A PROTOTYPE EXPERT SYSTEM TO ASSIST IN SELECTING STUDENTS INTO THE DIFFERENT SPECIALIZATION OPTIONS IN THE FACULTY OF COMMERCE

By

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A Management Research Project Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Business and Administration, Faculty of Commerce, University of Nairobi

July, 1993

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DECLARATION

This Management Research Project is my original work and has not been presented for a degree in any other University

Signed .... Date 9/7/1993

MBAMBA, ULINGETA O. L.

This Management Research Project has been submitted for Examination with my approval as University Supervisor

Signed .... Date 9/9/93.

MR. DANNY FERNANDES

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DEDICATION

"To Him who sits on the throne and
the Lamb be praise and honour and
glory and power for ever and ever."
Amen.

Revelation 5:13

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LIST OF ABBREVIATIONS

AI	Artificial intelligence
DMS	Department of Management Science
DSS	Decision Support System
ES	Expert System
KB	Knowledge base
KBS	Knowledge Based System
MS	Management Science
OHA	Organized Human Activity
OOP	Object Oriented Programming
UoN	University of Nairobi

ABSTRACT

This paper describes the construction of a prototype expert system to assist in selecting students into different specializations in the Faculty of Commerce University of Nairobi. The Management Science Option offered in the Department of Management Science was used as a case study.

The expert system was constructed from scratch using Turbo Pascal as a programming language. The knowledge solicited from the experts, in this case lecturers in the concerned department, was represented in the expert system as production rules (IF ... THEN ... statements).

The expert system developed makes use of a relatively small number of rules - twenty one. The prototyping methodology was ideally suited for constucting an effective expert system within the time available.

The project report is divided into five sections. Section one introduces the topic and describes what an expert system is and how it works. Section two is devoted to literature review. The objective of the literature review is to give an over view of expert systems development.

Section three discusses how the prototype expert system was constructed while section four reviews different stages passed while forging this model. Section five closes the discussion. One definite conclusion emerging from this work which may be relevant to other researchers is to recognize that the capture of expertise in any domain poses a challenge for expert systems development.

SECTION ONE

INTRODUCTION

1.1 Background

Students are concerned about their academic performance (Austin, 1971) and strive to reduce the risk of failing or performing poorly. In a course, they choose the subjects which they think they will perform well in. Many employers believe there is a high positive correlation between academic performance and job performance. Many scholarship offering agencies award scholarships based on academic performance. Also, in order to be admitted for further studies, one has to perform well in a previous course.

In many cases, students' performance is tied up with the option for specialization selected. A student who is suffering from number phobia or has a poor background in Mathematics, has a high chance of performing poorly in quantitative subjects. Therefore, poor selection of students into options or specializations may result in poor overall performance. This is supported by Dr. Kohler's Report[1], in which he indicates that the selection criteria is partially responsible for failure rates in the Faculty of Commerce.

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1 Kohler, Dr. D.: <u>Ad Hoc Committee's Report on the High failure rates in some of the Faculty's Examinations</u>, 1980.

There are several Management Science techniques available for classifying students performance. These include: minimum entry characteristics, regression analysis, discriminant analysis, correlation analysis and expert systems and decision support systems.

Minimum entry characteristics of performance, e.g. in various subjects, entail setting the minimum mark/grade level that a student has to attain in specified subjects in order to be admitted into a program. Regression, correlation and discriminant analysis are statistical based classification methods. Expert systems and decision support systems approach use artificial intelligence techniques to classify students into different categories.

1.2 Faculty of Commerce Selection Criteria for Different Option Specializations

The introduction of the 8-4-4 educational system[2] in Kenya required a revision of the University of Nairobi syllabi in every faculty. The Faculty of Commerce used this revision exercise to offer additional options for specialization for the undergraduate students. The Faculty has three departments and offers six specializations (Table 1.1). Three of these options are new and will be offered for the first time in the 1993/94 academic year.

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2 The 8 - 4 - 4 Educational system in Kenya is the one where primary education lasts 8 years, secondary education 4 years and university undergraduate education 4 years.

Table 1.1 **Departments and Specialization for Undergraduate Students.**

Department	Specializations
Business Administration	Insurance, Marketing, General Management*
Accounting	Accounting, Finance*
Management Science	Management Science*

* new options.

Previously, only the Department of Accounting set entry requirements for students wishing to specialize in accounting. It required the interested student to attain a score of at least 50% in *Fundamentals of Accounting* course and 55% in *Quantitative Methods* course. Chirchir (1989) argues that none of these criteria have been objectively determined. The other deciding factors had been student preference, number of students requesting that option, and the student capacity of the Department.

1.3 Department of Management Science

The Department of Management Science (DMS) of The Faculty of Commerce started in 1972/73. For the first time in twenty years of its existence, it will be offering a Management Science (MS) specialization to undergraduate students. Currently, the DMS has twelve full time lecturers and offers eighteen courses (See Table 1.2). Three courses are offered in the first year, two in the second year, six in the third year and seven in the fourth year of the 8-4-4 undergraduate program.[3]

3 The Department also offers courses to M.B.A. degree students and services other Faculties of the UoN.

Table 1.2 8-4-4 Courses offered by the Department of Management Science.

Code	Course	Semester
DMS 100	Management Mathematics I	1
DMS 101	Management Mathematics II	2
DMS 104	Fundamentals of Computer Science	1
DMS 201	Business Statistics I	1
DMS 202	Operations Research I	1
DMS 300	Computer Programming I	1
DMS 301	Computer Programming II	2
DMS 302	Operations Research II	2
DMS 303	Business Statistics II	1
DMS 304	Systems Analysis	2
DMS 306	Electronic Data Processing	1
DMS 401	Management Information Systems	1
DMS 403	Project Management	1
DMS 404	Advanced Business Statistics	1
DMS 402	Micro Computer Applications	2
DMS 405	Materials Management	2
DMS 406	Production Management	2
DMS 407	Heuristic Simulation	2

With a large number (about 400) of students in the third year of the 8-4-4 system, admitting them into different specializations will be a challenging and involving task for the faculty administration. It would be convenient if the task could be largely automated. An automated system would facilitate efficient counseling and selection of students.

Chirchir (1989) foresaw a student facing problems in selecting options to take. He predicted that this problem of choice would be compounded when additional options are introduced in the 8-4-4 educational system.

Consultation with departmental lecturers has revealed that in addition to handling the large number of students involved, the option selection system should be:

a) considered fair by students

b) consistent in its results

c) able to explain its decision process

d) able to easily incorporate actual experience over the years

e) easy to operate so that the initial selection can be delegated by the Chairman and he/she handles only special cases

f) preferably computer based.

It should be noted that for the pioneer group of 8-4-4 students making their option selection, there is no pertinent historical data on actual performance in the final year. But the expertise of the faculty lecturers to relate student entry point characteristics and subsequent performance is available.

The expertise of Faculty lecturers can be relied upon because Butterworth (1988) argues that in modelling problems which contain uncertain outcomes we can often use subjective expert opinion(s) to describe the uncertainty. This subjective expert opinion is the degree of belief that an expert has in the likelihood of an event occurring.

The use of expert opinion is not new. Murphy and Winkler (1977) examined the abilities of US weatherman to forecast the likelihood of rain, and found that their judgements were reliable. Yates and Curly (1985) investigated the predictions of baseball results for a professional odds-maker and physicians' abilities to diagnose pneumonia. The professional group (in this case physicians and professional odd makers) tended to perform far better than the corresponding amateur/students groups. Butterworth (1988) comments that this is not unreasonable since the professionals are making judgements in their own fields.

1.4 What is an Expert System (ES) ?

Expert Systems are the most celebrated result of artificial intelligence (AI)[4] research application to date (Chabris, 1990). An ES is a knowledge based computer program containing expert domain knowledge about objects, events, situations and courses of action which emulates the reasoning process of human experts[5] in the particular domain (Wiig 1990). The main components of an ES are:

a) Knowledge base

b) Inference engine

c) User interface.

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[4] There is no widely accepted definition of AI, but for the purpose of this study AI is defined as a science that studies primarily techniques for making computers exhibit intelligent behavior, ways of imitating human cognitive processes and the construction of autonomous, generally intelligent, artificial systems (Chabris, 1990).

[5] Experts are considered to be best at what they do. They usually use less information in making decisions. Shanteau (1991) identifies about 20 attributes that experts possess. They are distinguished from novices who are intermediate in skill and are trying to become experts. Naive decision makers know little or nothing and usually they do not know that they do not know.

Figure 1.1 shows a diagrammatic representation of an ES. A user poses a problem to the ES through the user interface. The inference engine performs reasoning through the knowledge base and finally gives a response to the user.

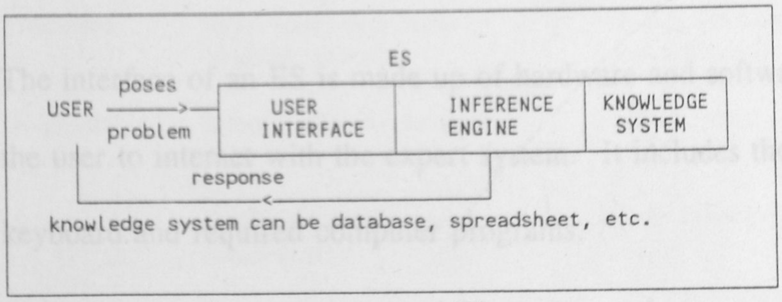

Figure 1.1 Structure of Conventional ES
Adopted from Holsapple & Whinston, 1989.

Table 1.3 shows some of the successfully implemented ESs. Some of these have proved to outperform their human counterparts in the field of their domain (Chabris, 1990).

Table 1.3 Some of the successfully implemented ESs

Purpose	Expert System
Medical diagnosis	MYCIN, PUFF, PIP, CASNET, INTERNIST
Engineering Diagnostic	SACO
Geology Diagnostic	PROSPECTOR
Chemistry	DENDRAL, SECHS, SYCHEM
Circuit Analysis	EL
Genetics	MOLGEN
Mechanics	MECHO
Programming	PECOS
Configuring Computers	R1
Machine Acoustics	SU/X
Medical Measurements	VM
Electronics Tuition	SOPHIE
Medical Tuition	GUIDON
Knowledge Acquisition	TEIRSIAS, EMYCIN, EXPERT, KAS
Building Expert System	ROSIE, AGE, HEARSAY III, AL/X, SAGE, Micro-Expert

Adopted from : Naylor, 1990.

An ES is designed to cover a specific area of expertise called the domain area. The knowledge base constitutes the store regarding the domain as obtained from relevant experts. This knowledge can be stored using various methods. (See Section 2.2).

The interface of an ES is made up of hardware and software components that allow the user to interact with the expert system. It includes the computer monitor, keyboard and required computer programs.

The inference engine component of an ES is the software that automates the reasoning process in order to come up with suggested solutions to the problem. The reasoning method is done by manipulating the knowledge in the knowledge base. An ES shell is an "*empty*" ES. Mathematically, it is equated as

ES shell = ES - Knowledge base.

The knowledge base (KB) can be created by human experts without AI experience. It usually provides guidance to simplify initial knowledge acquisition. EMYCIN (Empty MYCIN) is an example of ES shell after removing medical diagnostic knowledge. If one takes EMYCIN and creates a structural engineering knowledge base he/she automatically gets a structural engineering ES.

Table 1.4 Generic Categories of ES Applications

Type	Problem addressed	Type Systems
Interpretation	Infers situation description from sensor data	Speech understanding, image analysis, surveillance
Prediction	Infers likely consequences of given situation	Weather forecasting, Crop estimation
Diagnosis	Infers system malfunctions from observations	Medical, electronic
Design	Configure objects under constraints	Circuit layout, budgeting
Planning	Designs actions	Automatic programming, Military planning
Monitoring	Compares observations in order to plan vulnerability	Nuclear power plant regulation, fiscal management
Debugging	Prescribes remedies for malfunctioning	Computer software
Repair	Executes a plan to administer a prescribed remedy	Automobile, computer
Instruction	Diagnoses, debugs and corrects students behaviour	Tutorial, remedial
Control	Interprets, predicts, repairs and monitors system behavior	Air Traffic Control, battle management

Source : Reid, G.S.: "On the Development of Commercial ESs." *The AI Magazine*, Fall 1984, page 61-73.

Table 1.4 shows the generic categories of ES applications. All ESs given in Table 1.3 can be classified in one of the types showed in Table 1.4. Therefore, ESs can be used almost in every field from Accounting to Zoology in predicting, designing, interpreting and other tasks which are currently thought to be done well by human experts.

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1.5 Objective and Importance of the Study

The objective of this study was to design a prototype ES to assist in selecting students into Management Science option offered by Department of Management Science, Faculty of Commerce, University of Nairobi. An ES has all the features listed as desirable for such a selection system (see page 5).

The Chairman of Department of Management Science considered such an ES would be an invaluable tool for making an appropriate and fair selection into the Management Science option.

The ES prototype developed has potential application in any department in the university. What is unique to each department is the knowledge base of the ES. The ES prototype incorporates features to allow for easily changing the knowledge base to suit specific departmental needs.

SECTION 2

LITERATURE REVIEW

Two characteristics of good managers and other professionals are their ability to make decisions and to make the decisions quickly. A primary goal of an ES is to increase expertise in an organization as measured by better and faster decisions. ESs are built to make expertise more available to non experts. Users of ESs may learn from the system augmenting their own domain knowledge by regular use of the ES, thus ensuring better and faster decision making.

The management of organization expertise has received particular attention with development of ES technology that attempts to embody this valuable organizational capability.

2.1 Expertise and Experts

Expertise is the skill and knowledge that some people possess, which results in performance that is above the norm (Oz et al, 1990). This skill and knowledge is constituted by massive amounts of factual knowledge, rules of thumb, simplifications, rare facts, and wise procedures for integrating these various components to tackle a specific problem situation. Shanteau (1992) identifies several characteristics for cognitive science research in relation to expertise. These include:

1) Expertise is domain specific

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2) Expertise is acquired through stages of development

3) Experts use different thinking strategies

4) The thinking of an expert is more automated

5) Expert processes are reflected by and can be studied through viable protocols.

Cognitive science research views experts as competent and different from novices in virtually every aspect of cognitive functioning.

Shanteau (1992) further points out that judgement/decisions making literature presents another view on the ability of experts. According to this view, experts are not immune to cognitive illusions that affect novices. Shanteau integrates the two opposing views in the *Theory of Expert Competence*. This theory assumes competence depends on five components:

1) A sufficient knowledge of the domain

2) Psychological traits associated with experts

3) Cognitive skills necessary to make tough decisions

4) The ability to use appropriate decision strategies

5) Task with suitable characteristics.

Efforts to produce an objective definition for an expert has proved illusive. There are as many definitions of an "*expert*" as there are researchers who study them (Hoffman et al, 1991). In the absence of an objective definition, Shanteau (1988) defines Experts as those considered by their colleagues to be best at making decisions.

Experts are essential in precisely those domains where there are "*no right answers*."

It is the experts who set the standards and they have the power to change them.

Experts acquire, organize and disseminate knowledge through experience, stories about past cases and by keeping abreast with current development in their particular area of expertise. Some decision strategies used by experts are domain specific (Shanteau, 1988). These include

1) Experts are willing to make adjustments in the initial decision, taking advantage of feedback

2) Experts rely on others to assist in decision making

3) Experts know how to learn from past decisions and to make appropriate changes in future decision strategies

4) Experts have developed informal decision aids such as written records of prior decisions which allow them to avoid the biasing effect of heuristics

5) Experts avoid large mistakes

6) Experts employ a divide and conquer strategy when tackling large problems.

Research has indicated that experts display similar psychological characteristics which belong to decisions style or set of abilities common to many experts. These include

1) Highly developed perceptual / attentional abilities (Krogstad et al, 1984)

2) A sense of what is relevant and irrelevant when making decisions (Geath and Shanteau, 1984, Shanteau et al, 1981)

3) An ability to simplify complex problems (DeGroot, 1965, Nagy, 1981)

4) Effective communication of their expertise to others (Dino and Shanteau, 1984, Goffman, 1959)

5) Ability to handle diversity better than non experts (Shanteau, 1987, Dino et al, 1984)

6) Are selective in picking decision problems (Dino and Shanteau, 1984)

7) Show strong outward confidence in their decision making ability (Shanteau and Phelps, 1977)

8) Have an extensive and up to date current knowledge (Gaeth, 1980)

9) Are more creative in discovering new decision strategies (Dino et al, 1984)

10) Are generally inarticulate about the processes used to make decisions (Lusted, 1960, Anderson, 1982).

The above discussion has major implications for getting experts to interact with the ES. In certain respects, ESs should be designed with the needs of experts in mind. Otherwise, capturing expertise that can be embodied in an ES can prove to be very difficult. Given the complex and intricate nature of expertise, its capture represents a primary challenge for expert systems development and its dynamic nature makes the maintenance of an ES difficult. An ES thus needs to be constantly updated and its knowledge base fine tuned.

2.2 Knowledge, Knowledge Representation and Knowledge Engineering

Modelling involves representing a world at some level of abstraction (Neale, 1990). Knowledge modelling is done by a knowledge engineer. The task of a knowledge engineer is to discover essential principles of the domain by abstraction from the mass of information gleaned from experts and other sources, and to use this knowledge to create an outline model which gives a framework for further knowledge acquisition (Motta et al, 1990).

Knowledge refers to information available to an individual from internal or external sources about relationships and rules that describe Organized Human Activity (OHA). The OHA, however complex or simple, may be described in terms of formal or informal relationships between variables, procedural rules and information inputs (Shanteau, 1992) (see Figure 2.1 below).

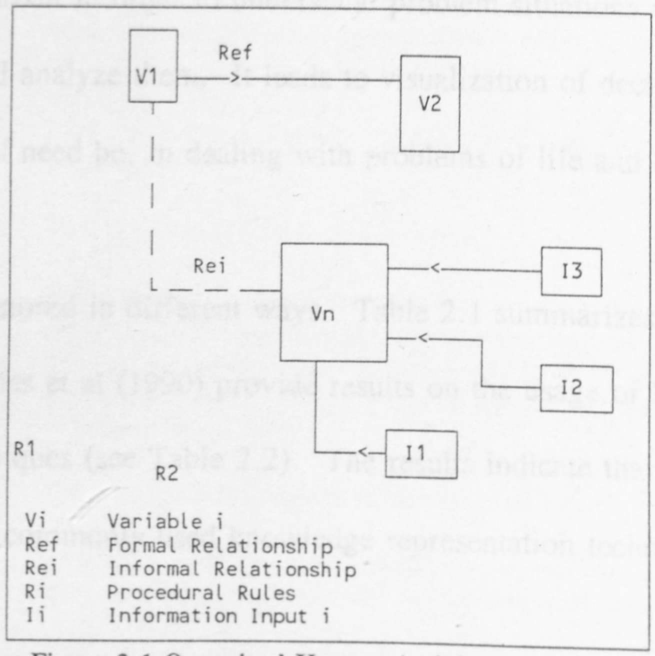

Figure 2.1 Organized Human Activity

Structuring the knowledge involves knowledge representation encompassing the situation of interest. Knowledge bases are as dynamic in nature as the human mind.

Expert knowledge is a combination of theoretical understanding of a problem and collection of heuristic problem solving rules that experience has shown to be effective in specific domains. ESs are constructed to obtain this knowledge from human experts. Expert knowledge differs from ordinary human knowledge not in the nature of knowledge but the fact that it integrates with experts routine function (behaviour).

Experts' knowledge can be classified into two types

1) Deep knowledge acquired through learning, e.g. from textbooks

2) Shallow knowledge or heuristic acquired through experience.

Knowledge is important in order to understand problem situations and in order to be able to describe and analyze them. It leads to visualization of decisions and possible courses of actions if need be, in dealing with problems of life and society.

Knowledge can be stored in different ways. Table 2.1 summarizes these storage techniques. Doukides et al (1990) provide results on the usage of knowledge representation techniques (see Table 2.2). The results indicate that production rules are by far the most commonly used knowledge representation techniques.

Table 2.1 Methods of Storing Knowledge in ES

Technique	Explanation
Predicate logic	This is through the use of symbols like ¬, ∩, U, ->, and so on.
Production rules	Use of IF ... THEN ... statements.
Nonmonotic systems	Extension of predicate logic to incorporate incomplete and uncertain models. e.g. A statement can be believed to be true, believed to be false or not believed to be either.
Statistical reasoning systems	They are extensions of the first three but in this case trying to show to what extent through the use of probabilities, certainty factors, fuzzy logic and so on.
Semantic networks	In this case a meaning of a concept comes from the ways in which it is connected.
Conceptual dependency	This is a natural language processing.
Scripts	Representing knowledge that stored in series of slots, the events and expectations for situations that evolve over time. A slot in a frame or script knowledge representation contains a specific attribute of an object. The attribute may have value or it can be a procedure that can be executed on command (Wiig, 1990).
CYC	This is intended to capture human common sense.
Frames	Frames are data structures similar to relational data base, which represent each concept with a name and various properties arranged in slot / filler pairs.

Table 2.2 Use of Knowledge Representing Techniques

Technique	Usage (%)
Rules	62
Trees	18
Semantic Nets	16
Frames	15
Hybrid Scheme	15

Chamuriho (1992) suggests reasons for wide usage of production systems. These include simplicity and transparency.

Engineering refers to application of scientific principles to design maintain and construct an artifact. Therefore, knowledge engineering can be described as

1) Methods that permit the development of mathematical or computer analysis of OHA.

2) The process of moving from science to application. AI, ESs and neural networks are used to bridge the gap between scientific descriptions of logical statistical and mental problem solving process to application to real world.

A computer specialist who extracts knowledge from human experts and builds a knowledge base is called a knowledge engineer. He/She concentrates on duplicating in an information system, the behaviour of a human expert in order to solve narrowly defined problems. A knowledge engineer "*debriefs*" or extensively interview human expert(s) in a specific domain, and codifies the information into rules and strategies that he represents symbolically and transfers them into computer programs.

There are several knowledge engineering methodologies. They include

- Observation
- Deduction
- Induction
- Correlating causes and effects
- Developing design hypothesis
- Organizing materials and people
- Formal definition of problem

- Structuring facts

- Discriminating between facts and assumptions

- Ability to draw on scientific knowledge to supplement the engineering know-how.

In ES development a knowledge engineer assists in all stages by performing two main tasks, namely, knowledge elicitation and structuring of the knowledge base.

Knowledge, knowledge representation and knowledge engineering have implications for ESs in several ways. There are different types of experts and they work under uncertain conditions. The degree of uncertainty because of an ill structured environment, will determine how the experts will react to a situation. Different experts will react differently to the same environment. Training is important for an expert to increase his knowledge base and to keep track of changes that are relevant. It should be noted that training cannot make a novice an expert.

2.3 Knowledge Inferencing Techniques

An inference mechanism is an interpreter of the knowledge base and it is the heart of the ES. This consists of a reasoning method and the mechanism for using the knowledge stored in the knowledge base. The knowledge can be manipulated by this inference engine.

Inference engines use two knowledge processing strategies:

a) Forward Chaining (Bottom-Up processing): this is whereby the system begins with the facts and looks for the best conclusion. It is sometimes referred to as a Data Driven strategy.

b) Backward Chaining (Top Down processing): where the system begins with the hypothesis and works backward, checking to see if the facts support the hypothesis. Literature also refers to this as a Strategy Driven Approach.

Forward chaining takes facts of the problem and applies the rules to produce new facts. Backward chaining focuses on goal, finds the rules that could produce that goal and chains backward through successive rules and sub goals. In the final analysis, both methods result in the same state space (Chamuriho, 1992). However, the order and the actual number of the states searched may differ.

2.4 Designing and implementing ESs and Expert System Benefits.

New management approaches, unlike those employed for most software development project are required for ESs. Meyer and Curley (1989) have identified and classified attributes of successful ES projects. They have used two dimensions for classification - complexity of the knowledge and the complexity of the technology involved. This classification framework is shown in figure 2.2 (page 21).

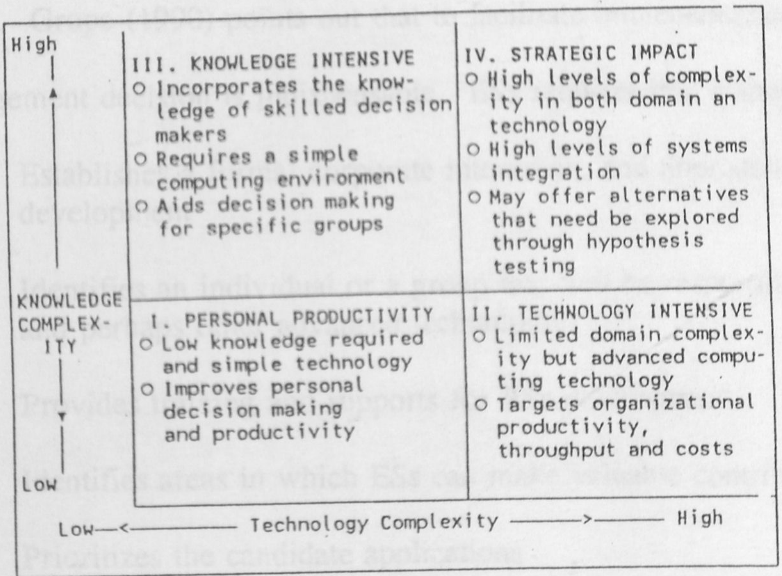

Figure 2.2 A Classification Framework of ES

Source : Meyer, M. H. & Curley, K.: "Expert System Success Models." *Datamation*, September 1, 1989.

Their research revealed that successful development of an ES requires a strict focus on the application and not the technology, and sustained management support. Lyons (1990) identifies four management issues for successful implementation of ES technology. These are

1) Designing robust information systems
2) Viewing information systems as change agencies
3) Altering the traditional systems development life cycles
4) Quality assuring the knowledge bases.

Many ESs are developed in an incremental fashion because the knowledge requirement is not fully understood at the start. Addressing oneself to the above listed issues allows the knowledge bases of an ES to be designed to accommodate revisions

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easily. Grope (1990) points out that to facilitate implementation of an ES a conscious management decision is indispensable. ESs requires that management

1) Establishes a formal corporate interest in, and approach to, expert systems development

2) Identifies an individual or a group that will be responsible for the use of ESs and perhaps other advanced technologies

3) Provides training and supports for ESs development

4) Identifies areas in which ESs can make valuable contribution

5) Prioritizes the candidate applications

6) Controls technologies used to implement ESs

7) Controls the politics of ES implementation

8) Plans ahead for technology transfer

9) Provides for the evaluation of ESs development and usage.

Understanding the benefits of ESs is essential for obtaining top management support. Meyer and Curley (1990) have summarized general ES benefits on a Knowledge-Technology grid (see Figure 2.3, page 23).

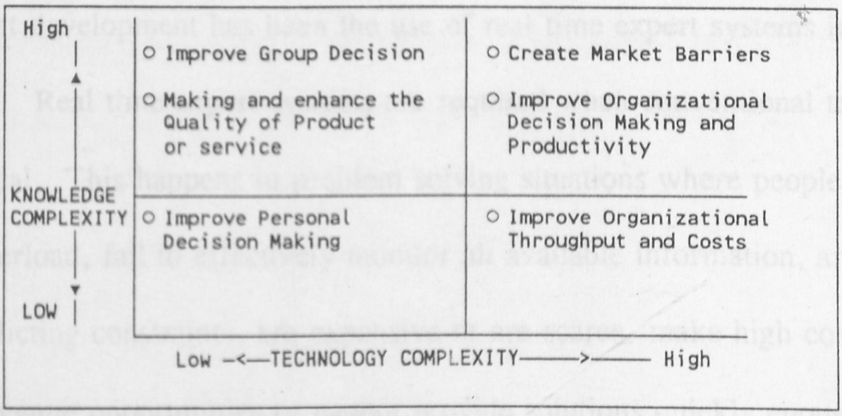

Figure 2.3 The Benefits of ESs

Source : Meyer, M. H. & Curley, K.: "A Framework For Managing ESs Development." Proceedings of ORSA/TIMS Joint Conference, 1990.

2.5 Expert Systems Applications

In Table 1.3 (page 7) a wide range of specific application of ESs was provided.

Barkocy and Blanning (1988) list three areas of industrial application of ESs:

1) Decision Support Systems

2) Information management systems

3) Tools for increasing competitive advantage

Holsapple and Whinston (1989) identify various business areas for potential ES application. These are listed in Table 2.3.

Table 2.3 Potential Applications of ESs in Business

1. Establishing Sales Quotas	10. Offering Job Costing Advice
2. Conducting Trainee Orientation	11. Performance Evaluation
3. Selecting Transport Routes	12. Job Shop Scheduling
4. Providing Investment Counselling	13. Requirements Planning
5. Recommending Acquisition Strategies	14. Facilities Maintenance
6. Analyzing Market Timing Situations	15. Application of Discounting Policies
7. Generating Project Proposals	16. Selection of Forecasting Models
8. Planning Advertising Spot Layout	17. Determining Credit Limits
9. Assessing Job Qualifications	18 Responding to Customer Inquiries

Source :Holsapple, C. W. & Whinston, A. B.: **Business Expert Systems**. New Delhi, Galgatia Publications pvt. Ltd., 1989.

A very recent development has been the use of real time expert systems in industry and business. Real time expert systems are required when conventional techniques are impractical. This happens in problem solving situations where people suffer from cognitive overload, fail to effectively monitor all available information, are unable to resolve conflicting constraints, are expensive or are scarce, make high cost mistakes, miss high revenue opportunities or cannot provide solutions quickly enough (Laffey, 1991).

Application areas for real time ESs include space operations, air traffic control, communication network monitoring and control, factory monitoring and process control, financial market monitors and patient monitoring in hospitals.

ES can aid decision making in the domain of classification expertise e.g. in selecting students to different specializations, in three ways (Edwards & Bader, 1988):

a) Improving the consistency of an admissions tutor's decisions

b) Enabling some aspects of the admissions work to be transferred from admissions tutor to clerical staff

c) Help in the training of both new and existing admissions tutors by making selection criteria more explicit.

O'Keefe et al (1986) argue that ESs are good at classification where this involves deciding between a small number of possible outcomes. With ESs, ten possible outcomes can be considered as a small number because e.g. Medical Diagnosis ESs can have up to approximately one hundred possible outcomes. With discriminant analysis five possible outcomes can be considered to be to many for such model to be adopted.

Holroyd et al (1985) note that a small amount of information has to be obtained to place each applicant in a handful dimensions in ESs. Pollitzer et al (1985) point out that by far the most common use of ESs is in classification systems.

There are several successful ESs which are currently used to admit students in different universities. One of them is the Admissions tutor at Loughborough University of Technology to recruit 30 students every year to their M.B.A. program. This group as a whole is supposed to have a good mix of skills and backgrounds (Finlay and King, 1989). This ES helps to ease reply to 300 telephone and postal inquiries and around 100 applications for the M.B.A. course that are received.

Table 2.4 shows the performance of Admissions Tutor ES used by Aston University, Birmingham to recruit Bachelor of Science students into Managerial and Administrative Studies. This ES is producing results about as accurate as those of the human expert. It assists in reducing the workload of the admissions tutor, who is the human expert. It is worth while to note, at this point that all the ES "*mistakes*" were on the border line, except two where the admissions tutor was wrong. This system is in full operation and it has improved consistency, reduced workload and improved quality of decisions made by human experts (Edwards & Bader, 1988).

Table 2.4 Performance of Admissions Tutor at Aston University

System	Number of cases tested	Agreement with actual decision	Difference in conditions Tutor Wrong	System Wrong	Offer/Reject disagreement
Prototype	50	48 (96%)	1 (2%)	1 (2%)	0
Imitation Tutor	100	92 (92%)	2 (2%)	6 (6%)	0
Admissions Advisor	150	121 (80.7%)	4 (2.7%)	25 (16.7%)	0

Source : Edwards, J. S. & Bader, J. L.: "Expert Systems for University Admissions." *Journal of Operations Research*, Volume 39, Number 1, page 33-40, 1988.

Similarly, Hart (1985) used the Admissions Tutor ES for a course in Higher Education as the expert in evaluation of rule induction using Expert-Ease and a success rate of 93% was achieved.

SECTION THREE

RESEARCH METHODOLOGY

The software prototyping methodology was adopted in this project. This is an iterative process in nature that begins with developing the system prototype, a live working system which may become the actual system (Kioko, 1991). The purpose of the prototype is to test out assumptions about user's requirements and/or a system design architecture. Kioko (1991) lists several advantages of prototyping. These include

- shortens the development cycle
- helps to build "*quick and dirty*" systems in response to user needs
- better received by users because they are actively involved in all stages of the system development
- interviewing skills are not as important as in the conventional systems development.

Designers or programmers can thus build a system in a very short time and easily amend it. Further, the analyst or programmer does not need to know all user needs initially. Chapnick (1990) notes that rapid prototyping and expert system technology may help build systems more quickly, but building incorrect or incomplete systems ten times faster is no gain. The prototyping process is depicted in Figure 3.1.

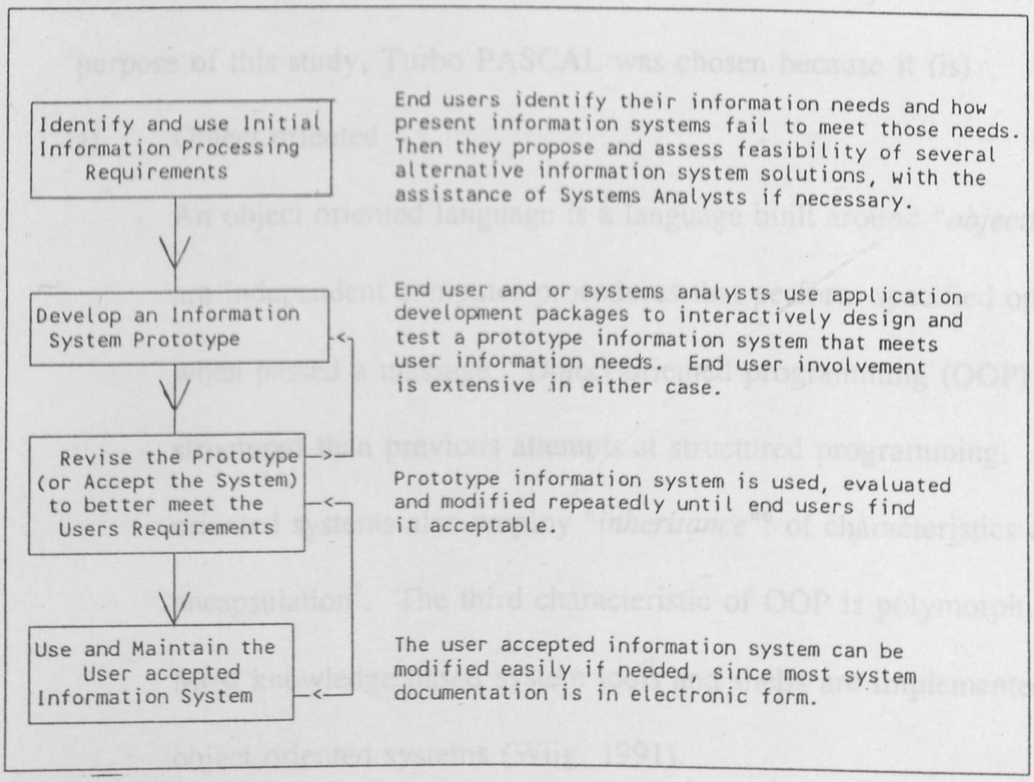

Figure 3.1 Prototyping Process
Source: O'Brean, J. A.: **A MIS: A Managerial End Perspective**. New Delhi, Galgatia Publications (p) Ltd., 1991.

3.1 Development Environment

The development environment consists of software and hardware system components selection. Selection of knowledge representation and elicitation techniques also determine the development environment.

3.1.1 Programming Language

AI programs can be easily implemented using declarative languages such as LISP and PROLOG. These require powerful computers (Chabris, 1990, Naylor, 1990). But in recent years, high level languages like BASIC, FORTRAN, C, PASCAL and C++ have been extensively used. For the purpose of this study, Turbo PASCAL was chosen because it (is)

a) Object oriented

An object oriented language is a language built around "*objects*" which are independent computer procedures that perform specified operations when passed a message. Object oriented programming (OOP) is more structured than previous attempts at structured programming. Object oriented systems also employ "*inheritance*"[6] of characteristics and encapsulation[7]. The third characteristic of OOP is polymorphism.[8]

Most knowledge based system tools and shells are implemented as object oriented systems (Wiig, 1991).

b) Fast

It has both an interpreter and a compiler which can compile 27,000 lines per minute.

c) Easily linked to Assembly language

Some procedures are easily written using assembly language rather than conventional high level programming languages.

---

6 Each descendant inheriting access to all its ancestors code and data.

7 Combining a record with procedures and functions that manipulate it to form a new data type called an object

8 Polymorphism is a Greek word for many shapes. This characteristic gives an action one name that is shared up and down an object hierarchy, with each implementing the action in a way appropriate to itself.

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d) Comes with many in built modules

This helps to shorten the programming time by using those module source codes, e.g. screen routines.

3.1.2 Hardware

A 286 Compaq PC was used to develop this ES. Doukides et al (1990) did a survey of applications of AI techniques and found that about 85% of developers of AI use personal computers and 86% of users also use a PC. This justified the use of a PC.

3.1.3 Knowledge Representation

A good system of representation of knowledge in a particular domain should possess several properties. Some of these are shown in Table 3.1 below.

Table 3.1 Properties of Good Knowledge Representation Technique

Property	Explanation
Representation adequacy	ability to represent all kinds of knowledge that are required in that domain
Inferential adequacy	ability to manipulate available knowledge in order to get new knowledge
Inferential efficiency	ability to incorporate into the knowledge structure additional information
Acquisitional efficiency	ability to acquire new knowledge easily.

Source : Rich, E. K. & Knight, K.: Artificial Intelligence. 2nd Edition, New Delhi, Tata McGraw Hill Edition, 1991.

Unfortunately up to now, there is no single knowledge representation technique which has all the four listed properties. Based on the problem at hand and the programming language selected, the production rule knowledge representation format was adopted for this study.

The inference technique adopted was a goal driven approach (see page 20). This was appropriate because

a) system goals were known

b) there were a large number of outcomes with a single cause

c) whenever problem data is insufficient to predict the outcome, the system will request for more information.

It is generally acknowledged that a purely data driven, bottom up development path is inadequate for a KBS project (Neale, 1990).

3.1.4 Knowledge Elicitation

Knowledge elicitation involves obtaining domain knowledge from the experts. Direct elicitation methods were employed. These included personal interviews with lecturers to obtain information on relevant student entry level characteristics and questionnaires to predict student performance. These characteristics were in specified subjects.

When the initial prototype was developed, it's demonstration was used to elicit knowledge from the experts. In Appendices 1 and 2, the format of data collection instruments are shown.

3.2 Stages of Development

The stages in the development of the prototype ES are:

1) Operational Analysis and System Conceptualization
2) Knowledge Modelling
3) Constructing, Demonstration and Interactive Prototyping
4) System Implementation and Final design
5) Knowledge Maintenance and System Expansion.

3.2.1 Operational Analysis and System Conceptualization

The plan of the prototype development was set, cost/benefit analysis was done and availability of resources required to develop this system were checked.

The Department of Management Science was selected as the application area.

The required resources of hardware and software were available in the Department. The Chairman of the Department considered such a prototype model as very beneficial to the Department.

3.2.2 Knowledge Modelling

The domain of this ES was the academic performance of 8-4-4 Bachelor of Commerce undergraduate students applying for the Management Science option. The experts in this context were the lecturers in the DMS. The expertise that was solicited from them covered two areas :

a) students' entry level factors that are important in determining their performance in MS option.[9]

b) predicting performance[10] for students with specified student entry characteristics.

3.2.3 Prototype Construction

This stage involved writing the necessary Turbo PASCAL code to:

a) provide a software interface component

b) construct the knowledge base using the facts and opinions elicited from the experts

c) construct the inference engine component which would apply the production rules.

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9 This was subject grade performance in specified subjects in first and second years of the Bachelor of Commerce program.

10 For the purpose of this study performance is operationalized in terms of three result categories at the end of the fourth (final) year of study as:

1. First class honours or Upper second class honours degree
2. Lower second class honours or Pass class degree
3. Fail.

The ES was trained with hypothetical examples of student subject performance categories.

3.3.4 System Implementation and Final Design

During this stage the ES prototype will be used to select students into MS option. The students report on campus in July, 1993. Staff designated by DMS was to be trained to use the ES.

3.3.5 Knowledge Maintenance and System Expansion

Because of time constraints, the project did not incorporate the fifth stage.

The fifth stage can be carried out once data is available on actual performance of students selected into MS option. This will be incorporated into the ES, adding additional knowledge and functions to the ES.

The prototype developed was an *expert system shell* for classifying objects into specified categories. The system can thus be easily expanded to cater for any department in the University.

SECTION FOUR

MODEL CONSTRUCTION AND IMPLEMENTATION

4.1 Scope

4.1.1 Systems Review

The aim of the ES system was to provide support to the department in admitting undergraduate students into the Management Science option. The system would have to classify students into specified performance categories in the option. Such a system would enable the Departmental Chairman and staff to provide counselling to the student applicants.

The input to the system were identified as student inquiries regarding the Management Science option or applicants for the option. The output would be the advice given to the students on their likely performance in the final year of the Management Science Option course.

The Departmental lecturers were considered as relevant experts. To be of practical use to the Department, the prototype had to ready before the end of July, 1993, when students would be making their option selections.

A simplified diagram of the option selection system is shown in Figure 4.1. The selection system is the prototype ES. After the ES has categorized the applicants, the lists are forwarded to the Department Chairman for a final approval.

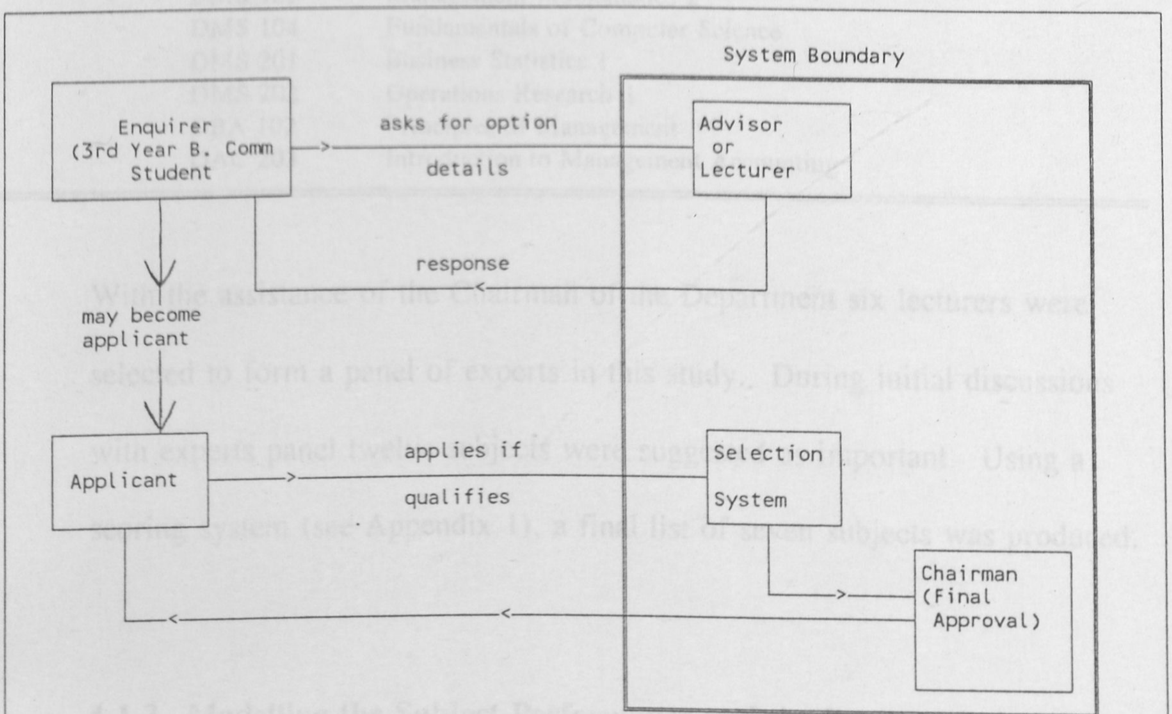

Figure 4.1 Simplified Diagram of Option Selection System

4.1.2 Structuring the Knowledge

The knowledge area of the lecturers investigated was what they considered as key subjects in the first and second year of the Bachelor of Commerce program to determine good performance in the Management Science Option. The results of these investigation are shown in Table 4.1. Therefore, only examination grades in these courses were treated as variable input to the system.

Table 4.1 Key First and Second Year Subjects for Management Science Option

Code	Title
DMS 101	Management Mathematics 1
DMS 102	Management Mathematics 2
DMS 104	Fundamentals of Computer Science
DMS 201	Business Statistics 1
DMS 202	Operations Research 1
DBA 102	Principles of Management
DAC 203	Introduction to Management Accounting

With the assistance of the Chairman of the Department six lecturers were selected to form a panel of experts in this study. During initial discussions with experts panel twelve subjects were suggested as important. Using a scoring system (see Appendix 1), a final list of seven subjects was produced.

4.1.3 Modelling the Subject Performance and the Decision Process

The subject performance was input as grades. The grade ratings used were those of the University of Nairobi (see Table 4.2). Initially, students' performance categories in the system were related to the final degree qualifications in the Faculty i.e.

a) Pass with First Class Honours Degree

b) Pass with Upper Second Class Honours Degree

c) Pass with Lower Second Honours Degree

d) Ordinary Pass Degree

There is also a possibility that a student fails in the final year.

After discussions with the panel of experts, it was decided to reduce total number of performance categories on the basis of practical relevance for decision making purposes by the students. These were identified as

a) Pass with First/Upper Second Class Honours Degree

b) Pass with Lower Second/Ordinary Pass

c) Fail/Supplementary Exams.

Table 4.2 Subject Grading System

Marks	Grade
>= 70	A
60 - < 70	B
50 - < 60	C
40 - < 50	D
< 40	E

The performance rating was based on student grades in the identified subjects. The model consisted of seven variables (subject courses), three outcomes (performance ratings) and twenty one rules.

4.2 Prototype Construction and Revisions

The knowledge base and inference engine were coded in Turbo PASCAL. A compiled version of the system was tested on potential users and their feedback was incorporated to construct revised versions of the prototype.

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The ES was fully menu driven with the extensive use made of bar menus, pull down menus and pop up menus. An on line error control and help facility was also incorporated. Some 200 hypothetical cases of student performance grades were input into the system in order to train it. The main opening menu of the ES is shown in the figure 4.2 below.

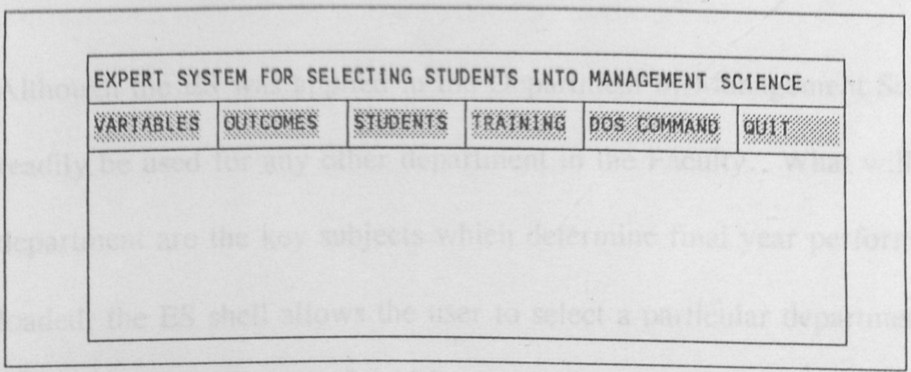

Figure 4.2 The main menu of the ES

The first three submenus on the bar each have four options - add, edit, delete and view. The training option allows the user to train the currently loaded ES further. The DOS command option allows the user to execute standard DOS command and then return to the ES.

Information of student performance in the Faculty is currently being kept on a system designed using a dBASE III+ package. Under the student option of the ES main menu, a facility exists to directly import the relevant file containing data on student name, registration number and performance in individual subjects in terms of marks. The marks are automatically converted to grades by the facility and the user may output the three lists of the performance category predicted by the ES:

a) Pass with First or Upper Second Honours Class

b) Pass with Lower Second or Ordinary Pass

c) Fail or Supplementary Examination(s)

Within each of the performance categories listing, students are arranged in descending order of performance.

Although the ES was applied in the Department of Management Science, it would readily be used for any other department in the Faculty. What will differ in each department are the key subjects which determine final year performance. When first loaded, the ES shell allows the user to select a particular department for which to use the ES.

A diskette containing an executable file of the ES prototype is included on the inside of the rear cover of this project report. To run the ES from e.g. drive A of a PC type "ES" and press "Enter" at the A:prompt.

SECTION FIVE

DISCUSSION AND CONCLUSION

The prototype ES will be used on the current third year 8-4-4 students. A data base file containing students' name, registration number and marks in the relevant subjects in their first and second academic years will be prepared by the Department. The information on this file will be imported to the ES and the ES will classify the students into the three predicted performance categories. These lists will be used as the basis for selecting the third year students into the Management Science Option when they begin their third year of study in July 1993.

Various experiences were gained in developing this ES prototype. As the literature suggests, the prototyping methodology proved to be useful in obtaining cooperation and acceptance from the eventual users of the ES. Before revisions of the ES were made, further system analysis was often found to be necessary in order to incorporate feedback from the users.

Knowledge elicitation and modelling proved a challenging task during the ES development. In particular, the knowledge engineering component consumed a relatively large amount of time and required various revisions. There was a tangible experience of the difficulty in capturing expertise from the lecturers. This is in no way due to any recalcitrance on the part of the lecturers but rather their inability to formally articulate their decision processes.

Contrary to the researcher's expectations, factors other than performance in selected first and second year subjects were not considered relevant by experts. One would have thought that e.g. pre-university academic performance would also be relevant.

The literature points out that ESs are ideally suited for classification type problems. In the prototype ES developed, relatively simple rules allowed the system to predict students performance after a brief period of training.

This study is not free from limitations. An ES represents expertise of selected people, in this case the departmental lecturers. It is therefore subjective. Given the lack of historical data for the final year performance of the 8-4-4 system, the issue of validating expert judgement was not possible. Thus, this ES will be enhanced when information on the pioneering 8-4-4 final year class is available and incorporated.

Another underlying assumption of the ES is that the grades in the specified subjects truly reflect ability to perform well in the Management Science Option. Even if other factors were not necessary for this purpose, one would still have to assume that the examined subjects were objectively marked and graded.

The prototype system can handle up to six hundred students at any one time. This fact should be kept in mind if there is to be a large expansion on the current intake of four hundred students in the Faculty of Commerce. The predicted performance categories may be further refined in future to allow for example a distinction between a first class honours degree and upper second honours degree. Also it should be noted that choice of programming language, knowledge representation method and inferencing technique selected affect performance of the ES.

Conclusion

The capture of expertise in the specified domain poses a primary challenge for ES development. The ES must be able to cope with the dynamic nature of both the reasoning and the knowledge base level of the human experts.

An ES development approach should also recognize that an expert does not have formal awareness of his cognitive process in the specified domain. Development efforts and the tools used should facilitate the elicitation of the expertise.

In the final analysis, the positive contribution of an ES may be measured in terms of increased efficiency and effectiveness of decision making skills in the domain. If the users of this ES in the Department of Management Science are able to improve the quality of their decisions regarding students selection for the Management Science Option then the ES may be regarded as having been successful.

APPENDIX A

INTERVIEW GUIDELINE

Please rank in descending order the courses in which you consider a good performance crucial for a student wishing to specialize in the Management Science Option.

Year I		Year II	
Rank	Course Title	Rank	Course Title
1	....	1	....
2	....	2	....
3	....	3	....
4	....	4	....
5	....	5	....

Other comments.

....

....

....

....

APPENDIX B

QUESTIONNARE TO OBTAIN INFORMATION ON PREDICTED PERFORMANCE

STUDENT NO	C1	C2	C3	C4	C5	C6	C7	PREDICTED PERFORMANCE
1.	A	D	D	C	B	C	D	....
2.	C	B	C	D	B	D	C	....

(COURSES: C1–C7)

.....

Course Titles

C1 : DMS 101 Management Mathematics 1
C2 : DMS 102 Management Mathematics 2
C3 : DMS 104 Fundamentals of Computer Science
C4 : DMS 201 Business Statistics 1
C5 : DMS 202 Operations Research 1
C6 : DBA 102 Principles of Management
C7 : DAC 203 Introduction to Management Accounting

Predicted Performance

1 : First/Upper Second Honours Degree
2 : Lower second/Pass Class Degree
3 : Fail/Supplementary.

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