do the exercises, consider the validity of the statements, write the appropriate number in the response box and complete the comment box. *Statements are in italics.*	1 Strongly Agree 2 Agree 3 Neither 4 Disagree 5 Strongly Disagree	Navigation paths through the Expert Advisor System	Critical Success Factors (CSF) for the Expert Advisor System were identified through consultation with College Managers, The Further Education Funding Council (FEFC), Auditors and Inspectors and the Database Administrators (DBA) team. Please consider whether the CSFs have been met when making your comments
The Expert Advisor System provides a click and point system using the mouse that enables the user to select an answer to a question. The answer to the question corresponds to the rules related to the question. In the 'Answer Case Questions' exercise the rules are those of the funding body - the FEFC. *It is simple for a user to answer case questions.*		User menu View Questions in Cases Case Panel	2. User Exercise - Answer Case Questions
The Expert Advisor System provides a key word question search facility for the user. When a funding bid, a strategic planning return or something similar is being completed it is extremely important that the organization knows how it has dealt with similar returns in the past. Questions that sound very similar can mean very different things. If questions are not handled carefully a wrong message can be given out, wrong data can be extracted resulting in a lower level of income being accrued than what is attainable, or an incorrect image of the organizations can be portrayed. It is important that similar questions in other cases can be viewed. *When a new case is being set up it is easy to find and view similar questions that have already been used..*		User Menu View Questions in Cases Question Panel	3. User Exercise - Key Word Question Search

Figure G.1.2
Exercises 2 (Answer Case Questions) and Exercise 3 (Key word Question Search)

Statement	Response	Menu Option	Comment - please use a continuation sheet if required
Please read the following scenarios and statements, do the exercises, consider the validity of the statements, write the appropriate number in the response box and complete the comment box. *Statements are in italics.*	1 Strongly Agree 2 Agree 3 Neither 4 Disagree 5 Strongly Disagree	Navigation paths through the Expert Advisor System	Critical Success Factors (CSF) for the Expert Advisor System were identified through consultation with College Managers, The Further Education Funding Council (FEFC), Auditors and Inspectors and the Database Administrators (DBA) team. Please consider whether the CSFs have been met when making your comments
Managers not only want to look at past questions but at past cases (a grouping of questions used together to inform decision making) to gain knowledge and understanding about how similar situations have been handled in the past. *The system enables the User to identify similar cases.*		User Menu View Questions in Cases Search Panel	4. User Exercise - Natural Language Case Search To provide a natural language interface (CSF)
Most organizations store their data in a relational database. When information is needed from the database a query is written to extract the required information. Information that matches what is specified in the query is extracted. Sometimes Managers need information from a system that is not an exact match although it is very similar. The Expert Advisor System uses 'fuzzy logic' to provide this facility for the user. *The Expert Advisor System facility for finding cases that nearly match as well as those that match perfectly is a useful facility for informing decision making. It could help many organizations.*		User Menu View Questions in Cases Search Panel Answering questions according to the rules	5. User Exercise - Finding Partially Matching Cases

Figure G.1.3
Exercise 4 (Natural Language Case Search) and Exercises 5 (Finding Partially Matching Cases)

Statement	Response	Menu Option	Comment - please use a continuation sheet if required
Please read the following scenarios and statements, do the exercises, consider the validity of the statements, write the appropriate number in the response box and complete the comment box. *Statements are in italics.*	1 Strongly Agree 2 Agree 3 Neither 4 Disagree 5 Strongly Disagree	Navigation paths through the Expert Advisor System	Critical Success Factors (CSF) for the Expert Advisor System were identified through consultation with College Managers, The Further Education Funding Council (FEFC), Auditors and Inspectors and the Database Administrators (DBA) team. Please consider whether the CSFs have been met when making your comments
Further Education Colleges regularly need to complete funding returns and extractions of the supporting, auditable data for the Further Education Funding Council (FEFC). The Expert Advisor System captures the funding request as a case and captures the supporting, auditable data. The data aspect is covered later in this survey. *The ISR case in the Expert Advisor System consists of questions that represent the FEFC Individualised Student Record (ISR) aggregate return, ISRAGG3 shown in appendix B.1 of the thesis*		User Menu View Questions in Cases Case Panel	6. User Exercise - Comparison of Funding Bid Question and Individualised Student Record Case
The Expert Advisor System provides a facility for looking at individual records that have been used to support past decisions. The records can be viewed at different points in time. This is a useful function when the rules relating to cases have changed, anomalies in the data have occurred or organizational changes have taken place i.e. staff restructuring or technical changes *The Expert Advisor System provides a facility for viewing detailed data that has been used to support a funding bid i.e. a case*		User Menu Display Case Data	7. User Exercise - Display Case Data

Figure G.1.4
Exercise 6 (Comparison of the Funding Bid Questions and the ISR Case)
and Exercise 7 (Display Case Data)

Statement	Response	Menu Option	Comment - please use a continuation sheet if required
Please read the following scenarios and statements, do the exercises, consider the validity of the statements, write the appropriate number in the response box and complete the comment box. *Statements are in italics.*	1 Strongly Agree 2 Agree 3 Neither 4 Disagree 5 Strongly Disagree	Navigation paths through the Expert Advisor System	Critical Success Factors (CSF) for the Expert Advisor System were identified through consultation with College Managers, The Further Education Funding Council (FEFC), Auditors and Inspectors and the Database Administrators (DBA) team. Please consider whether the CSFs have been met when making your comments
Relational databases are used extensively by most organizations but the data held in this type of database is overwritten when records are updated so data cannot be accessed at different points in time The Expert Advisor System handles data differently. It holds snapshots of data for each academic year. These snapshots of data are not overwritten and could be held monthly, weekly or for whatever period the organization required. *It would be extremely useful for organizations other than education that have a need for accessing historic data at different points in time to inform their decision making to use the Expert Advisor System.* It allows users to view aggregated data at different points in time and displays comparative data as numbers and in graphical format i.e. bar charts, pie charts etc to allow quick and easy assimilation. College Managers, the FEFC and Auditors identified these options as Critical Success Factors for the system. *The Expert Advisor System enables aggregated figures, graphs and detailed data for each question in a case, for each time period to be viewed. Organizations other than education find anomalies in their data and could use the Expert Advisor System to look at this detailed level of data to gain deeper understanding before making decisions*		User Menu Display Historical Data and Charts	8. User Exercise - Display Historical Data and Charts To view data at different points in time (CSF) To view aggregated data (CSF) To provide graphical representation of data for quick and easy assimilation (CSF) To provide easy extraction of comparative information (CSF)

Figure G.1.5
Exercise 8 (Display Historical Data and Charts)

Statement	Response	Menu Option	Comment - please use a continuation sheet if required
Please read the following scenarios and statements, do the exercises, consider the validity of the statements, write the appropriate number in the response box and complete the comment box. *Statements are in italics.*	1 Strongly Agree 2 Agree 3 Neither 4 Disagree 5 Strongly Disagree	Navigation paths through the Expert Advisor System	Critical Success Factors (CSF) for the Expert Advisor System were identified through consultation with College Managers, The Further Education Funding Council (FEFC), Auditors and Inspectors and the Database Administrators (DBA) team. Please consider whether the CSFs have been met when making your comments
Many organizations other than Further Education colleges are operating during a period of rapid change, handling complex data sets, working to rules that are frequently changing, are susceptible to restructuring and often have to bid for funds, undertake strategic planning and marketing exercises, and are working in an extremely competitive market. Making informed decisions is difficult for these organizations. *It would be relatively easy for Cases to be set up to help Managers operating in other complex problem domains such as the police force, the health service or local government to assist them in their decision making.*		Administrator Menu Insert or Adapt Cases Case Panel 'New' Questions - 'New' or 'Add' 'Save' or 'Save As'	9. Administrator Exercise - Setting Up Cases
			Yes / No Option
			Text Option
			Min / Max Option
			List Option

Figure G.1.6
Exercise 9 (Setting Up Cases)

Statement	Response	Menu Option	Comment - please use a continuation sheet if required
Please read the following scenarios and statements, do the exercises, consider the validity of the statements, write the appropriate number in the response box and complete the comment box. *Statements are in italics.*	1 Strongly Agree 2 Agree 3 Neither 4 Disagree 5 Strongly Disagree	Navigation paths through the Expert Advisor System	Critical Success Factors (CSF) for the Expert Advisor System were identified through consultation with College Managers, The Further Education Funding Council (FEFC), Auditors and Inspectors and the Database Administrators (DBA) team. Please consider whether the CSFs have been met when making your comments
Many researchers have found the problem of Case adaptation difficult. Mark W, Simoudis E., and Hinkle D. identified this problem in the statement they made in Case-Based Reasoning: Expectations and Results, in Case Based Reasoning Experiences, Lessons & Future Directions, 1996, Cambridge, M.A:AAAI Press / MIT Press, p 293 'One of our consistent findings was that automated adaptation of case was not feasible. The required depth of domain understanding consistently forced us into ad hoc approaches that had limited coverage... ' *Using the Expert Advisor System it is easy to adapt an existing case and save it as a new case.* At present Colleges use Database Administrators (DBA) to undertake a lot of the technical work associated with funding bids, strategic planning and marketing. Using the Expert Advisor System would mean people with understanding of the business, who are not DBAs could do work related to these tasks. The technology could be used to enable the processes and the processes themselves could be business driven *The procedure for inserting and adapting cases is simple to use and does not require specialist technical skills.*		Administrator Menu Insert or Adapt Cases Case Panel	10. Administrator Exercise - Case Adaptation Adding a new question Editing a question Deleting an answer

Figure G.1.7
Exercise 10 (Case Adaptation)

Statement	Response	Menu Option	Comment - please use a continuation sheet if required
Please read the following scenarios and statements, do the exercises, consider the validity of the statements, write the appropriate number in the response box and complete the comment box. *Statements are in italics.*	1 Strongly Agree 2 Agree 3 Neither 4 Disagree 5 Strongly Disagree	Navigation paths through the Expert Advisor System	Critical Success Factors (CSF) for the Expert Advisor System were identified through consultation with College Managers, The Further Education Funding Council (FEFC), Auditors and Inspectors and the Database Administrators (DBA) team. Please consider whether the CSFs have been met when making your comments
Organizations completing funding bids, statistical returns etc frequently have to provide answers constrained by internal or external rules. The Expert Advisor System provides a facility for the User / Administrator to supply answers to questions and these answers then form the rules. The answers to the case in the Expert Advisor System are rules supplied by the Further Education Funding Council *The rules supporting each of the questions in a case are easy to set up*		Administrator Menu Insert or Adapt Cases Question Panel	11. Setting up rules to support questions in a Case
Exercise 6 evaluated the capture of questions in the FEFC Individualised Student Record return against the questions in a Case. Exercise 10 evaluated the complexity of inserting and amending cases. Exercise 11 evaluated the complexity of providing rules to form the answers to case questions. Consider the level of learning that was necessary to undertake these tasks and the level of complexity involved in doing the tasks. These tasks demonstrated the process an organization would need to undertake to translate a statistical return into a case. *It is simple to translate a statistical return into Case questions and answers.*			12.Translation of Statistical Returns into Case Questions and Answers (no exercise)

Figure G.1.8
Exercise 11 (Setting Up Rules to Support Questions in a Case) and
Exercise 12 (Translating Statistical Returns into Case Questions and Answers)

Statement	**Response**	**Menu Option**	**Comment - please use a continuation sheet if required**
Please read the following scenarios and statements, do the exercises, consider the validity of the statements, write the appropriate number in the response box and complete the comment box. *Statements are in italics.*	1 Strongly Agree 2 Agree 3 Neither 4 Disagree 5 Strongly Disagree	Navigation paths through the Expert Advisor System	Critical Success Factors (CSF) for the Expert Advisor System were identified through consultation with College Managers, The Further Education Funding Council (FEFC), Auditors and Inspectors and the Database Administrators (DBA) team. Please consider whether the CSFs have been met when making your comments
Senior Managers need to view Cases representing how questions were handled previously. Sometimes they also need to look at the data that supports the answers to the questions. The 'Queries and SQL' menu provides an option that supports the extraction of data. It allows existing queries to be viewed or amended and saved as new queries to support new questions in new cases or as additional questions to existing cases. *The procedure to view queries, view SQL, amend queries and save them as new queries to support new questions in new Cases, or additional questions in an existing Case, is simple and easy to use and does not require a very high level of technical understanding. After a short training course staff with a lower level of technical expertise than the DBA could amend queries.*		Administrator Menu Queries and SQL option	13. Administrator Exercise - Queries and SQL View Queries View SQL Amending Queries

Figure G.1.9
Exercise 13 (Queries and SQL)

Statement	Response	Menu Option	Comment - please use a continuation sheet if required
Please read the following scenarios and statements, do the exercises, consider the validity of the statements, write the appropriate number in the response box and complete the comment box. *Statements are in italics.*	1 Strongly Agree 2 Agree 3 Neither 4 Disagree 5 Strongly Disagree	Navigation paths through the Expert Advisor System	Critical Success Factors (CSF) for the Expert Advisor System were identified through consultation with College Managers, The Further Education Funding Council (FEFC), Auditors and Inspectors and the Database Administrators (DBA) team. Please consider whether the CSFs have been met when making your comments
The Expert Advisor System uses Metadata to identify where data is stored and enable the system to function. When new entries are added to the system or existing entries are amended the Metadata tables need to be updated. *The facilities for viewing, amending or adding new entries to the tables that form the Metadata used by the Expert Advisor System are useful and easy to use*		Administrator Menu Tables option	14. Administrator Exercise - updating the Metadata
The Expert Advisor System provides technical staff with a BNF report. The report shows the sequence of steps the system takes to acquire decision support knowledge. *The BNF report is a useful technical report that shows the order of execution of the inference steps undertaken by the system whilst gaining knowledge about Cases. It helps staff understand how the Expert Advisor System is working*			15. Administrator Exercise - BNF report

Figure G.1.10
Exercises 14 (Updating Metadata) and Exercise 15 (The BNF Report)

General Questions	
The Expert Adviser System menu is clear and easy to follow	
The menu options meet the needs of a business User and a technical Administrator	
Cases can be used to inform management decision making	
Any Other Comments	

Signature ....

Date ....

Figure G.1.11
General Survey Questions

APPENDIX H - EXTERNAL DISCUSSIONS TO ACQUIRE KNOWLEDGE AND TO EVALUATE CBR SOFTWARE

Association of College Registrars and Administrators / College Management Information Systems (ACRA / CMIS) (1994)
Student Examinations & Achievements - The Data Explosion Workshop.
March 1994.

British Computer Society (BCS) (1994)
Expert Systems '94 14th Annual Conference
December 1994.

British Computer Society (BCS) (1995)
Expert Systems '95 15th Annual Conference
December 1995.

Business Intelligence Conference (1997)
Olympia Conference Centre, London.
November 1997.

Business Intelligence Conference (1998)
Olympia Conference Centre, London.
November 1998.

Business Intelligence Conference (1999)
Olympia Conference Centre, London.
November 1999.

Cognos98 (1998)
Cognos Forum, Manchester, UK.
21 July1998

Colleges Management Information Systems Group (CMIS) (1993)
The National Conference
March 1993.

Colleges Management Information Systems Group (CMIS) (1994)
Student Tracking Seminar
October 1994.

Department for Education and Science (1993a)
Further Education Statistical Return (FESR) Seminar
October 1993.

Department for Education and Science (1993b)
Publication of Student Achievement Seminar
October 1993.

Further Education Funding Council (FEFC) (1994a)
Data Collection Seminar - ISR
March 1994.

APPENDIX H - EXTERNAL DISCUSSIONS TO ACQUIRE KNOWLEDGE AND TO EVALUATE CBR SOFTWARE

Further Education Funding Council (FEFC) (1994b)
Individualised Student Record Seminar
July 1994.

Further Education Funding Council (FEFC) (1994c)
Staff Individualised Record Seminar
August 1994.

Further Education Funding Council (FEFC) (1995a)
Individualised Student Record Phase II Seminar
February 1995.

Further Education Funding Council (FEFC) (1995b)
Individualised Student Record Workshop
April 1995.

Institute of Electrical Engineers Colloquium (IEE) (1998)
Knowledge Discovery and Data Mining
8th May 1998

Inference Ltd. (1995)
CBR Express Case-Based Reasoning Package Evaluation Meeting
Inference Corporation
April 1995.

Ingres (1993)
Ingres User tools Training
September 1993.

Joint Pacific Asian Conference on Expert Systems / Singapore International Conference on Intelligent Systems (PACES / SPICIS) (1997)
Singapore, 24-27th February 1997.

National Association for Information Technology in Further Education (NAITFE) (1992)
Incorporation and Information Systems Conference
September 1992.

National Association for Information Technology in Further Education (NAITFE) (1995)
NAITFE Conference
October 1995.

Nord Ltd. (1992a)
Information Systems - A Management Overview Seminar
November 1992.

Nord Ltd. (1992b)
Unix Training
November 1992.

APPENDIX H - EXTERNAL DISCUSSIONS TO ACQUIRE KNOWLEDGE AND TO EVALUATE CBR SOFTWARE

Nord Ltd. (1993a)
Unix, Fecas and Ingres Security Seminar
March 1993.

Nord Ltd. (1993b)
Student Records Administration System (FECAS) Training
June 1993.

Nord Ltd. (1993c)
Course File Structuring
June 1993.

Nord Ltd. (1994)
Fecas Student Examinations Seminar
February 1994.

Salford University (1994)
Case-Based Reasoning Tutorial. In:
Expert Systems 94 Conference
January 1994.

Salford University (1995)
CBR Seminar
March 1995.

Sanderson PSS Ltd. (1994)
Fecas Student Record and Finance integration Seminar
August 1994.

Sanderson PSS Ltd. (1995a)
Fecas Student Examinations Seminar
March 1995.

Sanderson PSS Ltd. (1995b)
Fecas Student Applications software used to substantiate FEFC Counselling & Guidance Requirements
April 1995.

SAS (1997)
Meeting between Axelby Training & Consultancy and SAS

SAS (1998)
Business Intelligence Conference, London.
November 1998.

SAS (1999)
MSc Industry Partnership Planning Meeting
12 October 1999.

APPENDIX H - EXTERNAL DISCUSSIONS TO ACQUIRE KNOWLEDGE AND TO EVALUATE CBR SOFTWARE

SAS (2000)
Enterprise Miner Course
23-14 February 2000

SDGUG '99 II European User Conference (1999)
Italy, October 1999.