The Development of a Model for Organising Educational Resources on an Intranet

by

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Declaration

I, **Yvonne Monica Sing Min**, hereby declare that:

- The work in this dissertation is my own work.
- All sources used, or referred to, have been documented and recognised.
- This dissertation has not previously been submitted in full or partial fulfilment of the requirements for an equivalent or higher qualification at any other recognised educational institution.

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Abstract

The twenty-first century has found education at the crossroads of change. There are burgeoning challenges facing the modern educator. To rise to the importuning, educators find themselves turning to Information Technology for the answers. The technologies utilised in attempts to overcome the challenges often include the Internet and electronic educational resources.

Although the Internet is not unduly called the Information Highway, it is also fraught with misleading and incorrect information. Educators' arduous searches result in few good and useable resources. Thus, to store, organise and efficiently retrieve the discovered resources is a matter of time-saving.

The aim of the study was to develop a method to organise and retrieve educational resources in an efficient and personalised manner. In order to do this, an exploration into pedagogy and educational paradigms was undertaken. The current educational paradigm, constructivism, proposes that each learner is an individual with unique learning and personal needs.

To develop a new model, the current models need to be understood. The current solutions for the organising of educational resources are realised as several software packages, also called e-learning packages. A list of criteria that describes the essential requirements for organising educational resources was established. These criteria were based upon the pedagogical principles prescribed by educators and the practical technological frameworks necessary to fulfil the needs of the teaching/learning situation. These criteria were utilised to critique and explore the available solutions.

It was found that although the available e-learning packages fulfil a need within their genre, it does not meet with the core requirements of constructivism. The resource base model seeks to address these needs by focussing on the educational aspects of

resource delivery over an Intranet. For the purposes of storing, organising and delivering the resources, a database had to be established. This database had to have numerous qualities, including the ability to search and retrieve resources with great efficiency. Retrieving data in an efficient manner is the forte of the star schema, while the storing and organising of data is the strength of a normalised schema. It is not standard practice to utilise both types of schemas within the same database. A star schema is usually reserved for data warehouses because of its data retrieval abilities. It is customary to utilise a normalised schema for operational databases. The resource base model, however, needs both the storage facilities of an operational database and the efficient query facilities of a data warehouse. The resource base model, therefore, melds both schemas into one database with interlinking tables. This database forms the foundation (or the back-end) of the resource base. The resource base model utilises web browsers as its user interface (or front-end). The results of the study on the pedagogy, the current e-learning solutions and the resource base were written up within this dissertation.

The contribution that this dissertation makes is the development of a technique to efficiently store, organise and retrieve educational resources in such a manner that both the requirements of constructivism and outcomes-based education are fulfilled. To this end, a list of technological and pedagogical criteria on which to critique a resource delivery technique has been developed. This dissertation also elaborates on the schema designs chosen for the resource base, namely the normalised schema and the star schema. From this schema, a prototype has been developed. The prototype's function was two-fold. The first function is to determine the feasibility of the technique. Secondly, to determine the success of the technique in fulfilling the needs expressed in the list of criteria.

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Chapter 1

Introduction

1.1 AN INCEPTION

Education within today's society has evolved over the ages. The earliest education is often considered the parent-child handing down of trades and social graces from the beginning of time. Today education has been formalised to the educator-learner situation within classroom settings with the help of text books, multimedia and computerised educational aid.

This modern situation is not, however, without its own set of triumphs and tribulations. These triumphs and tribulations may be attributed to the changes in society and technology. While the triumphs are beneficial, the challenges facing today's educators are numerous and occasionally difficult to solve. These challenges include increased learner numbers, financial restraints and diverse social demands. It is thus not surprising that educators turn to contemporary technology to solve these prevailing challenges. One of these contemporary technologies is Information Technology.

It is within this new computerised world that educators have found electronic educational resources. These resources may be utilised within the educational settings in order to enhance teaching and learning. However, finding these educational resources and utilising them within the classroom presents its own set of challenges. One of the challenges includes the storage and efficient retrieval of the resources.

This project will investigate a variety of challenges within modern education and investigate the possibility of utilising educational resources to help ease some of these challenges. In addition, a model for the storage and retrieval of educational resources will be developed as a suggested amelioration to some of the educational challenges.

A more detailed outline of the dissertation is presented at the end of this chapter.

1.2 EDUCATING TODAY

Education may be considered an important part of society as it enables learners to become valuable members of society. Society is a dynamic, progressive factor, i.e. social norms change periodically. In the modern era, society, and especially business, has changed to form what is known as the "Information Age" or the "Knowledge Age". Since society is a dynamic factor, it implies that education must also be progressive. The change in society suggests that education should be preparing its learners to become "Knowledge workers". This suggests that education itself should change (Casas, Isaac, Vergara, Soto & Vasquez, 1998; Trilling & Hood, 1999).

Before one can change education, one should understand the current educational norms. The current norms are encapsulated in what can be termed as Traditional Education or traditional teaching methods. Traditional teaching methods involve an educator lecturing learners in a fixed venue at a fixed time (period). This method tends toward the loss of individuality on the part of the learner. The causes of this malady include the increase in learner numbers, the growing need for education, and the increase in demand for more diverse and new topics. A number of educators and researchers have suggested a plethora of solutions to these challenges. These solutions often have a common denominator, namely, computer technology (Göschka & Riedling, 1998; Hui, 1998).

Computer Technology seems to be a popular solution due to its potential to be a valuable teaching tool that can support both educator and learner (Campbell, Yates & McGee, 1998). Computer Technology may be utilised within the classroom genre in order to introduce flexibility and enhance individuality (Demuth, Rieke & Sommer, 1998;

Göschka & Riedling, 1998). Flexibility and individuality may be introduced by giving the learners their educational resources on a customised level. This customisation could be based on a variety of aspects. These aspects may include learning styles, language abilities and misconceptions. The aspect of misconceptions could be further divided into two attributes: prior learning and gaps in knowledge (Kennet, Tara Stedwill, Berril & Young, 1996). The topic of misconceptions is further discussed in Chapter 2. The factors of flexibility and individuality help in making computer technology an attractive solution to the large classes' problem.

1.1.1 Internet Resources

In particular, the technologies of the Internet, World Wide Web (WWW) and Intranets, seem to be the technologies that attract numerous educators (Astleitner & Sams, 1998; Baaberg, 1998). These technologies are being used to replace or supplement traditional teaching methods. In the case of distance education, the Internet and Intranets are becoming the choice replacement for traditional land postage (snail mail). This is true especially in America and Europe (Astleitner & Sams, 1998; Baaberg, 1998). When computer technology is used to supplement traditional teaching methods, the Internet is becoming one of the favoured media.

The Internet is accepted for its reputation as a rich source for information and instructional materials. The Internet also has the potential to aid educators in the exchange of ideas, materials and solutions. However, the use of the Internet and especially the WWW as a source of information and exchange is a veritable Pandora's Box. There are plenty of sites on the Internet on a wide variety of topics that do not contain suitable materials for education. There are also a number of educational sites that contain blatant errors and mistruths. However, there are also a large number of sites that are educationally sound and contain sound and accurate information. Searching for these sites can become very time-consuming. Once the appropriate sites have been found, the pages either have to be stored or a link to the pages have to be stored, otherwise one must go through the entire search process the next time that the site is needed (Astleitner & Sams, 1998; Demuth, Rieke & Sommer, 1998; Small, Sutton, Miwa, Urfels & Eisenberg, 1998).

1.1.2 Other Resources

Educators' choices are not and should not be limited to web pages. Other media are also available for use in the classroom. These media include computer simulations, animations, presentation slides (e.g. PowerPoint or Presentations) and text files. The suppliers of the above-mentioned types of resources are many and varied, they include: publishers, colleagues and even learners, to name but a few. Once again, finding or creating these resources is time-consuming. To reduce the burden on the educator, it is possible for the educator to ask the learners to search for the resources. While this is a good exercise for the learners, it is not a task that should be given to learners on a continued basis. This is because the solution has a multitude of drawbacks. The first drawback is that learners can easily be sidetracked from their original search. Another drawback is the amount of guidance educators must give their learners in order for them to locate the appropriate resources. The biggest drawback is the amount of pedagogical and technical criteria that must be applied to determine the suitability of the resources (Casas *et al.*, 1998; Deal, 1999; Small *et al.*, 1998).

This implies that many educators not only look for suitable resources but also create their own resources or edit resources to suit their unique situation. This creates a new problem. Once an educator has gone to the effort of finding, creating or editing a resource, he or she would like to be able to find that resource again in the most efficient and expedient manner. This implies that an organisation of the resources is necessary to aid educators in relocating their previously discovered, modified or created resources (Montgomery, 1998; Small *et al.,* 1998).

1.1.3 Organising Resources

The correct organisation of resources allows them to be reused. There are many ways in which a resource may be reused. The first is to allow different learners to use the resources for a variety of courses. Educators might also allow fellow educators to use their resources. The second is to be able to use the same resource over a period of time for differing reasons. There are numerous other motivations for the reuse of resources. However, it remains that the resources need to be organised in an effective and efficient fashion (Gordillo & Díaz, 1998; Montgomery, 1998).

Effective organisation of resources implies that time and money are saved. This is because effective resource organisation reduces the maintenance on resources, the storage of the resources and the dissemination of the resources to fellow educators and to learner (Sandelands & Wills, 1996).

1.1.4 Individuality in Resource Delivery

Each of these systems is valuable and assists educators in delivering quality instruction to their learners. However, none of the systems cater for the learners as individuals, with unique learning styles and conceptual problems. The systems also do not allow learners to access educational resources other than what was prescribed by their educator. These educational resources include electronic textbooks, supplementary resources that could aid the learners in their studies, assignments and exercises. In addition, none of the above-mentioned systems allow the learners to organise their own learning materials.

Thus, what is missing is a system that can allow educators to suggest or recommend the appropriate resources for their courses. This system should also allow educators to make remedial resources available to the learners. The learners and educators should be able to access the available resources in a number of ways: by keywords, by topic, by conceptual problem, by misconception or by course objectives. These activities should take place within a safe, secure environment. There is a variety of techniques that could possibly be utilised to achieve these goals: for example, document management, data warehousing, data mining and multi-dimensional databases. Each of these techniques has its own unique advantages and disadvantages.

1.3 PROBLEM STATEMENT

There is a need for a technique which will allow educators to organise their educational resources. This technique, further, requires a facility which allows for quick and efficient search and retrieval of these resources. These searches should allow educators and learners to find resources based on keywords, topics, outcomes and misconceptions. Learners should be able to receive their educational resources on an individual basis where the criteria for customisation are based on the learners' unique misconceptions.

There are several "ready-made" solutions available from a variety of vendors. The problems with the pre-packaged solutions are a lack of flexibility in allowing both educator and learner to customise and/or individualise learning resource delivery; a lack of flexibility in the types of learning resources that can be stored and a lack of flexibility in enabling accommodating searches to allow both educator and learner to find learning resources via keywords, topics, learning objectives and/or misconceptions.

1.4 OBJECTIVES

The objective of this study will be to develop a suitable and efficient technique for storing a variety of electronic teaching materials (hyperlinked documents, electronic tutorials, word processing documents, amongst others) in an application for the use of both educator and learner within the Intranet environment.

This technique should also concentrate on the methods of access available to both educator and learner. A number of access methods should be made possible. These access methods include the finding of resources by keywords, by outcomes, by courses and by misconceptions.

There should also be a strong emphasis on individualisation within the sphere of the learner profiles. The individualisation should allow learners to find and link resources to their profiles for personal study. The individualisation should also allow educators to suggest suitable resources to struggling learners for remedial purposes based on individual misconceptions.

1.5 METHODOLOGY

A literature study into the educational background surrounding the didactic aspects of this dissertation was done. This includes the challenges facing education, the various educational paradigms and the solutions which have been offered by a number of researchers. The literature study also investigates the models of Internet/Intranet utilisation, i.e. how tertiary educational institutions put courses onto the Internet.

This study investigates the various issues and strategies for the effective storage and retrieval of educational materials in an Intranet/Internet environment by means of a literature study. Several of the issues surrounding the storage and retrieval of electronic educational materials are also investigated as a part of the literature study. These issues include access rights, security/privacy concerns, copyright matters and access to equipment.

A set of criteria or requirements for the storage technique is developed. This set of requirements is utilised in the reporting of the existing strategies. The requirements are also utilised in the evaluation of the technique developed. This investigation is conducted via a literature study.

This dissertation utilises the identified set of requirements to report on the existing strategies available for the organising of educational resources in the Internet environment and explore their practicality within the South African context. Techniques such as data warehousing and data mining is examined and evaluated for their usefulness. This investigation is conducted via a literature study.

The concept of individualisation is explored as a literature study. The argumentation includes the motivation behind individualising learner profiles or portfolios and the techniques available to implement individualisation strategies.

A suitable method for the implementation of an Intranet educational resource is established by developing criteria and guidelines for implementation and maintenance of the resource database. Furthermore, a model for the resource database is described.

A prototype of the Intranet resource database is developed to determine the viability and practicality of the above-mentioned model. The prototype does not strive to model the technique in its entirety. It does, however, strive to model the technique sufficiently to determine the technique's abilities. Both the prototype and the model are evaluated utilising the set of identified requirements.

The conducted study is being reported as a dissertation and several academic papers.

1.6 A PREVIEW

Education has a pivotal role to play in society. It was Abraham Lincoln who said "The philosophy of the schoolroom in one generation will be the philosophy of the government in the next". This sentiment is echoed by Nelson Mandela who said "Education is the most powerful weapon which you can use to change the world."

The world today is living in the "digital age" where knowledge is an important asset. It is therefore the responsibility of education to ensure that learners are prepared to survive in the "Knowledge era". This, in itself, presents some unique challenges to both the learner and the educator. In the "digital age", people are turning towards a "digital solution". This digital solution has a number of facets, one of which is the Internet. Teaching and learning with the support of the Internet pose their own specific advantages and disadvantages. Educational theory and expectations have increased the stakes for the digital solution by advocating the individualisation of education.

The individualisation of education implies that learners should be treated and taught as unique personalities. The educational resources they receive should reflect this paradigm. The implementations of this paradigm are numerous and divided into two major areas of study: education and computer science.

The educational issues are considered in Chapters 2 to 5. Chapter 2 investigates the challenges of education. Chapter 3 briefly describes the current models being utilised by institutions to organise their educational resources and discusses a number of possible solutions to the challenges posed in Chapter 2.

Chapter 4 specifies the criteria necessary for the "perfect" solution. Chapter 5 looks at a few solutions currently being offered by commercial concerns.

The technical concerns for the implementation of a suitable technique for the storing and organising of educational resources are considered from Chapter 6. Chapter 6 describes what such a technique should be able to facilitate, the standards available and introduces a possible solution model. Chapters 7 and 8 deal with the components of the model as well as outline the techniques utilised within the model.

Chapter 9 describes the prototype produced and includes a "walkthrough" of the prototype.

Chapter 10 outlines the experiences and further considerations which became evident from the development of the prototype and the structure of the model developed in Chapters 7 and 8.

This brief outline is the roadmap to the journey that awaits…

Chapter 2

Challenges for Education

2.1 TRADITIONAL EDUCATION

2.1.1 Defining Traditional Education

The starting point of any journey is the destination of a previous journey. The paradigm of "traditional" education in the modern world is the destination of a previous era. Traditional education often has the connotations of the typical "David Copperfield" experience, which Charles Dickens immortalised. It is the grey-haired teacher (or educator) instilling knowledge into a small group of young, impressionable minds in a dreary, dusty and dark classroom. The mental image usually conjures up negative feelings of boredom, fear and frustration. Most of the modern world's education, however, takes place within the concepts and confines of traditional education. It stands to reason that a method of teaching that has stood the test of time for so long still has some of the positive aspects, which have made it the standard for teaching for almost two centuries. Thus, aside from the negative overtones of dusty books and strict disciplinarians, what exactly does traditional education involve?

Traditional education, typically, means that an educator teaches learners within the confines of a fixed venue (the classroom) for a limited time (the lecture period). The ideal situation within this paradigm is where there are few learners under the guidance of one educator. This situation will allow the educator to interact with each learner on a personal level. The implications of the interaction are that the educator contextualises the knowledge within the learner's framework and the educator and the learner are both active participants in the learner's learning experience (Hui, 1998). Even though both learner and educator participate in the learning experience, it is the educator who plays the greatest role. The educator is the primary focus of the classroom. The educator is the one who decides when, where and how a lesson should be conducted. It is the educator whose motivation, dedication, personal commitment, skill and experience determine the direction and motivation of the learners. The quality of the transfer of knowledge depends largely on the quality of the educator (Bastiaens & Martens, 2000). The transfer of knowledge takes place over a number of media: written, graphical, verbal and expressive. The last media include facial expressions and body language (Hui, 1998). Quality educator-learner interaction helps to develop higher order thinking, such as the abilities to analyse and the development of critical thinking skills (Gibbs, Lucas & Simonite, 1996). Thus, the capacity of traditional teaching to convey ideas or thoughts should not be discounted.

2.1.2 The Learning Theory Behind Traditional Education

The name for the traditional way of teaching is often called objectivism. The main trait of objectivism is that the educator is in control of the classroom. The other trait is that the learners are seen as the recipients of the educator's knowledge (Yaverbaum & Liebowitz, 1998). The theory of objectivism has its roots in the philosophy of behaviourism (Tenenbaum, Naidu, Jegede & Austin, 2001).

Behaviourism has a number of facets or types. All these types, however, have one common thread. They all believe that it does not matter what the inner considerations are, as long as the result is the desired result. For example, a behaviourist educator is not concerned about the learning styles or the metacognition of the learners, but in the ultimate product (the examination result). The advantage of the behavourist approach in the classroom is that the ultimate products are simple to assess and analysing success is an uncomplicated process (Byrne, 1994; Teslow, Carlson & Miller, 1994). Another common tenet of behaviourism is that behaviour is only influenced by circumstances and external pressures. These external pressures might be individuals trying to shape the behaviour of others by issuing a series of rewards and punishments or even personal goals and ambitions.

This philosophy has influenced the manner in which educators regard learners. This, in turn, has further influences on teaching styles and authority and control in the classroom. The teaching style is based on the belief that the educator must serve as the source of knowledge and information. Thus, the educator is the primary focus of the traditional classroom. The other focus of the behaviourist classroom is knowledge. Behaviourism divides knowledge into three main categories: practical, theoretical and self-regulated. Self-regulated knowledge may be considered a synonym for metacognition or learning to learn. Under the behavourist culture, theoretical, practical and self-regulated knowledge are separate and independent entities. Theory takes place in the classroom and the practical may take place after the theory under a different set of circumstances. The learner is encouraged to attend special classes that offer components that include study skills and note-taking proficiency (Tynjälä, 1999).

Behaviourism colours not only the perception of educators and learners, but has a profound influence on assessment. In behaviourism the assessment emphasis is on examinations and tests that require learners to memorise facts and formulae. The tests and examinations are separated by content and time. Each test covers a distinct piece of curricula. This type of assessment suits some learners, while it puts others at a disadvantage (Tynjälä, 1999).

2.1.3 Traditional Education and Today's Educational Needs

The advantages of traditional education are becoming swamped under the weight of the demands of the new millennia. These modern demands stem from the paradigms of the modern world where an abundance of merchandise is mass-produced. Unfortunately, industry and politics apply the same principles to education. Educational institutions in many countries are being forced to work with less money (from sponsorships and government grants) and expected to "mass-educate" learners in greater numbers. A great number of countries are also facing an increasing educator shortage (Bastiaens & Martens, 2000; Kennet *et al.*, 1996; Kirkwood, 1996).

"Mass-education" has a number of advantages, though. The biggest advantage is that it costs considerably less in terms of finances, work force and commitment (i.e. the responsibility for learning is shifted from the institution and onto the learners). The other, more surprising advantage is that learners (especially those at the tertiary education level) do not necessarily do worse under these circumstances. In fact, a study done in 1994 implied that learners at tertiary level do marginally better in larger classes (Gibbs *et al.*, 1996).

However, this same study also states that while learners' performances in multiple-choice questions did not waiver, their performance in essay questions declined dramatically. It was also found that learners who studied under the large-class conditions did not develop higher-order thinking abilities, such as application and synthesis (Gibbs *et al.*, 1996).

2.2 CHALLENGES FACING EDUCATION TODAY

The ability to apply and synthesise knowledge is not the only problem facing learners and educators in the arena of modern education. There is a plethora of other obstacles that need to be overcome, such as lack of resources, reduction in class interaction and diversity issues. The obstacles tend to have an influence on each other and are thus related by varying degrees. Each of these obstacles will be visited in turn.

2.2.1 Financial Complications

The financial status of an institution has many repercussions on the abilities of the institution to deliver essential services. A lack of funds could be reflected in the scarcity of resources. Library budgets are cut and/or more stringent rules are applied to facilities such as the photocopying services.

Many educational institutions are reliant on government funding. Some governments are granting less money while demanding that services be amplified by increasing the number of learners and by delivering “first-class education”. Unfortunately, ideal traditional teaching is educator-intensive. This, in turn, means that an educator can no longer teach a maximum of thirty learners, but now has to consider teaching maximums of perhaps sixty or even six hundred learners at a time (Kennet *et al.*, 1996; Kirkwood, 1996).

2.2.2 Learner Drop-outs & Failure Rates

With so many learners in one class, it makes it very easy for a learner to “disappear” or become invisible to an educator. This is no fault of the educators, since it is difficult to distinguish particular learners in a sea of faces. The interaction between the educator and the learner is lost in a large class. The larger the class, the more difficult it becomes to give each learner individual attention. It becomes more challenging for an educator to hold the learners’ interest. This loss of interactivity and individuality creates an unseen chasm between the learners and the educator (Bastiaens & Martens, 2000).

Not only do the educators become distanced from the learners, but the learners also become distanced from each other. Isolation is the symptom of the distancing problem. Isolation might be cited as one of the largest reasons for learner dropouts. Thus, the dropout rate for large classes can be exponentially greater than for those in smaller classes (Gibbs *et al.*, 1996; Pérez *et al.*, 1998; Arnaud, 2000).

Isolation can also lead to discouragement, which is yet another reason cited by learners for their poor performance and ultimate decision to terminate their studies. The larger the class, the easier it becomes for individual learners to miss vital concepts taught in the classroom due to lack of attendance. This, in turn, can lead to poor examination performance (Gibbs *et al.*, 1996).

2.2.3 Human Resources

In several parts of the world, there is a dire lack of educators in all sectors, from the pre-primary to the tertiary level. The reasons for this deficit in educators vary from country to country. One common factor, however, is the weight of the responsibility on educators. These responsibilities are varied and profuse and range from lesson objectives to the personal well-being and development of learners. It is often these responsibilities that discourage a person from pursuing education as a career path (Bastiaens & Martens, 2000).

What defines a talented educator is motivation and quality. Learners view these talented educators as being able to encourage learners and being able to discuss a variety of topics with learners. Learners also perceive good educators as being sincere and skilled. An accomplished educator can maximise the benefits of a traditional classroom. Without an experienced, expert educator, the advantages of the traditional classroom often disappear (Tynjälä, 1999, Bastiaens & Martens, 2000).

2.2.4 Industry Demands

One of the imminent challenges facing educational institutions is the "marketability" of their courses. The industries that will eventually employ graduated learners exert increasing pressure on educational institutions to produce quality knowledge workers (Åkerlind & Trevitt, 1999; Teslow, Carlson & Miller, 1994).

Currently, there are proponents in industry that complain that graduates know facts but do not have the skills essential for the workplace. These proponents are requesting educational institutions to teach learners how to interact and adapt in an unstable economic climate. Industries recommend that learners or graduates should be flexible and competent within their own field of study. Furthermore, graduates are expected to perform a vast variety of tasks in ever-growing, supplementary fields of expertise. (Göschka & Riedling, 1998; Slay, 2000; Tergan, Harms, Lechner & Wederkind, 1998; Bastiaens & Martens, 2000).

An interesting complication of the rate at which knowledge and information is growing in this century is the need for continued education (also called life long learning) (Dowling, 2000; Tergan *et al.*, 1998). Businesses cannot afford to allow their employees to work with out-dated skills, but also cannot afford to permit these employees to study fulltime at an accredited educational institution. In this light, distance learning is becoming more popular, as is part-time education, especially amongst more mature learners (Braun, Borcea & Schill, 2000). For educational institutions, this growing trend presents a dynamic new market and the competition for tertiary-level learners is not only strong, but also international (Göschka & Riedling, 1998; Casas *et al.*, 1998).

2.2.5 Diversity Differences

Having an international market is a feather in any institution's cap; but this brings complications of its own. When dealing with an international audience, one has to remember that there will be a great variety of differences such as language, culture and educational backgrounds, to name but a few (Braun *et al.*, 2000; Hawkridge, 1996). Even without an international audience, there is diversity within each classroom. Any educator can testify to an incredible variety of personalities in each learner group. This variety can be attributed to a number of factors, including personality traits, culture, background and gender.

Background and Culture

One of the most obvious differences, but also one of the most subtle, must be culture. This is deeply ingrained in the background of each individual. It is said that learners from different cultures learn in dissimilar ways because of contrasting worldviews

(Saha, 1998). Previous memories and experiences influence the manner in which learners associate with, and relate to, objects, events and ideas. For example, Japanese learners will react differently to a lesson about the Second World War than their English counterparts, especially if the educator is a patriotic American (Marsden, 1996; Saha, 1998; Grimus, 2000).

The ability to relate to concepts, events and objects within a lesson has an impact on the learner's capacity to progress. The manner in which an educator relates a concept over to learners might aid the development of misconceptions instead of correcting the misconceptions (Kember, Ng, Tse, Wong & Pomfret, 1996). The issue of learners' cultures and backgrounds is complex and has far-reaching consequences. Some of these consequences include the learners' attitudes towards learning as well as their attitudes towards fellow learners who might be perceived as different to themselves. Furthermore, studies have shown that culture may also suggest an individual's preferred learning style (Slay, 2000).

Learning Styles and Intelligence

According to psychology studies, there are numerous ways in which to categorise learning styles (O'Connor, 2000). The most basic of these consists of four main types of learning styles: audio, visual, tactile and a combination of audio and visual. Audio learners are efficient at translating what they hear into knowledge, while visual learners discover more from the graphical world, such as pictures or graphs. Tactile learners have to feel objects to better understand them. The fourth category of learners represents about 25% of the population. These are learners who, in varying degrees, can concentrate on both the audio and visual worlds around them (Arnaud, 2000).

Studies show that learners tend to gravitate towards methods or teaching styles that suit the thinking style with which they are more comfortable (Passerini & Granger, 2001). Unfortunately, the classroom does not necessarily cater for all these types of learners. In fact, the traditional classroom situation tends to be biased towards the audio learner

(Arnaud, 2000). This implies that about 40% of learners (the visual and tactile learners) are at a severe disadvantage in the classroom (O'Connor, 2000).

Another categorisation of learning styles includes the complex relationships between an individual's environmental preferences, emotional preferences, sociological preferences and psychological preferences (O'Connor, 2000).

Intelligence also plays a part in learning. There are two basic intelligence theories: the multiple intelligence theory and the emotional intelligence theory. The multiple intelligence theory suggests that learners are adept in one or a combination of the following fields: spatial, kinaesthetic, logical-mathematical, musical, linguistic, interpersonal and intrapersonal. This particular theory of intelligence, even though it has more to do with the selection of vocation than the presentation of a course, does impact on the choice of learning style (Anderson, 1997). The emotional intelligence theory, on the other hand, suggests that learning takes place in three domains: cognitive, affective and psychomotor. Each learner processes knowledge more effectively in one of the three domains (Passerini & Granger, 2001).

Cognitive Style

Each person has a cognitive style, whether this person is studying or not. A cognitive style is the process through which an individual perceives the world, converts information and remembers that information. There are four dimensions to the cognitive style: extroversion/introversion, sensing/intuition, thinking/feeling and judging/perceiving (Ramsay, Hanlon & Smith, 2000).

The extrovert is a person who enjoys socialising and it is suggested that the extrovert might enjoy group work more than an introvert. An introvert, it is hypothesised, finds social interaction strenuous and prefers the inner world of ideas.

The sensing/intuition dimension refers to the manner in which people absorb ideas. The sensate (or sensing type of person) prefers to use the five senses, namely touch, sound, sight, taste and scent, to interact with the world. The intuitive types prefer to look beyond the focus of the hard facts and consider the potentials that might come out of situations.

The manner in which a person can review information is described as either thinking or feeling. A thinking person will consider reasoning and logic to be of primary importance when making a decision. A feeling person will make more emotive decisions which are based on personal perspectives.

The approach a person uses to tackle tasks is the fourth dimension. In this dimension, a person is either task-orientated or adaptable. The task-orientated person prefers to schedule assignments and enjoys completing the assignment before moving onto the next one. The task-orientated person is also known as a judger. The more adaptable person prefers to be spontaneous and does not enjoy schedules. The flexible person might commonly be known as the perceiver (Ramsay, Hanlon & Smith, 2000).

Gender Differences

Gender differences go beyond just the physical differences. John Grey (1992), the author of *"Men are from Mars and Women are from Venus"* describes distinctive approaches made by each gender in many arenas. In the classroom, educators should be made aware that there are differences between the attitudes of men and women towards learning. Women have a tendency to display less attachment to equipment (e.g. computers) than men. Even though women's attachment to the computer systems or hardware is noticeably lower than men's, women do display a high interest in the logical progressions that are involved in the computing process. This interest in the understanding of logical processes is fuelled by contexts. Women, it seems, need to understand the relevance of their learning in the greater scheme of things. It must be made clear to the female learners what the ultimate purpose of their learning will have and of what relevance it will have in the marketplace and their future careers (Slay, 2000).

Attitude is not the only dissimilarity between men and women. The choice of communication between learners can be affected by gender. Women have a discernible partiality towards face-to-face communication. The partiality suggests that women are more likely to prefer a more social learning style, such as group work as opposed to isolated learning, i.e. learning alone (Anderson, 1997). Preferring group work, however, is no guarantee that a woman will participate in the groups.

Studies have found that a majority of women have a negative self-image of themselves when considering their abilities and possible contributions that they could impart into a class or into a group. Some women consider themselves only able to listen and to possibly glean knowledge off others, who consider themselves authorities on the topic of discussion. Others might fall into the belief that they are not allowed to think for themselves, or even worse, that they are unable to think for themselves. A few women actually recognise that they are capable of acquiring knowledge and adept in reproducing the knowledge that they have learned. These above-mentioned women, on the other hand, are not confident that they are able to produce their own knowledge and believe that they are not capable of the synthesis level of cognition without the help of others (Taylor & Burgess, 1995; Gallos, 1995).

Maturity Level

Adult learners are a group of learners that are disadvantaged by the traditional learning system. The traditional learning system is based on pre-adult education models. These models imply that the learner is not particularly skilled in making decisions, nor is the learner fully capable of exercising self-discipline. In the pre-adult education models, it is the educator who is the main role-player in the classroom. It is the educator who makes particular decisions and maintains discipline. In the world of adult education, this role is not necessarily needed, since the adult, hopefully, has a degree of self-discipline and is proficient enough to make crucial decisions. There is a growing argument amongst educators in adult education that the traditional perspectives and models are not suited to educating mature learners (Bastiaens & Martens, 2000). The maturity of a learner does not only affect the way in which educators conduct lessons, but also influences other aspects of learning, such as academic achievement.

An incorrect perception amongst some educators is the one that mature learners cannot achieve as much as their younger counterparts. This perception is being refuted by recent studies in the field of learning. These studies imply that mature learners obtain greater understanding of concepts than immature learners. Immature learners do better at rote learning and memorisation, also called surface approach learning (Richardson, 1995; Passerini & Granger, 2001). Mature learners seem to prefer to understand what they are learning (also called the deep approach), while the immature learner has merely the goal of passing in mind. Tertiary education institutions prefer that learners use the deep approach to learning, which is an explanation as to why mature learners tend to fare better at the more logically-orientated and application courses (Kember *et al.*, 1996; Richardson, 1995; Passerini & Granger, 2001).

Another complication of the mature learner is that he or she is often the part-time or distance learner, who already has a full-time job and family commitments. It is thus important to consider the work and family commitments of the mature learner when implementing a course designed specifically for this niche market. One of the more important considerations for mature learners is that they need to have flexibility in their study hours. This means that library hours might not suit these learners. An impediment with a full-time job is that the mature learners might have to sacrifice a few lectures to fulfil their work commitments (Berge, Collins & Dougherty, 2000).

Motivation is one of the greatest driving forces within an individual. It is also one of the most complicated aspects of human life. What motivates one person will not motivate another. It is argued, however, that most learners, especially young learners at the tertiary level, are motivated by the need to pass. Only once learners are certain that this need is met, do some of them go beyond memorisation to deeper understanding and further study (Elton, 1996). Studies in the differences between mature and young learners have shown that a good majority of young learners need to be extrinsically motivated. A mature learner, however, has the tendency to find aspects within the course to motivate him- or herself. Mature learners are more inclined to be intrinsically motivated. Intrinsic motivation and a deep approach to learning, it appears, are two of the secrets of success of mature learners (Richardson, 1995).

Prior Learning

One of the most challenging obstacles to learning is one of ineffective prior learning. If a learner is ill prepared for a course, it could lead to a lack of achievement. This lack of achievement could lead to frustration, especially if the learner puts a lot of effort and time into the course (Elton, 1996).

Prior learning does not always refer to the learner. In a traditional classroom, the qualifications of the learner are not always taken into consideration. The traditional educator (and sometimes the institution) tends to "paint all learners with the same brush". These traditionalists consider all learners at the beginning of a course to be equally lacking in knowledge or skills. Unfortunately for these traditionalists, this situation is very rare, considering each learner is an individual with diverse skills and experiences (Berge, Collins & Dougherty, 2000).

Study Time and Effort

The amount of time and effort a learner puts into a course plays a significant role in the success of the learner. Studies have shown that the amount of time learners spend on a course (outside of class) will help determine their success. The ratio of study time to success is not a simple one, however. The ratio is greatly affected by the learner's ability to "study smart" or the learner's learning strategy. Learners with good learning strategies can spend much less time studying and still achieve more than learners with poor learning strategies who expends several more hours on their studies (Kember *et al.*, 1996). One study strategy that is advocated by a number of tertiary educational institutions is that of deep learning. As previously discussed, deep learning favours the understanding of the content over the memorisation of facts (Richardson, 1995).

Disabilities

The politically correct insist on naming disabilities as physical (or mental) challenges. However, being politically correct should go further than just labels. It is important that institutions are able to accommodate those learners whose physical challenges do not exclude them from the mental elite. Steven Hawking, renowned astrophysicist and the current Lucasian Professor of Mathematics at Cambridge University, is a prime example of an individual whose value as a scientist outweighs his physical challenges (Seale, 1998; hawking.org, 2003).

The abovementioned points are not the only factors that influence learning. Other factors such as available study funds, personal relationships, living conditions and class attendance may play significant roles in determining the success of a learner.

2.2.6 Gaps in the Learners' Knowledge

Class attendance is seen as a significant factor in the success of learners. Unfortunately, it is not possible for every learner to be able to attend every lecture. The reasons could range from transportation problems to illness. Certain learners, therefore, might have gaps in their knowledge due to their poor attendance (Marshall, 1999; Marshall & Hurley, 1996; Ruffini, 1999).

Poor attendance is not the only reason for gaps in knowledge. Some learners have poor note-taking skills and have a tendency to miss crucial concepts in class while frantically writing their notes instead of listening (Marshall & Hurley, 1996). Unfortunately, learners with knowledge gaps or misconceptions often do not know that these problems exist and thus do not ask for help. It is perhaps the traditional lecture situation that best breeds this kind of problem. A paradigm shift in how the classroom is managed and educators' perceptions of learners might offer learners better understanding in classrooms (Kennet *et al.*, 1996).

2.3 CONSTRUCTIVISM

A paradigm may be considered in the same light as a worldview. It determines how people interact with each other. In the educational world, a paradigm determines how an educator views the learners, and in turn, how the educator interacts with learners.

Since the 1980s, a change has started taking place in the educational world. A new paradigm is emerging, namely constructivism. Educators are encouraged not to consider learners as "empty vessels" needing to be filled with knowledge, but rather as individuals who construct their own knowledge. This has coincided with the move away from teacher-centered instruction (Forsyth, 1996; Kinnucan-Welsh & Jenlink, 1998). All of this has to do with the emerging paradigm: constructivism.

Constructivism is a theory of learning that has won many a champion in the educational world. The basic premise of constructivism is that learners are individuals who create their own knowledge. This knowledge is constructed partly by the rearranging of ideas and thoughts within the brain of the learner. The other part of learning is built on a foundation of prior learning and experience. As with all foundations, if they are incorrectly built, the remaining structure will be unstable. These unstable foundations represent the constructivists understanding of the misconceptions a learner might harbour (Tynjälä, 1999). Constructivist educators are aware that knowledge may be represented in divergent forms. In the constructivism world, it is important for learners to gain metacognition and self-regulation skills. Learners must know how to learn. The social context of learning should not be ignored. Constructivism suggests this learning should be done within realistic settings, with the learner actively participating in meaningful exercises and simulations (Grimus, 2000; Fung & Yeung, 2000; Deal, 1999; Honkela, Leinonen, Lonka & Raike, 2000; Kinnucan-Welsch & Jenlink, 1998; Tynjälä, 1999).

Constructivism, as a theory, does not have a complete and explicit definition. It is rather a mélange of analogous passages of thought which have been channelled into a few main streams (or types) of constructivism (Tynjälä, 1999).

There is **social constructivism**, which claims that an individual's knowledge and understanding is constructed within social settings. In social constructivism, learners grasp knowledge as they talk, debate and discuss topics and issues relevant to the curriculum. The social constructivists are the advocates of group work and group activities within the classroom (Smith-Gratto, 2000; Squires & Preece, 1999; Wilcox, 1996; Anderson, 1997; Tynjälä, 1999).

On the other side of the scale, there is **radical constructivism**. This theory expounds on the work of Piaget, a brilliant scientist and behaviourist, who studied the learning patterns of children. Radical constructivism holds as its tenet that no knowledge can be shared. Radical constructivism states that individuals must make sense of world in their own way and no one else can understand how they think or learn. The emphasis of this viewpoint is on the way in which knowledge and understanding is created, internally. The mental processes and metacognition are the primary focus of radical constructivist (Kinnucan-Welsh & Jenlink, 1998; Grimus, 2000; Thomas, 2000; Tenebaum *et al.*, 2001; Tynjälä, 1999).

The **socio-cultural approach** has a more community focus. It tries to bridge the gap between the radical and the social approaches. Socio-cultural constructivism states that learners may become skilled through both individual reflection and group interaction. John Dewey is credited as the expounder of the socio-cultural approach (Tynjälä, 1999).

There are additional facets to the constructivist theory; these include symbolic interactionism and social constructionism. It seems, however, that the smaller facets are beginning to align themselves with the larger groups of either radical constructivism, social constructivism or the socio-cultural approach (Tynjälä, 1999).

The above-mentioned theories of constructivism seem to be in total opposition; however, they do have some common ground. All the theories acknowledge that learning is built on prior knowledge and experience. What a learner knows or understands now has an effect on how he or she learns in the future. Furthermore, constructivists believe that facets such as gender, culture, and maturity (discussed in diversity differences) have a definite impact on learning and teaching. An additional point of agreement is that learning should be active and that the learners should have more control over their learning. It is generally agreed that gaining knowledge and understanding is not passive and that learners should be involved in their learning. (Kinnucan-Welsh & Jenlink, 1998; Tenebaum *et al.*, 2001; Honkela *et al.*, 2000; Deal, 1999). For learners to be involved in their learning means that their attention should be captured. Attention is easy to hold if the learners are interested in what they are learning or doing (Marsden, 1996).

All these aspects of learning and teaching are difficult to achieve in the traditional classroom. It is no wonder that educationalists are rapidly seeking novel solutions to these complex challenges.

2.4 A DEPARTURE POINT

Traditional education has served mankind for many a decade (or even many a century). The modern world, however, is imposing an increasing amount of pressure on this time-honoured system. A number of learners and educators have expressed disappointment in the ability of the traditional educational system to meet the needs of these modern pressures (Bastiaens & Martens, 2000). Some of these pressures include massification (or mass-education), lack of resources and shifting worldviews. These pressures are being exerted not only by businesses, but also by governments. Thus there is an escalating call from educators and theorists alike to review the traditional educational system.

Amidst all the hype and the fuss, a number of solutions have come to the fore. These include active learning techniques, new open- and distance learning strategies and resource-based education. One more approach uses the idea of supplementing the traditional lecture or classroom situation with computer-based resources (Squires & Preece, 1999; Marshall, 1999; Anderson, 1997). The next chapter will investigate computer-based resources and the implications they have for the learner, the educator and the institution.

Chapter 3

Educational Resources

3.1 RESOURCES AND THE CLASSROOM

As seen in Chapter 2, educators are facing diverse challenges, many of which are not new to education. The increased global need for education, however, has fuelled the search for creative solutions. Amongst these solutions is the use of computer-based resources. Applications for the use of computer-based resources in and out of the classroom abound.

Although there are several educational theorists (and politicians) that would like to eliminate the classroom as a component in the process of education, there are various reasons why numerous educators disagree. Classrooms give the educator an opportunity to guide and motivate learners while giving a general overview of the course content in an easily digestible format. Moreover, the classroom gives the educator a platform from which to emphasise the important components within the syllabus. There are also the multiple social aspects within a classroom that can enhance a course (Anderson, 1997; Benest, 1997; Gillham, Buckner & Butt, 1999; Pullen, 2000).

Learners seem to agree that the classroom should still be a part of teaching (Åkerlind & Trevitt, 1999; Benest, 1997). Hall and Dalgleish (1999) conducted a general survey of learners and concluded that it is not only the educators that value the face-to-face contact of the traditional classroom. Learners also appreciate the educator-learner interaction only possible in the classroom. The arguments in favour of educator-learner interaction are realistic and there seems to be few detractors to these arguments (Cronjé & Clarke, 1999). Thus, the classroom is to remain a part of most teaching, at least for the time being.

Even though classrooms are effective, it is always possible to improve on and enhance the current techniques (Mudge, 1999; Marshall & Hurley, 1996; Ruffini, 1999; Sandelands & Wills, 1996). There are numerous models that have been proposed to enhance the effectiveness of the classroom using resources. These models will be discussed below:

3.1.1 The Marketing Model

The first model has more to do with advertising than education. In this model, course outlines and descriptions are put on the Internet with the purpose of attracting learners and potential education partners (as well as sponsors). This type of marketing can be done at an institutional level or at the individual course level. There are a number of options for this marketing model. The first is to put only the course syllabus or outline onto the web. The second is to put an interactive component into the syllabus. This interactivity may be achieved with a plethora of techniques, for example, e-mail course instructors or marketing personnel. Besides marketing a course, one may also advocate favourite teaching ideas and concepts to be used in the classroom (Bonk, Cummings, Hara, Fischler & Lee, 2000).

3.1.2 The Open Resource Model

The second way in which educational resources may be utilised in the classroom is called the open resource model. In this model, learners and educators use the Internet to retrieve information. The primary aim of the model is to create interest in the subject matter being studied. Expanding the knowledge of learners by pointing them to interesting and relevant resources is a secondary aim. Thus in this model, learners are not compelled to interact with electronic resources. The learners should not consider themselves condemned if they feel more comfortable with paper-based resources, e.g. books (Hall & Dalgleish, 1999).

3.1.3 The Learning Materials Model

The third model is called the learning materials model. In this model, educators suggest sites and resources to learners as additional reading (Hall & Dalgleish, 1999). These suggestions normally come in the form of links on a web page. An educator may also place a large number of multimedia resources in a central access area. The learners should, however, also be inspired to search for resources themselves. Once the learners have found interesting and relevant resources, they should be encouraged to contribute these links to the educator's website.

Finding resources for themselves helps the learners become active in their own learning. The element of curiosity and the novelty of new technology and learning tools contribute to building learner enthusiasm about education (Gilliver, Randall & Pok, 1998). An added advantage is that knowledge can be added to a course. Where the classroom only has the time to introduce learners to surface ideas, the resources can "fill in the gaps". Adding links to additional reading provides the learners (and educators) with the opportunity to learn and appreciate the depth of the concepts being presented in the course (Bonk *et al.,* 2000).

3.1.4 The Teaching Materials Model

In the teaching materials model, the educators store information about courses on the Internet for learners to retrieve. The learners should be able to access this information both inside and outside of the class. The main aims of this model are to capture the learners' interest and imagination as well as give depth to the concepts being taught. Allowing the learner to explore suggested, relevant links and materials does this. The materials stored may include relevant class resources. Lecture slides that will be shown in class (or have been shown in class) are useful revision tools for learners. The lecture slides help learners to complete the notes that they have written in class. Another good revision tool is chapter summaries, which give a good overview of the course in general. The general course information should also be included. Such information as curriculum, assignments, test dates, educator expectations and course objectives are important guides for learners (Hall & Dalgleish, 1999). A secondary aim of such a model is to allow learners to explore possibilities such as their future professions within the subject area. Learners may explore and discover small pockets of self-interest topics, which might lead them to further investigation (Bonk *et al.*, 2000).

From the learners searching for relevant resources, an educator may take this idea one step further. The learners, themselves, can make their own resources. These resources are normally web pages, since learning how to generate simple pages is relatively easy. There are an increasing number of intuitive webpage generators available on the market, e.g. *MS FrontPage* ™ which is available from Microsoft. The advantage to this is that the learner not only learns how to create a useful resource, but the educator may also have a resource (or a good example) for the following years. The educator could assess the learners' work and use it as a part of their term mark and display the best work (or at least put in a link) on the course web pages (Bonk *et al.,* 2000).

3.1.5 The Directed Learning Model

The directed learning model expands the concepts of the teaching materials model by including interactive- and distance-learning components. In the directed learning model, the Internet (or intranet) is used to store and organise educational resources as well as test or assess learners (Hall & Dalgleish, 1999). This model suggests that the educator not only include syllabi and course objectives on the web page, but also resources. The educators generally create these resources themselves. Lecture notes, lecture slides (e.g. PowerPoint presentations), class handouts and educator guides and tips are the most common of the resources available in this model. The educator could also utilise resources created by other educators, with their permission. Permission could be obtained to edit or modify the resources to suit the needs of the learners, the course and the learning situation. The advantage of creating one's own resources or modifying someone else's is that the resource would be specifically tailored to the course and the learners. The benefits of sharing resources with trustworthy colleagues are that one may get a quality resource for free as well as starting building relations for future ventures.

Resources, however, are not the only items that can be placed on the web site. What could also be included in this model are FAQ about the course, links to allow learners to share experiences and collaborate on group projects, electronic bulletin boards and learner information. Learners may be graded on their participation in group projects and the bulletin boards. This is a further incentive for learners to share information and participate in their own learning. The opportunity to participate in online discussion groups aids the learners to create their own knowledge and comprehension of the course concepts. The main aim of this model is to help learners in developing higher order thinking skills (Bonk *et al.*, 2000).

The directed learning model may be extended beyond the campus. This is done by adding tools such as video conferencing and electronic activities (tutorials). Then both off-campus and on-campus learners have access to the course materials and educators via the Internet (Bonk *et al.*, 2000).

The next step for the directed learning model is to take it to the institutional level. This is where, not only a particular course for a specific year in a degree or diploma is placed on the web, but the entire degree or diploma is published to the Internet. This is the virtual campus, also called the virtual university or cyber-university. Learners can "come and go" as they please from all over the world. All the lectures and classroom activities are not done in classrooms, but directly on the web.

Learners might also get a deeper understanding of where a particular course fits into the larger picture of the degree. Sharing experiences, knowledge and information are imperative. At this level of cyber learning the learners are able to communicate with colleagues in other classes. For example, a second year student could contact a third year student to ask for advice or help on a particular subject. For the educator (and the institution) it means that curricula must be meticulously planned. Educators must have the necessary technical support and essential web technology know-how (Bonk *et al.,* 2000).

3.1.6 The Computer-Assisted Learning Model

The computer-assisted learning model is mostly used for self-study. Learners have complete control over when, what and where they learn. Computer-based training packages are the "teachers" in this model (Hall & Dalgleish, 1999).

3.1.7 Summary

All of the abovementioned models are currently being used in educational institutions on a variety of levels. Educational resources, if effectively implemented, can overcome the hurdles of the classroom (Anderson, 1997; Marshall, 1999). As discussed in Chapter 2, these hurdles include such problems as lack of active learning, attention problems, absenteeism and large class sizes (Forsyth, 1996).

3.2 USING RESOURCES TO MEET THE CHALLENGES

Educational resources have a multi-faceted role to play in overcoming the challenges of teaching and learning described in Chapter 2. Some of these challenges and how educational resources can be used to prevail over these remonstrations is the main focus of this section.

3.2.1 Self-directed Learning

Self-directed learning facilitates the development of learner accountability with regard their education. It also teaches, within a safe environment, that action (or lack of it) has consequence. An added bonus of self-directed learning is that if it is correctly and carefully implemented, it facilitates the development of higher-order thinking skills by teaching learners to form their own opinions on issues and topics (Wei, Kang, Wang & Huang, 2000; De Morais, Machado, Menezes & Reis, 2000; Demuth, Rieke & Sommer, 1998; Passerini & Granger, 2001).

For learners to start to develop their own opinions, it is useful to expose them to a variety of points of view. This exposure cannot always be done within the time constraints of the classroom. Since educational resources may be available to learners outside of classroom boundaries, educational resources can be used to allow learners to encounter a collection of diverse beliefs held by people or organisations from different walks of life (Rossbottom, Crellin & Fysh, 2000).

Since, in self-directed learning, the learners are in control of their own learning, it means that the learners are able to selectively view the resources that are available. It is thus important to provide the learner with sufficient resources to enable effective learning to take place (Gibbs, Lucas & Simonite, 1996; Ruffini, 1999).

Even if self-directed learning techniques are out of the question, educational resources may be effectively used in the traditional teaching paradigm.

3.2.2 Budgets

Electronic resources may have a positive effect on budgets. Photocopying is expensive and time-consuming. Libraries, too, are experiencing budget constraints that are limiting the materials that they can afford. Electronic resources are relatively easy to share and thus may eventually eliminate the need for photocopying class notes and class handouts (Marshall, 1999; Mudge, 1999). Libraries may buy one multi-user copy of a resource and share it on the network, thereby reducing the need for multiple copies of a book. Learners may reduce the amount of money they spend on textbooks, opting, rather for the electronic resources available to them over the network (Hall & Dalgleish, 1999).

3.2.3 Involving Learners

One of the largest roles of educational resources is to involve learners in their own learning, i.e. making learning active, enjoyable and interesting (Barker, 1999; Ruffini, 1999; Nah, Guru & Hain, 2000; Wei *et al.*, 2000). Learning cannot take place without the learners' interest, motivation and attention. To this end, a large portion of these researchers agrees that the use of electronic educational resources in the classroom is beneficial (Gilliver *et al.*, 1998; Bauer & Glasson, 1998; Mann, 1997). It is often the interest and realism aspects of multimedia that capture the learners' imagination and attention (Grandgenett & Grandgenett, 1997).

3.2.4 Time and Space

Not only do these educational resources reduce budgets but they also give learners the freedom to decide when and where they want to study. Different learners have dissimilar preferences: there are those learners who prefer to learn in the evenings or early mornings; some learners prefer to learn in the comfort of their own home, while others might prefer to learn inside a library. Library or classroom hours, however, could restrict these learners to learning when it is convenient for the library or the educator (Mudge, 1999; Rossbottom, Crellin & Fysh, 2000; Richards *et al.*, 1997).

Many researchers agree that learning does not necessarily take place in the classroom. In fact, studies have shown that learners learn more outside the boundaries of the classroom than inside it. It becomes imperative that sufficient educational resources are available to learners who are interested in reading or learning more about a topic (Gibbs, Lucas & Simonite, 1996; Ruffini, 1999). If the resources are put on a network that is accessible from outside the library then learners could study not only when it suits them, but also where it suits them (Marshall & Hurley, 1996; Nah, Guru & Hain, 2000).

The aspect of being able to choose where to study is of most benefit to distance and part-time learners. These learners cannot attend classes as often as full-time, on-campus learners. Having electronic, educational resources available may help overcome the time and distance barriers these learners might face (De Morais *et al.*, 2000; Demuth *et al.*, 1998; Pèrez *et al.*, 1998; Berge, Collins & Dougherty, 2000).

3.2.5 Filling the Gaps

Barriers to learning are not only geographical, but also cognitive. Learners might have misconceptions or incomplete knowledge. Having educational resources available to these learners may help fill the gaps in their knowledge. Not only can learners access the resources when it is convenient for them, they can also choose the resources that would best aid them in their understanding of important concepts (Marshall, 1999; Marshall & Hurley, 1996; Ruffini, 1999).

Since one of the aims of educational resources is to increase learner understanding of fundamental concepts, it is comforting to know that these resources may be accessed and utilised by the learners as many times as they deem necessary (Mudge, 1999; Neild, 1997). This enables learners with different comprehension levels to grasp key concepts. If the resources are made available to learners outside of classes, individual learners are able to review those concepts with which they are wrestling, without feeling as though they are retarding the progress of the entire class (Berge, Collins & Dougherty, 2000). Educational resources can help learners to fully grasp difficult concepts in a manner that is not possible in the classroom. Complex technical or abstract concepts can be demonstrated using multimedia. This enables the learners to visualise the concepts and create a more concrete understanding of the technical concepts (El Saddik, Fischer & Steinmez, 2001, Taylor, 1996; Åkerlind & Trevitt, 1999).

Another advantage of using educational resources is their ability to complete concepts that have been introduced in class or not fully explained within the classroom. This aids individual learners with differing personal goals. Each learner registers for a course with a particular, personal goal in mind. These personal goals are often dissimilar and involve personal interests in certain aspects of the course. These interests can be utilised to improve the learners' involvement and interest in the course (Marshall & Hurley, 1996; Mudge, 1999; Stefanov, Lomev, Verbanov & Nikolov, 1998; Spalter & Simpson, 2000).

A creative educator can find a multitude of techniques in which to use educational resources. One technique is to use educational resources as the foundation on which to build a class. An educational resource may be used to introduce a concept or a problem on which the rest of the class (or group work) could be based (Hampel & Keil-Slawik, 2001; Cann, 1999). Another technique is to use educational resources to provide learners with a background to the entire course. Giving them a greater understanding of where the course fits into the larger picture of their academic careers (Pulkinnen & Ruotsalainen, 1998).

Constructivism advocates that people learn from their mistakes. Educational resources may facilitate this facet of constructivism: if learners are given a relatively complex and safe environment filled with multifaceted ideas, they can explore without feeling threatened. The environment should present problems and exercises that allow learners to experiment with their own solutions. This trial-and-error method allows learners to discover what works and what does not, without the fear of criticism. These learning environments must be able to implicitly guide learners to the correct solutions or allow educators to supply support to the learners (Squires & Preece, 1999).

Educational resources can also be used to help learners develop their sense of judgement within a relatively safe environment. Critical thinking and learning how to distinguish between facts and fiction are important life-skills. Educational resources can be used to develop these skills by allowing learners to practice their abilities to analyse, discern and filter information (Berge, Collins & Dougherty, 2000).

3.2.6 Learning Styles

Misconceptions and gaps in knowledge might also find their roots in teaching and learning styles. The manner in which an educator teaches is influenced by the learning style that suits him or her as an individual. As mentioned in Chapter 2, each person is an individual and what suits one person might not suit another. The learners who prefer a learning style other than the one being utilised in the classroom are therefore disadvantaged (Cock & Pickard, 1996; O'Connor, 2000; Rossbottom, Crellin & Fysh, 2000).

Learners should be able to select learning resources according to their learning styles. An advantage of such an approach is that a learner's understanding of concepts can be deepened (Grimus, 2000; Passerini & Granger, 2001; Ruffini, 1999).

3.2.7 Interaction

In the realm of self-directed learning, learners are responsible for their own learning. Responsibility alone, however, does not help learners in understanding relevant concepts. Active learning, as mentioned in Chapter 2, is an important part of learning.

For learners to be active participants in their learning, it means that somehow, they have to interact with the course materials, with each other and with the educators. Interactivity is important, since studies have shown that if interactivity is low, then the learner's interest and motivation are reduced (Anido-Rifón *et al.*, 2001; Gilliver, Randall & Pok, 1998).

To be able to interact with the course materials is important to any learner. It can be argued that it is at this point that the learner actually starts learning. Thus, to encourage learners to learn, interactivity in the course materials is important. Multimedia resources are particularly focussed on delivering course content in an interactive manner (Hampel & Keil-Slawik, 2001).

Interaction between learner and materials often helps to focus the learners' attention on the task or content being taught. This interaction can be achieved by giving the learner specific problems, tasks or reading material (Squires & Preece, 1999).

3.2.8 Recollection

The human brain is designed in a similar fashion to the Web. Information is not stored in a logical and sequenced manner. Written sources, such as books, have a logical and sequential presentation format. Web pages allow users to jump to topics as they please and exploration in an unpredictable manner is facilitated. This characteristic of the web makes it comparable to the manner in which the brain stores its information. It follows that electronic resources, such as multimedia web pages, can offer a lot more than information (Hampel & Keil-Slawik, 2001).

This is possible due to the natures of both knowledge and multimedia. The character of knowledge is multifaceted and may be presented in using several techniques. As previously mentioned, one of these techniques is the linear and nonlinear approach. The nonlinear exploration of information, as some educators have implied, leads to a greater understanding of the material being presented. Some educational resources present information in a non-linear fashion with the aid of multimedia (Marshall & Hurley, 1996). The character of multimedia that lends itself to improving the presentation of knowledge is the variety of methods in which multimedia may portray its content. It may be said that multimedia understands the complexity of knowledge. The understanding that knowledge can be complex is known as the cognitive flexibility theory. The cognitive flexibility theory implies that knowledge should be represented in ways that develop adaptable mental frameworks in which to store and organise knowledge. These structures can then aid learners to apply the knowledge in a variety of novel circumstances (Barker, 1999; Passerini & Granger, 2001; Grimus, 2000).

Educators caution that even though the use of educational resources can increase understanding, it can also lead to confusion. The non-linear presentation of information of web pages and the ability to "jump" from one topic to the next in web pages are often cited by educators as the cause for a measure of confusion. This is especially true amongst novice computer users and learners with well-established misconceptions. The ability to "jump" from one topic to the next could also create gaps in knowledge, with the learner skipping out important topics to jump to the next (Gordillo & Díaz, 1998; Bayram, 1999).

Another problem that may be associated with hyperlinks is the "lost in hyperspace" syndrome. The "lost in hyperspace" syndrome is where learners get disorientated or lost when using hypermedia applications such as websites. The cause of the problem is the presence of too many hyperlinks or different types of associations, especially on sites that are not well structured. Again, it is the novice computer user who is more likely to fall prey to the "lost in hyperspace" syndrome (Gordillo & Díaz, 1998; Bayram, 1999).

Learners can also get frustrated with a resource that does not give sufficient feedback (Marshall, 1999). This is where the role of the educator is extremely important. It is imperative that the educator guides the learners through their learning (Hampel & Keil-Slawik, 2001; Grimus, 2000).

Studies have shown that learners find educational resources an advantage when revising before examinations (Marshall & Hurley, 1996). If the educational resources are carefully structured, they give learners an excellent overview of the materials (Göschka & Riedling, 1998).

Studies have proved that people remember what they do more readily than what they hear or read. Interactive educational resources allow learners to test situations and scenarios out for themselves by facilitating real-time simulations. Interactive resources are especially good at repetitive learning, which is necessary in certain fields such as Mathematics. Thus educational resources provide the "doing" part of recollection (Taylor, 1996; Neild, 1997).

3.2.9 Learning Environments

Educational theorists argue that learning can only be effective if the environment in which learning takes place is appropriate. The educators involved in the trade industry (e.g. electrical engineering, building and tool-making) agree that learning within authentic (or realistic) environments is influential in the training of learners, especially that of artisans. These realistic environments include the issuing of tasks that are simplified bona fide assignments in the workplace (Teslow *et al.*, 1994). Educational resources are able to provide this creative and complex environment in which to work and learn. Simulations, especially virtual reality simulations, are excellent training partners (Bauer & Glasson, 1998; Passerini & Granger, 2001).

Multimedia resources and simulations, in particular, have the potential to deepen a learner's understanding of concepts that are awkward to explain on paper. These concepts include processes and ideas that are difficult or too dangerous to demonstrate; for example, demonstrating the interior of an erupting volcano (Åkerlind & Trevitt, 1999). An example cited by Shelbourn, Aouad and Hoxley (2001) is one in the building trade in a Building Pathology class. Building Pathology is the identification of faults in a building. Educators cannot take their learners onto the sites of decaying or defective buildings due to insurance and safety reasons. These enterprising educators have, instead, turned to educational resources in the form of simulators to demonstrate the danger of particular building techniques and material flaws.

Another type of concept which is awkward to explain includes abstract theories. Examples of abstract theories include graphs and theories of how the brain functions. Yet another example of a concept that is better facilitated by multimedia is the development of a foetus within the womb (Neild, 1997; Marshall & Hurley, 1996; El Saddik, Fischer & Steinmetz, 2001). Other concepts that are difficult to demonstrate are those that include projects that develop over a relatively long period of time. An example of this is the construction of a high-rise building. Learners do not have the time to watch a skyscraper being built over a number of months. With electronic resources, however, the "process" could take a number of minutes (Shelbourn, Aouad & Hoxley, 2001; Neild, 1997).

Learning environments can also be made more comfortable for learners with disabilities (Seale, 1998).

3.2.10 Individualisation

One of the important foundations of constructivism is individualism. As previously discussed, each person learns in their own way and is affected by differing circumstances and abilities. This implies that educational resources should cater for individual needs, according to the individual's situation. This is the basis of personalisation or individualisation (Shaofeng & Kehong, 2000).

The argument for individualisation is that it makes learning more effective (Barker, 1999). The individualisation of education means that the educational resources should be constructed to meet the needs of each learner (Bastiaens & Martens, 2000; Slay, 2000). It is also important that the educational resources can be tailored to the needs of individual educators as well. This is because each educator is also a person with a unique personality and individual learning and teaching styles (Stefanov *et al.,* 1998).

There are several arguments in favour of using electronic means to provide individualisation in education. The first is that electronic media, especially multimedia, by its very nature facilitates personalisation. Multimedia presents information in a variety of means: graphics, text and audio. This presentation allows learners to concentrate on the media that best suits their own learning style (Passerini & Granger, 2001; Gilliver, Randall & Pok, 1998; Stefanov *et al.*, 1998; Hampel & Keil-Slawik, 2001).

Although the implementation of individualisation in education is still in its infancy, there are a few proposals as to what individualisation should entail (Fung & Yeung, 2000).

The first is that detailed information regarding the learners' knowledge should be stored. This information includes the learners' understanding of the key concepts of a course. Other information about the learners that should be considered are individual learners' abilities to solve problems, as well as each of the learners' needs in the area of educator guidance (Rosas, Nussbaum, Strasser & Csaszar, 1997; Bastiaens & Martens, 2000).

All of the abovementioned information is important in offering individualised education, because it prevents teaching the learners what they already know. Knowledge about individuals' performance and progress also helps to determine the difficulty level of the learning material that should be presented to the learners. The information also aids educators in fine-tuning educational resources to suit individual needs and preferences. In other words, educators should select the resources that best suit the individual learners considering their unique situations (Rosas *et al.*, 1997; Bastiaens & Martens, 2000; Shaofeng & Kehong, 2000). Knowledge of the learners' understanding helps to diagnose individual problems and misconceptions (Weber, 1996; Squires & Preece, 1999).

3.2.11 Sharing Information

The concept of cooperation, ideally, should extend beyond the learners. Educators have a need to share information as well. The sharing of information aids educators in much the same fashion as the learners and has numerous rewards. It combats feelings of isolation. Sharing information generates discussions that lead to discoveries about themselves as educators, their learners and in the content of the courses being taught. Another influence is that of improved instruction. The information that educators share not only includes personal messages and course content, but also includes course delivery methods. The discussion of a course and how it is presented may produce a number of innovative ideas and concepts from a variety of educators. This, in turn, may lead to the development and sharing of best practices inside and outside of the classroom (Small *et al.,* 1998; Marshall & Hurley, 1996).

Another advantage of sharing resources is that the time spent looking for resources can be reduced. The quality of the resource is assured. If a colleague has produced a resource or is using a resource, then the quality of the resource can be easily verified. How one uses a type of resource in the classroom may be discussed with fellow educators (Jacobson, 1995).

Sharing educational resources is able to lower the cost of developing the educational resources. Interactive multimedia resources are comparatively expensive to create in terms of time, expertise and money (El Saddik, Fischer & Steinmetz, 2001; Brünemann, Hogenbirk & Puper, 2000; Dillon *et al.*, 1998). According to Kinman (1998), quality educational resources take approximately eighteen months to prepare if the development team is an experienced one. Since educational resources are expensive to create, it stands to reason that quality educational resources are in short supply (Seale, 1998). Some institutions and a majority of businesses charge fees for access to educational resources. This forces educators to develop their own resources. Unfortunately, many educators are unaware of similar developments being done by colleagues either in the same institution or in affiliated institutions. This leads to the duplication of educational resources that could have been shared and the time, effort and expertise employed in the development of the educational resource could have been used to create another learning object or improve an existing resource. An additional method to sharing educational resources could be the formation of a joint venture. Two institutions (or two departments) buy an educational package or a learning object and share the cost between them (Wei *et al.*, 2000; Capron, Mitchell & Oxley, 1999; Dillon *et al.*, 1998). Thus sharing resources can save educators both the time and cost it takes to develop educational resources.

3.3 ENSURING THE QUALITY OF RESOURCES

Having had an overview of how educational resources may be used to overcome some of the modern challenges, it must be mentioned that resources should be quality-controlled before used. Educators agree that finding resources, especially on the Internet, is fairly easy to accomplish. Finding good quality resources, however, is a different matter. In order to use resources in education, these resources should have a number of characteristics. These characteristics define what constitutes a quality resource. It thus follows that the defining of "quality" is an important concept for educational resources. Educators have proffered numerous suggestions as to what constitutes quality in an educational resource (Small *et al.*, 1998; Retalis & Avgeriou, 2002).

An attribute of a quality resource is its **reliability**. This includes issues such as truthfulness and trustworthiness. The issues of authoritativeness and validity also need to be considered (Retalis & Avgeriou, 2002; Small *et al.,* 1998). A study indicates that numerous academic staff do not trust resources that are available in electronic format. The main reason for this distrust is the lack of assurance of quality. There is no assurance as to who is submitting their work and if the standard of work will remain consistent (Jackson, Bartle & Walton, 1999)

Another attribute is one of **availability**. A resource should not just disappear overnight (Retalis & Avgeriou, 2002). Educators, especially, become extremely frustrated when links to resources no longer exist or the links to resources become outdated (Sumner & Dawe, 2001).

The attribute of **clarity** is another important concept. The educator needs to determine whether the goals and objectives of the educational resource are clearly stated. The methods in which these objectives are met are also to be stated in a concise and explicit manner. The educator also needs to establish if the objectives of the resource have been fulfilled. The process in which any assessment takes place should also be obvious (Small *et al.*, 1998). The order in which information is presented is also important. It should be clear to the learners, exactly where the resource is taking them. Presenting the information in a natural and logical order assists this "leading" of the learner. Clarity should also include the ease at which users can identify words, phrases and concepts within the resources (Squires & Preece, 1999).

Completeness is a further attribute. A complete resource will be up-to-date and include pertinent materials or at least links or suggestions about where to obtain the materials. Links to related materials should also be included in the resource (Small *et al.*, 1998; Sandelands & Wills, 1996).

A quality educational resource will capture the learners' attention and **motivate** them to participate in the learning experience. Actively engaging the learners and providing them with challenges are imperative properties of an educational resource. By stretching the learners to new challenges, learners not only become involved in their learning, but also improve their own skills (Nah, Guru & Hain, 2000). To achieve the goal of improving on skills and knowledge, a quality resource has to acknowledge and build upon prior learning and experience (Small *et al.*, 1998; Squires & Preece, 1999).

The **manner** in which the information is presented is also used to determine quality. Resources should be easy to use. Users of the resources should be subtly guided by headings and other cues (Small *et al.,* 1998). Guidance can also be given by regular feedback. This allows learners to determine their own progress and allows learners to orientate themselves within the resource. Ease of use is also determined by language of the resource. The words and phrases should be those used within the learner's environment. The concepts of the resource should not be totally foreign to the learners, either. The presentation of concepts, ideally, should be designed to build on known knowledge (Squires & Preece, 1999).

In prescribing resources, educators should be aware of the **appropriateness** of the resource. Analysis of the target audience (the learners) is crucial to the selection of resources. Educators should avoid resources that advocate or imply stereotyping or bias in any way. The language, concepts and activities presented in the resource should be suitable for the level of learner and the content of the course (Small *et al.*, 1998). It is important for learners to have resources that are on their level of understanding. Studies suggest that appropriate level resources persuade learners to become more interested in the course and thus facilitate the motivation to learn (Gilliver, Randall & Pok, 1998).

Educators are known to be wary of using resources from unknown suppliers. Some educators only access resources from well-known and trusted suppliers. This, to them, ensures quality (Sumner & Dawe, 2001). It might not, however, provide the best of the resources, nor provide resources for more obscure topics. To help alleviate the quality control obstacle, researchers have suggested a number of solutions. One of the solutions is the validation of resources. Educators should review materials and resources on the basis of quality. These reviews should then be made available to colleagues and other interested parties. Educators can then search the list of the reviewed resources to select the most appropriate resource for their learners. The reviewing process should ensure the quality of the appraised resources. There are several drawbacks to this solution: the first is the possibility of elitism, another is the possibility that the collection of resources will grow at a retarded rate and it might become a "media attic" where resources are stored, but not utilised (Fox, Heller, Long & Watkins, 1999; Retalis & Avgeriou, 2002).

Beyond the focus of quality is the issue of quantity. To be useful, a collection of resources needs to offer a smorgasbord of resources to suit almost any taste. Resource types available in the collection should range from the static text to dynamic, interactive animations and simulations. The learners (and the educators) need to be able to reference these resources to suit their own situations (Marshall & Hurley, 1996; Marshall, 1999).

3.4 RESOURCE BASE

As previously mentioned, searching for educational resources can become very frustrating. Many educators have suggested creating digital libraries or repositories in which electronic resources can be stored. These digital repositories can help educators find resources relatively easily, but work similarly to a library. Users who search for items in these systems need to know their exploration needs. Some of these digital libraries are very limited in scope and restrictive on their searchable fields (Duval *et al.*, 2001; Sumner & Dawe, 2001; Jacobson, 1995).

Another suggestion to help store and organise electronic resources is an adaptive hypermedia learning system. These learning systems consist of a number of lessons that can be offered to learners. The method in which the lessons are offered is the adaptive part of the system. Learners are divided into classes or groups and each class will receive a prescribed list of lessons covering the content of the course. The adaptation comes with the modification of the lessons to suit the needs of the course content, the individual teaching style of the educator and the overall needs of the learner group. The adaptation is generally done manually by the educator or administrator by exchanging one piece of a lesson for another in a modular fashion (Fischer, 2001).

The advantage of the hypermedia learning systems is that they offer guidance to the learner. One of the major disadvantages, however, is that the hypermedia learning systems are very prescriptive. They do not allow learners to freely choose their own learning materials. Digital libraries, however, do not restrict their users in terms of what they can read. The disadvantage of digital libraries is that the users can be overwhelmed by the selection presented to them. This implies that the digital library cannot offer the guidance that a hypermedia learning system is able to offer (Fischer, 2001; Jacobson, 1995; Sumner & Dawe, 2001).

What is needed is a resource database system (or resource base) that falls between these two types of educational systems. The resource base should have the searching simplicity and non-restrictive searching facilities of a digital library. However, it should also have the ability to suggest educational resources for learners, as it is in the case of the adaptive hypermedia learning systems. A further feature that the resource base needs is an ability to individualise the delivery of educational resources according to each learner's needs and preferences (Fischer, 2001; Gazzangia, Morrone, Ovcin & Scarafiotti, 2000; Jacobson, 1995; Sandelands & Wills, 1996).

3.5 IN BRIEF

There have been many arguments both in favour and against using computer-based educational resources in the classroom. The advantages of using computer-based resources outweigh the disadvantages. Studies have shown that creative implementation of these educational resources can help educators rise to the challenges of modern education.

A resource database system (or resource base) would not only store and organise educational resources, but it would also individualise the delivery of these resources to learners. Within the models discussed earlier in the chapter (Section 3.1), the resource base would fall under the auspices of the teaching materials model (Section 3.1.4). The aim of the teaching materials model is that of perking learner interest as well as offering the learner a deeper insight into the content matter. Thus the aim of the teaching materials model coincides with the primary aim of the resource base. The teaching materials model, however, does not prescribe which features and facilities should be available within the resource base.

The following chapter will look at the features that a good educational resource base should encompass. A list of criteria for a quality resource base will be developed and Chapter 5 will use these criteria to compare the existing products and repositories.

Chapter 4

Resource Base Facilities

4.1 THE CRITERIA FOR A RESOURCE BASE

As mentioned in the previous chapters, there are numerous reasons why educational resources are beneficial in education. From these reasons, one can determine some features that would be very useful in a resource base. These features can basically be divided into two main categories: the pedagogical criteria and the technical criteria. These two main categories are not mutually exclusive, but rather complement and interact with one another (Retalis & Avgeriou, 2002). Pedagogy is concerned with teaching, or theory of teaching (Ben-Ari, 1998). The pedagogical criteria, therefore, consist of the educationally related issues such as quality assurance in resources, didactic concerns and investment in terms of time, effort and expertise. The technical criteria are the more computer-related issues such as ease-of-use, security, infrastructure and availability (Retalis & Avgeriou, 2002).

4.2 THE PEDAGOGICAL CRITERIA

Based on the previous two chapters, it is possible to draw up a list of criteria on which to base the resource base. It is very necessary to create a list of practical teaching issues that directly affect the way learners (and educators) will interact with the resource base. The necessity is drawn from studies done at various institutions. At these institutions, in the excitement of implementing electronic teaching aids, educators have often ignored the pedagogical aspects of these aids to the detriment of the course being presented (Hazari, 1998; Firdyiwek, 1999; Astleitner & Sams, 1998).

This list of criteria can basically be sub-divided into a number of sub-sections, namely; teaching aids, resources, costs and delivery methods.

4.2.1 Teaching Aids

This sub-section includes such topics as learning objectives, syllabi and curricula (Retalis & Avgeriou, 2002; Small *et al.*, 1998; Montgomery, 1998; Hazari, 1998).

- The **courses** that will be aided by the resource base should exist inside the system. This enables learners and educators to be linked via the course.
- The **syllabi** for the courses should be linked to their respective courses within the resource base. The syllabi could be used to inform learners and potential learners about the scope and the level of the course. The syllabi can also aid educators in defining the objectives.
- The **objectives** for the courses should also be **linked** to the course and the syllabi. The objectives are a guide for the learners and help the learners to better focus their attention on key points and concepts.
- The objectives should have **sub-objectives** which expound the main objectives in order to give learners improved guidance.
- The **learners** should be **linked** to the courses for which they are registered.
- The **educators** should be **linked** to the courses which they offer.

4.2.2 Resources

As mentioned in Chapter 3, resources that are organised by the resource base need to have certain characteristics. These characteristics are as follows:

- The **resources** should be linked to the relevant **course objectives**.

  - One resource may be linked to more that one course objective (to enable reuse of resources in diverse courses).
  - These links between course objectives and resources should be created by the educators.
- The **resources** should be linked to possible **misconceptions.** (These links should enable individualised resource access according to personal misconceptions.)
  - Educators should be able to modify and create the links between the resources and the misconceptions.
- Both learners and educators should have the facilities to **add resources** to the resource base. The resource base should associate the user name and the role of the user who added a particular resource. This association ought to promote accountability and responsibility within the user community. The association could also be used to determine the quality of the resource. If an educator added the resource, then it can be assumed that the quality is good, unless the educator indicates otherwise. If a learner has added the resource, then it is assumed that the quality needs to be verified by an educator.
- The **resources** should be reviewed or critiqued in order to assure **quality**. It is educators' responsibility to ensure resource quality. However, learners too, may review resources and in the process, learn how to judge the quality of resources.
- The resource base may give educators (and learners) a set of guidelines to use in order to gauge the quality of resources. The guidelines should include the following criteria:
  - The reliability of the resource;
  - The availability of the resource;
  - The clarity of the goals and objectives (if stated within the resource);
  - The completeness of the information in the resource;
  - The ability of the resource to motivate learners and capture their attention (the interactivity level of the resource);
  - The ease of use, and

  - o The appropriateness of the resource. (This is the level of course at which the resource is aimed, i.e. beginner, intermediate or advanced.)
- For each resource a learner receives, there should be a rating. This rating helps the learners in determining how important the particular resource is to their learning. A simple, suggested rating for the resources is "required reading" or "not required reading".

4.2.3 Costs

Finances tend to be a restricting factor when selecting educational techniques or methods. Educators have thus indicated that there are a number of financial constraints when investigating the purchase of a resource base. These constraints may be measured in terms of:

- The amount of time spent searching for resources;
- The amount of time spent modifying or creating resources;
- The amount of time spent on administration (e.g. registering learners, issuing resources);
- The amount of time spent on maintaining the system;
- The cost of obtaining the expertise needed to create or modify resources in terms of hiring a specialist or in training courses;
- The cost of obtaining the expertise needed to maintain the system;
- The training costs in terms of learning how to use the resource base;
- The software and hardware that need to be purchased (this includes licensing), and
- The time and financial resources required to ensure that the legal requirements of obtaining the necessary copyrights are sufficiently met.

It implies that the resource base should have the following cost-saving features:

- The **sharing of resources** amongst courses, educators and learners should be facilitated;
- The facilities to **search for resources** using search criteria including key words, misconceptions, topics, course objectives, courses, syllabi and appropriateness level should be included;
- Ease of use for educators, learners and administrators lowers training costs and should lower possible technophobia;
- Ease of administration also lowers training costs;
- Ease of maintenance reduces the need for technical knowledge and could allow educators to function as administrators, and
- Licensing costs should be kept to a minimum.

4.2.4 Delivery Method

The manner in which resources are distributed amongst learners and educators is the delivery method. From Chapter 3, the following criteria have been identified:

- Self-directed learning should be encouraged. The facilities for the learner to access the resources at times (and places) convenient to the learner should be made available.
- Search facilities should be made available to both learners and educators.
- Individualised resource delivery should be facilitated. Learners should receive resources based on:
    - the courses for which he or she is registered;
    - the preferred learning style of the learner;
    - the misconceptions of the learner, and possibly
    - the learner’s personal background, culture and language

- Individualised learning can be further facilitated by allowing the learner to select resources other than those prescribed by the educator and the resource base.

From this list of criteria, it follows that the learner should have a profile which makes these features available to him or her.

The Learner Profile

Since the focus of the resource base is the learner, particular detail will go into describing the learner profile. The learner profile is different from the other profiles in the resource base, since it is the most restricted in access. This restricted access, however, should be bounded by a few properties (Elorriaga, Arruarte & Fer¨¢ndez-Castr, 2000). These properties include:

- A technique for storing individual preferences which include preferred learning style, the learner's ability to learn in a self-directed manner, personal background and interests (Rosas *et al.,* 1997; Adelsberger, Körner & Pawlowski, 1998; Finkel & Cruz, 1999).
- A technique for storing individual knowledge which include the knowledge which the learner has already acquired (acknowledging prior learning) and the knowledge with which the learner struggles (misconceptions). The individual knowledge might also store the learner's learning pace and level of knowledge for each of the course objectives. This allows the resource base to automatically suggest resources to learners' concerning particular problem concepts (Adelsberger, Körner & Pawlowski, 1998; Angelides & Paul, 1999; Rosas *et al.,* 1997).
- The learner profile should be dynamic, changing as the learner matures (Angelides & Paul, 1999; Elorriaga, Arruarte & Fer¨¢ndez-Castr, 2000).
- The learner's online presence should be acknowledged. The learner must feel a part of the online community within the resource base (Masie, 1999; Hui, 1998).

- Certain aspects of the learner profile should be available for viewing and reporting by the educators directly involved with the learner (Hui, 1998).
- The learner profile should allow the learner to add his or her own selection of resources from the resource base.
- The learner profile should be secure from others, thus protecting the learner's rights to privacy.

4. 3 THE RESOURCES OF A RESOURCE BASE

To facilitate the above-mentioned pedagogical criteria, a number of technical components have to be in place. These technical criteria may be separated into a few basic parts. O'Brien (2001) states that any information system may be divided into five basic resources: the people, the hardware, the software, the data and the networks. These components are not isolated pieces but work in unison to mould the resource base (Retalis & Avgeriou, 2002; Montgomery, 1998).

4.3.1 The People Resources

As already established, there are a number of people who have a definite stake in any resource base. These people are the educators, the learners, the administrators and, to a lesser extent, greater society (Retalis & Avgeriou, 2002; Llamas, Anido & Fernández, 1998; Montgomery, 1998). Each of these groups of people has a different role to play (Anido-Rifon *et al.*, 2001). This subsection will investigate the facilities that each of these types of users should have available to them. The techniques employed by which these facilities will be provided will be investigated later on in the chapter.

The Educators' Role

The educators' role is that of a facilitator who ensures learner progress. The educator is also a guide who encourages and directs learner attention (Henri, 1998). The educator is also the one who designates the learning materials to the objectives and updates the links between resources and misconceptions. The educator should also be the one who helps determine what possible misconceptions learners could develop (Retalis & Avgeriou, 2002; Llamas *et al.*, 1998). It follows that educators should have a number of facilities available to them. A few of these facilities include:

- The facilities to create courses within the resource base should be available.
- The creation the syllabi and course objectives for the relevant courses should be facilitated.
- The facilities to create the links between the course objectives and their sub-objectives should be included in the resource base.
- Search facilities to find relevant resources for courses and course objectives should be available.
- The facilities to link resources with relevant course objectives should be accessible.
- The facilities to define possible misconceptions should be encompassed.
- The facilities to link misconceptions with those resources that would help learners to correct their errors should be made readily available to educators.
- Educators should be able to readily and easily identify the individual misconceptions with which a learner struggles. This process should be available as an automated function and as a manual process.
- Diverse types of resources (or the links to the resources) should be readily stored within the resource base.
- The facilities to evaluate resources in terms of quality should be user-friendly and available to all educators.
- The facilities to check learner presence and activity on the resource base for progress reports are an important feature.

The Administrators' Role

The administrator or system manager of the system is usually a person with technical knowledge on the infrastructure of networks and databases, and has a number of responsibilities. The details of these responsibilities vary from institution to institution; however, there are a few duties that are commonplace. These general duties include ensuring the security of the system, aiding with the implementation of new systems, maintaining current systems and, in some cases, helping the users (Llamas *et al.*, 1998; Retalis & Avgeriou, 2002; Henri, 1998). It can thus be concluded that the administrator requires certain amenities within the resource base in order to fulfil his or her duties. These include:

- Facilities for user management (i.e. the creation, modification and deletion of users and the management of access rights) must be made available.
- Facilities for grouping users (i.e. associating learners with registered courses, educators with courses and perhaps even associating courses with courses) should be included in the resource base.
- Security (i.e. access control, regulation of backups, enforcing security policies and maintenance and repair functions) is an imperative feature for any program.
- The administrator should have the same facilities as that of an educator.
- Facilities for auditing should also be part of the resource base.

The Learners' Role

The learners should be the main users of the resource base (Llamas *et al.*, 1998). Their main function in the resource base is to utilise the resources that are available. As previously discussed under the Learner model, learners should have the following facilities (Henri, 1998; Retalis & Avgeriou, 2002; Rosas *et al.,* 1997):

- The facilities to perform unrestricted searches in the resource base for resources.

- The facilities to include resources for personal reasons should be included. This allows a learner who is studying fine art, but is interested in gardening to include those resources about gardening.
- The facilities to mark or label those resources they consider personally important for their own learning.
- User-friendly, context-sensitive help menus or help systems should be available.
- Learners should be able to navigate resources freely within the resource base.
- The resource base should allow learners to learn when convenient (i.e. be able to choose when and where learning takes place).
- Facilities to allow learners to decide what content to learn and the order in which learning takes place.
- Facilities to add resources to the resource base.
- Facilities to critique a resource for quality.
- Change links as their knowledge and personal interests grow and mature (Braun, Borcea & Schill, 2000).

The Developers' Role

There are two types of developers that can be identified. The first type of developer is the creator of the resource base. The second type of developer is the author of the resources. The first type of developer needs to have the skills of a programmer while possessing an extensive knowledge of the educational side, i.e. pedagogics and didactics, and how these issues may influence the learners. The second type of developer might need a number of skills, which is dependant on the type of resource being created. The more complex the resource (e.g. simulation), the more programming skills this type of developer will need. The more simple resources (e.g. static web page), may be developed by anyone who can use a web authoring tool or a word processing package such as *MS Word* ™ (Henri, 1998; Llamas *et al.*, 1998). Within the resource base, the developer of the system should ensure that the basic programming framework is available, e.g. simple user interface, the security facilities and sound database structures.

The developer of the resources should adhere to certain platform independence and resource development standards.

The above-mentioned roles are not necessarily mutually exclusive. An educator may take on both the roles of educator and developer. An administrator may take on the roles of developer, educator and learner, in addition to the role of administrator.

4.3.2 The Software Resources

The software resources of a resource base include those programs and software needed for the creation, installation, maintenance and use of the resource base. The diversity of software needed to maintain the resource base is depended on the type of resource base chosen. This decision impacts on issues such as costs (e.g. licenses), the people resources (e.g. how many administrators are necessary) and the hardware (e.g. what type of computer does one need to run the software) (Hazari, 1998). For example, a PC-based resource base will need a compatible operating system and upgrades, while a web-based resource base will need web browsers and the relevant plug-ins, e.g. *Shockwave*™ which is available from Atom Shockwave Corporation. There are thus a number of issues to consider before deciding which resource base to purchase, or how to create a resource base. One of the features that should be scrutinised before deciding on a resource base is the user interface. A feature which is a part of user interface, but is dealt with separately is the way in which users find their way through the system, also known as navigation.

User interface

The user interface is the method by which the educators, learners and administrators will interact with the resource base (Gazzaniga *et al.*, 2000; Taylor, 1996). There are a few guidelines which a number of educators have suggested:

- A user interface should be simple and uncluttered (Jacobson, 1995; Demuth, Rieke & Sommer, 1998).
- A user interface should be intuitive to use (Gazzaniga *et al.*, 2000; Demuth, Rieke & Sommer, 1998).
- The menus of the system should be few and simple (Jacobson, 1995).
- There should not be too many levels of menus (Jacobson, 1995).
- The user interface should make tasks, such as administration work, the creation of courses and the linking of resources, simple and intuitive (Azadegan, 2000).
- The user interface (particularly within a web-based environment) should provide facilities for user individualisation and privacy by allowing users to enter passwords, personal details and personal preferences (Azadegan, 2000; Henri, 1998).
- A graphical user interface is preferred, with the tasteful and meaningful use of metaphors (Ben-Ari, 1998; Cronjé & Clark, 1999).
- Context-sensitive help should be available to all users (Demuth, Rieke & Sommer, 1998).

Navigation

How the learners access these resources is an important aspect of the resource base. The manner in which access takes place may determine the usability of the system. If the users become disorientated within the resource base, it could lead to frustration and abandonment of the resource base. This disorientation within an Internet-like environment is commonly termed as being "lost in hyperspace". There are thus a number of basic guidelines that should be adhered to when designing the navigation system for the resource base (Gordillo & Díaz, 1998; Bayram, 1999).

The presentation structure of resources is but one of the issues that needs to be resolved. The structure of the resource base needs to be simple, yet robust. A well-structured resource base will help prevent disorientation in users. The feedback given to users via messages, links and user interface needs to be consistent. Consistent feedback helps the users not only to learn the effective utilisation of the system more swiftly but aids in orientating users, too (Gordillo & Díaz, 1998; Marshall, 1999).

The links (e.g. hyperlinks) are one of the paramount techniques employed by users to navigate through the resource base. It follows that careful attention must be paid to these links. The number of links is important. A novice user might be overwhelmed by the presence of copious numbers of links and might become disorientated. Too few links, on the other hand, will frustrate experienced users who enjoy navigating through materials at will. Thus, a balance between too many and too few links has to be discovered (Marshall & Hurley, 1996; Gordillo & Díaz, 1998).

Some educators have suggested that instead of the course or resource designers creating fixed links between course units and resources that cannot be edited or modified, that the learners should have the facilities to create their pathways through the course units. These have a number of advantages, which tend to apply mainly to the more experienced computer users. The first advantage is that the learner develops his or her own understanding of how the "pieces of the puzzle", which is the course content, fit together. The second advantage is that the learner creates pathways to the content that seem more logical to him or her. What the designer or educator might conceive to be the best possible route through the materials might not seem logical to the learner. The last advantage stems from the previous two advantages: since the learners have to develop their own pathways through the content, they have to consider the content more thoroughly and thus develop their own, deeper understanding of the content (Mudge, 1999; Neild, 1997; Marshall, Halasz, Rogers & Janssen, 1991).

The development of personal pathways through content can be facilitated by the tools made available by mind maps (also called concept maps). These mind mapping tools allow user to create their own view of how the content fits together. It does this organisation without prioritising any of the content. It has been shown that mind maps can become a memory aid, helping learners remember what they have learned (Honkela *et al.*, 2000; McAleese, 1999).

From this discussion, the following attributes should be noted in the resource base:

- Users should receive continuous or regular feedback on their location within the resource base. The navigation tools should offer guidance and orientation to the user (Jacobson, 1995).
- The number of links within the resource base should be balanced, i.e. not too few or too many links between sections.
- A feature which could make the users more comfortable with the system would be to allow them to personalise the number of links which will allow the learners to decide how many links to display at one time. This is to counteract the "lost in hyperspace" dilemma and to aid the balance between too few and too many hyperlinks between sections.
- The facilities to create, modify and delete personal links or pathways through the system (possibly the use of shortcuts) should be available if the previous feature is included.
- The facilities to create, modify and delete personalised concept maps should aid users in navigating through the resources.
- Resource links have to be current (i.e. up-to-date) and point to the correct location.
- When a user has requested a particular resource, it should be displayed in the current window (Sumner & Dawe, 2001).

Platform

The platform which the software utilises contributes to the issues of hardware, administration and usability of the software. Software that is reliant on an operating system such as UNIX or Windows is platform dependent and cannot be accessed from all users' systems unless the systems are compliant in terms of platform. These operating systems are continually being updated. This constant improvement of operating systems could have some repercussions with the software compatibility of the applications. An updated operating system usually takes advantage of new hardware technologies. This has a number of repercussions on legacy systems. Platforms such as Internet platforms are operating system independent (Retalis & Avgeriou, 2002; Montgomery, 1998; Llamas *et al.,* 1998; Zhiping & Chongrong, 2000). If the resource base is platform independent it implies that the systems being used to access the resource base need not be uniform. This aspect of non-uniformity is especially important when considering the personal computers used in learners' place of residence. These personal computers are often not "state of the art" machines and often cannot handle the latest software (Campbell, Yates & McGee, 1998; Cronjé & Clark, 1999).

Many educators have turned to the Internet and Internet technologies to provide platform independence and relatively cost-effective development tools. Another reason for utilising Internet technologies is the perceived ease at which educators can share resources and maintain the resource base (Retalis & Avgeriou, 2002; Zhiping & Chongrong, 2000).

Security

resource bases should provide a measure of security to safeguard the privacy of the learners. The security of the data inside the resource base can be achieved with the aid of a number of techniques:

- The authentication of all users: educators, learners, developers and administrators. This prevents people who are not registered for any courses from accessing the system (Campbell, Yates & McGee, 1998; Cann, 1999; Demuth, Rieke & Sommer, 1998; Mudge, 1999).
- The implementation of audit logs and unobtrusive monitoring tools not only helps protect the resource base from unauthorised access, but may also be used to

aid educators in determining the learners' digital presence and level of activity in the system (Campbell, Yates & McGee, 1998; Cann, 1999; Mudge, 1999; Barker, 1999; Anido-Rifón, 2001).

- The provision of access according to roles facilitates ease-of-use and offers a method of ensuring integrity constraints (Mudge, 1999).

These techniques might not be sufficient. Some administrators would feel more comfortable with the addition of external tools such as firewalls and anti-viral software (Mudge, 1999).

4.3.3 The Hardware Resources

The hardware resources include the database servers, file servers, networked computers and personal computers that are necessary for the implementation of the resource base. The choice of hardware resources is determined by the requirements of the software chosen for the resource base and the performance requirements of the users (O'Brien, 2001).

4.3.4 The Network Resources

The network resources include the hardware, software, people and data needed to support the necessary network services (O'Brien, 2001). Since the resource base is designed to run over an Intranet, it is imperative that the network should remain as stable and available as possible.

4.3.5 The Data Resources

The data resources required by the resource base include the database which drives the resource base. The database should include the files for storing user information, the resource information and the security logs. The user information is vital to the delivery of individualised services. Since the learner is the main user of the resource base, it follows that the learner profile is the most important user account.

Metadata

Metadata is data about data. The main purpose of metadata is for the identification of the various data structures within the database. Thus metadata should make managing the contents of a database relatively simple (Duval *et al.*, 2001). Another purpose of metadata in a resource base is to assist the process of searching for resources, for example, by simplifying the process of indexing (Sumner & Dawe, 2001; Fox *et al.*, 1999; Burke, 1996). It also facilitates the sharing of resources amongst the users.

To facilitate the sharing of resources, not only amongst users, but also amongst resource bases, many educators are calling for universal standards in the arenas of XML tags and metadata. The standards should be designed to allow sharing, protect multiculturalism and protect learner privacy (Retalis & Avgeriou, 2002; Sumner & Dawe, 2001; Duval *et al.*, 2001).

A number of standards currently exist. These standards are being developed by a number of institutions, including the IEEE Learning Technology Standards Committee, CEN/ISSS Learning Technology Workshop, the PROMETHEUS Special Interest Group on the Design of Electronic Learning Environments and the work on Educational Modeling Language (EML) as well as the Dublin Core (Retalis & Avgeriou, 2002; Sumner & Dawe, 2001; Fischer, 2001; Fox *et al.*, 1999).

Metadata should have the following characteristics:

- Facilitate easy searching;
- Support resource discovery (Sumner & Dawe, 2001);
- Facilitate resource sharing;
- Be created according to a standard (Retalis & Avgeriou, 2002), and
- Facilitate the creation of dynamic web pages (Barker, 1999).

Database Characteristics

Considering the learner profile and other criteria, the database should have a number of characteristics:

- The database should have the ability to store a vast array of resource types from static text files to dynamic, interactive simulations (Marshall & Hurley, 1996; Marshall, 1999).
- The individual profiles for each user should be stored. These profiles should be dynamically updated.
- The sharing resources amongst courses, educators and learners should be facilitated.
- A search facility, which is made possible by metadata, should be readily available.

4.4 SUMMARY OF THE REQUIREMENTS

There are many characteristics that should be encompassed by a resource base. To check for all these characteristics may become a rather large and tedious task. Thus, for simplicity and summary, the following basic and generalised requirements have been extracted and displayed in Table 4.1.

The following chapter will consider a few of the currently available products and compare their functionality to the requirements specified in this chapter.

TABLE 4.1: TABLE OF REQUIREMENTS

NO	REQUIREMENT
1	Educators should be able to create, edit and delete courses, syllabi, course objectives, sub-objectives and the links between them.
2	Educators and administrators should be able to create learner profiles and link them to courses. It should be possible to link one learner profile to more than one course.
3	Educators and administrators should be able to link learner profiles to one or more misconceptions.
4	Educators should be able add resources to the resource base.
5	Learners should be able to add resources to the resource base.
6	Educators should be able to identify possible misconceptions and link these misconceptions to the relevant objectives and resources.
7	Educators should be able to create, edit and delete the links between course objectives and resources.
8	Educators should be able to create, edit and delete the links between course objectives, resources and misconceptions.
9	Educators should be able to critique the resources for quality.
10	Learners should be able to critique the resources for quality.
11	Advanced search facilities should be available.
12	The sharing of resources between users should be facilitated.
13	The resource base should be cost effective and affordable.
14	The automated list of suggested resources should be individualised according to course, misconceptions, background and learning style.
15	Learners should be able to link their own resources into their profiles according to personal interest, learning style or misconceptions.
16	The resource base should be easy to maintain.
17	The resource base should allow for at least three types of user profiles: learner, educator and administrator.
18	The resource base should be user friendly and easy to navigate.
19	The resource base should ideally be platform independent and be executable from a wide range of computers.
20	The resource base should offer security in the form of authentication of users and audit logs.
21	The metadata should be compliant to one of the known standards.
22	The resource base should run on a network (e.g. intranet) and be scalable.

Chapter 5

Current Instruction Systems

5.1 INTRODUCTION

There are numerous products currently on the market that are currently being utilised by educational institutions. One website mentions that there are over seventy-five products currently on the market. These products have varying capabilities as a resource-base.

The aim of this chapter is to evaluate these products according to the list of criteria compiled in the previous chapter (Table 4.1).

5.2 CURRENT PRODUCTS

According to the Teaching, Learning and Technology Roundtable of the Wayne State University (1999), there are over seventy-five courseware applications available to consumers. Not all of the applications that are available are suitable for the educational environment. In fact, there is a growing market for courseware applications in the human resources departments of the commercial sector. Furthermore, not all of the available courseware may be categorised as resource-bases. A large number of courseware applications, however may be classified as resource-bases. Amongst the more popular of these applications are WebCT, Blackboard, Lotus LearningSpace and TopClass. Each of the products will be evaluated based on the basis of Table 5.1; however, it is necessary to first briefly introduce each of the products. After the brief history and short description of WebCT, Blackboard, Lotus LearningSpace and TopClass, a more detailed comparison will follow.

5.2.1 WebCT

The majority of educational institutions who have the capacity to buy electronic teaching aids have chosen to purchase WebCT. According to many of these institutions, one of the overriding factors for selecting WebCT as the product of choice is that WebCT was developed by an educational institution (the University of British Columbia). This implies that many of the features that the product offers are specifically designed for educators.

As with a growing number of resource-bases, WebCT does not only offer the software which drives electronic learning, but also supplies, at a price, content in pre-packaged formats called e-Packs (WebCT, 2001).

WebCT's website is `http://www.webct.com/`

5.2.2 Blackboard

Developed by Blackboard Inc., Blackboard is said to be striving for an "end-to-end e-learning solution". The product was originally conceptualised at Cornell University as a student-and-faculty project. The company, Blackboard Inc, arose from this collaboration in 1997. At first, Blackboard software was called "CourseInfo" and was very reasonably priced. However, the numerous stability and scalability problems put the new software at a disadvantage.

When Blackboard released the latest version of "CourseInfo" (version five), they changed the name to Blackboard.com. The application is particularly aimed at the complete institution, providing features to facilitate online communities, especially on-campus student communities.

Blackboard's pricing structure is developed around the services that are on offer. The greater number of services bought, the more one will pay for the licence. Blackboard's licences are available as level-one, level-two or level-three. A level-one licence will allow an institution to manage its courses; while a level-two licence includes all the features of a level-one licence and allows the institution to add the facilities to create a customised institution-wide learning portal. The level-three licence includes all the features of a level-two licence, improves the course management system and includes the ability to support online communities.

Blackboard allows institutions to either host their own servers or take advantage of their free hosting service (TeleEducation NB, n.d.; EduTech, 2002; Yaskin & Gilfus, 2002).

Blackboard's web presence is at `http://www.blackboard.net`.

5.2.3 Lotus LearningSpace

The Lotus Development Corporation holds the copyright for LearningSpace. It is currently being marketed under IBM Mindspan Solutions. Unlike Blackboard and WebCT, LearningSpace has been developed in the corporate world and has business enterprises as their target market. This is especially seen in the facilities that LearningSpace provides for the integration of its software with Enterprise Resource Planning (ERP) systems, Human Resource Systems and e-commerce systems. Lotus maintains that LearningSpace is a group of modules which can be combined to offer unique solutions to individual clients' needs.

Some of these options include the Lotus Domino system, the LearningSpace Core Module and the LearningSpace Collaboration Module. The LearningSpace Core Module contains the student and administrator interface as well as the engine that distributes tracks and manages the course content. The Collaboration Module is an optional module which requires that Lotus Domino be installed. The Collaboration Module adds the collaboration functions as well as the synchronous live activities such as white boarding and video conferencing.

The LearningSpace homepage is `http://www.lotus.com/home.nsf/tabs/learnspace` (TeleEducation NB, n.d.; IBM Mindspan Solutions, 2001).

5.2.4 TopClass

TopClass is a line of products developed by Web-based Training Systems (WBT Systems). These products include TopClass Mobile, TopClass LMS, TopClass Competencies, Topclass and TopClass Publisher. The architecture of the system is depicted in Figure 5.1 which is available from the TopClass Whitepapers.

WBT Systems claim that each of the modules may be bought separately and that not all of the modules need to be purchased in order for TopClass to run efficiently on a network. This is because each of the modules tackles a different focus area within the learning management system.

Starting at the top of Figure 5.1, the various modules of TopClass are as follows:

- TopClass Mobile is the module of TopClass that facilitates off-line learning. Learning material may be downloaded onto a PC or laptop for study at a later date.
- TopClass LMS or TopClass Learning Management System allows learners to register for the courses or lessons that are offered on the system. The LMS also controls the number of learners in each course and creates a waiting list of learners should a course be oversubscribed.
- TopClass Competencies is the assessment component of the learning system. It enables the testing or assessment of learners.
- TopClass or TopClass LCMS (Learning Content Management System) is the "engine" of the entire learning management system. This component controls

the interaction/collaboration facilities, the compilation of lessons and the learner profiles.

TopClass Publisher is the content layer of the TopClass system. It facilitates the editing, creation and importation of content or Learning Objects into the TopClass system. In TopClass, Learning Objects form the basis of the courses that are available on the system.

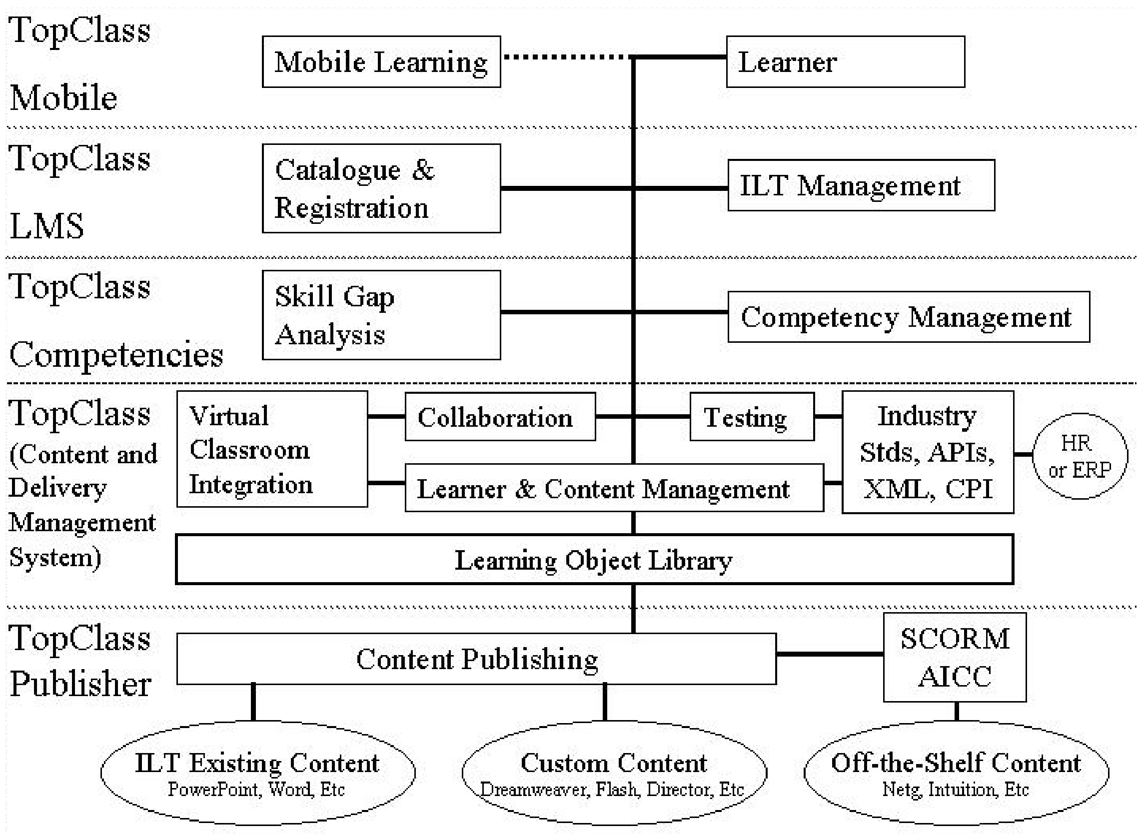


Figure 5.1: TopClass Architecture

Source: TopClass Whitepapers

The TopClass website encourages potential buyers to contact their consultants to develop a combination of the above modules that suits the buyers' teaching and learning needs. Although TopClass offer a wide range of services, the suite does not offer all the educational services. Added functionality is done by WBT Systems' partner, Centra.

The homepage of TopClass is http://www.wbtsystems.com/ (TeleEducation NB, n.d.; TopClass whitepapers, 2002; EduTech, 2002).

5.3 EVALUATION OF PRODUCTS

The information for the evaluation was not readily available. The official homepages for each of the products are complete with the necessary advertising materials, which focus only on the positive points of the system they are advocating. There are hardly any neutral sites that give evaluations of systems that aid learning and education. These sites are not only scarce but are also not all-inclusive in their investigation. A number of studies comparing the various systems have been done, but due to the rapid development and continual updating of software products, these studies become outdated at an alarming rate. The following evaluations, therefore, are a mixture of both the advertising materials (white papers) and the comments and evaluations done by fellow educators kind enough to publish their findings on the Internet.

5.3.1 WebCT

The release of WebCT which has been evaluated in the following study is version 3.6. The sites that form the basis of this evaluation are:

`http://www.edutech.ch/edutech/tools/comparison_e.asp` (EduTech, 2002).
`http://www.webct.com`
`http://software2.bu.edu/webcentral/research/courseware/index.html`
(Boson University, 2001).

The evaluation will be in the order of the criteria given in the table at the end of the previous chapter (Table 4.1).

Educators have the ability to define course objectives in WebCT. However, these objectives serve only as information and stand separated from the actual content and learning path of the courses.

The learners may be linked to more than one course at a time.

It is known that WebCT does not support the linking of individual learners' profiles to personal misconceptions.

Educators are able to create, import and delete courses in WebCT. The editor that is included in WebCT does not seem to support editing to a large extent. The importation of external resources is more commonly utilised than the creation of resources from within the WebCT program.

Learners are able to upload certain pages and create their own web pages for the purposes of assignments or to share information. These pages are only available to the learners once the educator has given the learners permission to do so.

The defining of misconceptions is not possible within WebCT.

As previously mentioned, WebCT does not fully support the concept of learning objectives and thus does not facilitate the linking of course objectives to the learning content.

Since the defining of misconceptions and the concept of learning objectives are not fully supported, it may be concluded that WebCT does not meet the eighth requirement.

Neither educators nor students are able to evaluate the quality of resources available to them via WebCT.

WebCT has facilities that allow users to perform advanced searches on key words. These key words could be found in the course content, content module table of contents, headings in content pages, and discussion articles. To be able to search the image database, the images have to be uploaded individually.

It is not clear whether or not resources may be readily shared amongst all the users of WebCT.

WebCT may cost quite a substantial amount of money. The most recent quote stands at $5000 USD (per year). This, at the exchange rate which was R6.54 on the 18th of December 2003 to the US Dollar), works out to be in excess of thirty-three thousand South African Rands per annum (South African Reserve Bank, 2003). Even in American terms, the recent price hikes by WebCT seem exorbitant and prohibiting. Many American educational institutions that have previously bought WebCT can now no longer afford to continue paying the ever-increasing licensing costs (Auer, 2001).

There is no indication that WebCT offers the personalisation services suggested by the requirements even though the WebCT advertising material insists that its software can offer learners personalised learning. The implementation of the "personalisation" functions of WebCT is not detailed or described on the WebCT site, nor are they reviewed in any other literature.

WebCT allows the learners to create their own web page. In this web space, the learners are allowed to create web pages and upload files. The learners may also track their own learning progress. Learners may also change the look-and-feel of their web portal (called myWebCT). No further details regarding the further personalisation of learning is available. It is therefore assumed that no additional facilities for the personalisation of learning exist.

WebCT have made their system relatively easy to maintain and control.

The seventeenth requirement states that "The resource-base should allow for at least three types of user profiles: learner, educator and administrator." WebCT has, in all, five user groups: administrator, designer (or instructor), student, teaching assistant and guest. WebCT only allows one administrator per server. The administrator has full rights to the system and may create the other users with relevant rights and privileges. The course designer (also called a course author) has full rights and privileges to the course content and may even create learner profiles with relevant privileges. There may only be one course designer per course. The designer may, however, grant access to other users as designers with limited privileges. The teaching assistant has the rights to grade quizzes and change the grades of the students within the relevant course as well as view the course contents. A guest is not a default WebCT account and is created by the course designer. The guest is a modified learner account with the same access privileges as the learners.

User-friendliness and ease of navigation are based on the fact that all the courses within WebCT have a similar look-and-feel. WebCT also provides a navigation trail that allows users to see the path taken to get to a particular page or screen. Boston University criticises the administrator's interface for being "inconsistent and unconventional" which gives the administrators a steeper learning curve.

A standard web browser is the interface for WebCT on the client side. On the server side, WebCT supports Windows NT, Windows 2000 and a wide range of UNIX versions, including Red Hat Linux. MacOS is not supported.

Authentication takes place in the form of username and passwords, which are the same for all the courses for which a learner is registered. For further security, a Kerberos password system may be implemented. Educators (or instructors) and administrators have a separate interface and also have username and password authentication.
WebCT advocates that it is IMS compliant.

WebCT is truly scalable and may be made able to a vast number of learners.

Overall, WebCT is a good program with many features and an excellent track record. For the purposes of individualised teaching, however, it does not fully fit the requirements.

5.3.2 Blackboard

Blackboard 5.0 is the current version available from Blackboard Inc. The websites used in creating this evaluation are:
`http://www.blackboard.net`
`http://astro.temple.edu/~jburston/CALICO/review/webct-bb.htm`
`http://www.edutech.ch/edutech/tools/comparison_e.asp` (EduTech, 2002).
`http://software2.bu.edu/webcentral/research/courseware/` (Boson University, 2001).

As in the WebCT evaluation, the order followed will be that of the requirements table at the end of the previous chapter (Table 4.1)

Requirement one states that educators should be able to create, edit and delete courses, syllabi, course objectives, sub-objectives and the links between them. Blackboard does not fully support this function. The course objectives have to be created separately from the course structure and thus do not support interlinking.

The second requirement is that of creating learner profiles. The educators and administrators should be able to link these profiles to courses and misconceptions. One should also be able to link learner profiles to more than one course. Blackboard does not support misconceptions. However, it does support a number of excellent user management functions. One of these functions allows for three methods of creating learner profiles: individual learner creation by educator, batch enrolment (upload a text file) and open enrolment. Learners may be registered for more than one course at a time. A level-three licence allows Blackboard to integrate with the institution's learner management system. A level-three licence, however, is rather expensive.

In Blackboard, it is not easy to add any existing resources. EduTech (2002) maintains that the "Add Existing Resources" functionality has a number of bugs. There is also a management system for external links which stores the Uniform Resource Locator (URL) of the resources related to each course.

The only manner in which Blackboard facilitates learners in being able to add resources to the resource-base is for the learners to create a personal webpage. Within this webpage they are allowed to publish three favourite links.

Educators should be able to identify possible misconceptions and link these misconceptions to the relevant objectives and resources. This is the sixth requirement. Blackboard's only support of this requirement is to make learners' grades available to them at the educators' discretion.

The seventh requirement states that educators should be able to create, edit and delete the links between course objectives and resources. As mentioned above, Blackboard does not fully support the development of course objectives. This implies that the resources for the course cannot be linked to the course objectives.

Blackboard does not support misconceptions.

Blackboard does not provide the functionality to allow educators to critique the quality of the resources within the resource pool.

Learners, too, are not able to critique the resources for quality.

The eleventh requirement is that advanced search facilities should be available. Blackboard has no search facilities whatsoever.

The sharing of resources between educators is facilitated by the creation of authors with varying access rights. If an educator is made an author, then he or she may view all the courses and their relevant resources.

The thirteenth requirement states that the resource-base should be cost effective and affordable. One of the most recent quotes for the purchase of a level-one licence from Blackboard stands at five thousand US Dollars per annum. A level-one licence is the most basic of all of the packages offered by Blackboard. This is a rather high price to pay for any educational institution. A source that was last updated in February 2001 quotes the price of a level-two licence to be at twenty-five thousand US Dollars and a level-three licence to be fifty-thousand US Dollars. Both of these prices are for systems of less than twenty-five thousand users (EduTech, 2002). Getting a quote from Blackboard is not an easy task. Their website claims that it is because an institution needs to select the solution which best suits the institution's needs. Each component of the solution costs money. Should the institution wish to actually add courses into this solution, then these need to be purchased either from Blackboard themselves or from their publishing partners. Some of the courses purchased for Blackboard need a licence per learner (Blackboard, 2001).

Suggested resources individualised according to course, misconceptions, background and learning style is a condition that is not fulfilled in Blackboard. Blackboard allows a learner to view the course content that is organised in a hierarchical structure. The learner is allowed to view any of the material within that structure. Educators are able to give individual learners materials by a manual process of "dragging-and-dropping" the resources into the learner's drop box.

The only links that learners are allowed to create are the three links that are contained within the learners' personal webpage. Thus, requirement thirteen has not been fulfilled.

Blackboard's resource-base is relatively easy to maintain, since it uses a basic SQL engine. Besides the import/export problems, that do not allow for links between pages or editing after uploading, Blackboard allows for easy organisation. Courses are structured into pages or text files and course folders. The pages can be simply moved between course folders.

Blackboard's user access allows for six types of users: instructor, teaching assistant, grader, course builder, student and guest. Thus, in this regard, Blackboard does very well, since it not only allows for the six types of users, but also allows individual user rights to be modified.

The eighteenth requirement necessitates that the resource-base should be user friendly and easy to navigate. Blackboard has a relatively good user-interface. The positive aspects to the user-interface are that it is consistent and simple to understand. Blackboard also provides a navigation trail that allows users to see the path taken to reach a particular screen or page. The negative aspects are that the "back" button on the web browser does not always work and that there are no previous-page or next-page navigation buttons. Navigation via the "Course Map" tool is potentially frustrating, since the documents cannot be accessed via their individual names. The only links in the "Course Map" are the chapter headings.

Blackboard is platform independent since the front-end is a Java applet. It thus works with the majority of web browsers and does not require any plug-ins or extra software to run at the client side. On the server side, the only operating system that is not supported is the MacOS. A two-server configuration is recommended for level-two and level-three licensed programs. Thus, Blackboard fulfils the nineteenth requirement.

User security within Blackboard is done via username and password security. A learner needs only one username and password to access all the courses for which he or she is registered. At the Boston University, the Blackboard security system is integrated with a Kerberos password system, thus creating a tighter security measure than normal.

Blackboard is one of the technical contractors for IMS and has announced its support for the IMS standard. The current version of Blackboard supports the following IMS metadata schemes: general, life cycle, technical and rights management information.

Blackboard can support at least twenty-five thousand users on any one licence and is fully able to run on a network and is fully scalable.

As a final note, once a licence has been purchased, Blackboard allows educators to host their courses on the Blackboard.com server for free. Blackboard, as with WebCT, does not cover the issues of individualised learning. Besides this point, it is a good teaching tool and has a very large following in the United States.

5.3.3 Lotus LearningSpace

LearningSpace (version 5.01) was released late in 2002. However, there are very few objective reviews on this software that are currently available. Thus, the previous version of LearningSpace (version 4.0) has been evaluated in this study. The sites used in the evaluation of LearningSpace are as follows:

`http://www.c2t2.ca/landonline`

`http://cite.telecampus.com/LMS/cms.html`

`http://www.EduTech.ch/edutech/tools/comparison_e.asp` (EduTech, 2002).

LearningSpace meets the first requirement since it offers curriculum development and curriculum management facilities. Instead of linking course objectives, however, LearningSpace links the requirements, competencies and skills to a job, course or class. An educator may specify as many learning objectives as deemed necessary. The learning objectives are considered a special resource within LearningSpace.

LearningSpace gives no indication as to whether or not learners may be linked to more than one course at a time.

LearningSpace also meets, partially, with the third requirement. This is due to the ability of LearningSpace to support individual learning paths to some degree. However, the creation of misconceptions is not possible in LearningSpace.

Educators are able to add a variety of resources to their courses. Thus the fourth requirement has been satisfactorily met.

LearningSpace offers learners the facilities to add resources to the CourseRoom. The educator may, if he or she finds the resource of value, add the resource to the MediaCenter. Thus the fifth requirement has been satisfied.

The identification of possible misconceptions and the ability to link these misconceptions to the relevant objectives and resources is the fifth requirement. Since the creation of misconceptions is not possible within LearningSpace, this requirement has not been fulfilled.

The seventh requirement requires that educators should be able to create, edit and delete the links between course objectives and resources. The facilities to link course objectives to resource are available to the educator.

As mentioned previously, LearningSpace does not support misconceptions and thus cannot fulfil the eighth requirement.

The next requirement is the availability of quality control mechanisms for resources. This is not available in LearningSpace.

The learners who use LearningSpace are also not able to critique any of the available resources for quality.

The availability of advanced search facilities is the next requirement. Unfortunately, LearningSpace does not even have the facilities to allow for a keyword search. Its image archive is not searchable either.

LearningSpace does not allow learners to share resources amongst themselves. Educators can share resources by allowing each other to become authors or co-educators their courses. Specific access rights to documents, web pages and activities have to be granted to each educator of a course. This seems a rather cumbersome method of sharing resources but it is the only one available, since there is no centralised management of resources available. LearningSpace requires one of the following databases to be installed on any system that uses the program: Microsoft SQL Server, Oracle or IBM's DB2. These databases are the external programs that manage the resources for LearningSpace.

At the time of writing, the purchase price for LearningSpace was not available. However, IBM is willing to negotiate deals with tertiary education institutions, on a one-to-one basis, that could possibly make LearningSpace more cost effective than its rivals.

LearningSpace allows for a certain degree of individualisation when it comes to access of resources. A pre-test allows the system to determine what skills the learner already possesses and eliminates the learning objects associated with the acknowledge skills. Therefore, for each module, a learner has to complete a pre-test and a post-test. The post-test ensures that the learner has a sufficient proficiency in the skills that are presented within the module. Should the learner fail to demonstrate proficiency, the module is repeated. As previously mentioned, LearningSpace does not make provision for misconceptions, neither does it make provision for personal learning styles nor personal backgrounds and thus cannot completely satisfy requirement twelve.

Learners are not able to personalise their learning profiles other than to decide how to sequence their learning.

LearningSpace makes use of an external resource manager.

User profiles can be custom designed by the administrator. Thus there can be as many user profiles as necessary. User access rights may also be granted on an individual basis. Thus LearningSpace fulfils the user-profile requirement.

EduTech (2002) describes LearningSpace's user interface as "intuitive". The instructor/developer and the administration user interfaces are all web-based.

On the client side, learners may have full access the system only if their computers have a Windows platform. If learners have a MacOS configuration or a UNIX or Linux configuration, some of the communication features are not available. On the server side, not only does the hardware have to be Intel, but the server's platform has to be Windows NT 4.0. The server also requires Oracle, MS-SQL or DB2 in order to run.

The tracking of learner activities within the various courses is one of LearningSpace's strong points. Tracking of the "checking out" and "checking in" by the course authors is also done. The resource manager is an external component, it was thus decided by LearningSpace not to cover the security of the resources. The second half of the requirement is that of user authentication. This is done by means of username and passwords. A learner has one username and password to access all the courses for which he or she is registered.

LearningSpace claims to support both IMS and AICC. It is known that it is possible to import AICC-compliant courses into LearningSpace.

LearningSpace's scalability is one of the top strong points of the software, according to EduTech (2002).

Since LearningSpace is a relatively new release, not much is known about it. A number of educational institutions are still running the older versions of LearningSpace. For example, the University of Wisconsin-Eau Claire is still running LearningSpace 2.6. The number of educational institutions that have purchased LearningSpace are less than those who have purchased into Blackboard and WebCT. LearningSpace, too, does not make any provision for individualisation beyond the cosmetics of look-and-feel.

5.3.4 TopClass

At the time of writing, the current TopClass system available from WBT Systems is TopClass 4.2. The sources used to complete this evaluation are available on the Internet:

`http://www.edutech.ch/edutech/tools/comparison_e.asp` (EduTech, 2002).
`http://www.wbtsystems.com/products`

Requirement one states, "Educators should be able to create, edit and delete courses, syllabi, course objectives, sub-objectives and the links between them". TopClass offers the facilities to create competencies or skills requirements. These learning objectives may be viewed as hierarchically as content and associated activities. Thus, it can be said that TopClass has implemented the first requirement in a suitable manner.

Requirement two states, "Educators and administrators should be able to create learner profiles and link them to courses. It should be possible to link one learner profile to more than one course." Not only are educators and administrators able to create learner profiles, but also learners are able to register themselves for courses. It is not clear whether or not it is possible to link a learner to more than one course at a time.

Linking learners to misconceptions, however, is not supported.

Educators should be able add resources to the resource-base. This is requirement three, which TopClass not only fulfils but WBT Systems claims that one is also able to include references to non-electronic resources such as books. This is to aid the learners to find the information they require to complete their courses.

In TopClass, learners are not able to add any supplementary resources of their own. Thus, requirement four is not met.

Educators are not able to identify possible misconceptions and link these misconceptions to the relevant objectives and resources in TopClass. Thus, requirement five is not met.

In TopClass, educators can create links between the courses and the relevant resources.

Since TopClass makes no provision for misconceptions, no linking between the resources and the misconceptions are possible.

TopClass Publisher allows educators to create and edit the components of courses (which TopClass calls Learning Objects). No provision, however, is made for educators to evaluate the quality of the resources that is being imported or utilised.

With no provision being made for educators to evaluate the quality of the resources, it is assumed that the learners also do not have this facility available to them.

TopClass allows for advanced searches by both educators and learners. These searches may be conducted on keywords that can be found in the body of the learning content or in the titles of the resources. Image searches are also possible.

It is possible for educators to share resources amongst the courses. This is done via the Learning Objects. The sharing of resources amongst the learners, however, is not facilitated.

A quote given on the 29th of July 2002 from IOCORE (`http://www.iocore.co.za/`) suggests that TopClass is not cost-effective for tertiary educational institutions. IOCORE is a South African company that installs and maintains learning systems for South African businesses. TopClass may cost an institution in excess of two million South

African Rands for a three-year contract or an average of over six hundred thousand Rands per annum.

TopClass does attempt to individualise learning by means of pre-testing and post-testing. This enables the system to gauge whether the learner needs certain Learning Objects. In this manner each learner could receive a differing set of Learning Objects for each course. TopClass, however, does not make provision for learning style, personal background, and, as previously mentioned, personal misconceptions.

The TopClass database is relatively simple to maintain. It uses the Oracle database as a foundation and allows for batch registration for learners. The disadvantage to this arrangement is that an Oracle licence is essential to the execution of TopClass modules.

There are six user profiles that may be applied: administrators, owners, instructors, students, guests, and world.

TopClass's interface is relatively good; EduTech (2002) describes it as intuitive. Learners can customise the "look and feel" by changing the colours and fonts of the web interface. TopClass also has a non-context sensitive help.

TopClass may be run from a standard web browser and supports Windows NT, Windows 2000 and Solaris for the functions that are server-supported. TopClass does not support MacOS.

TopClass supports the authentication of users by requesting a username and password at logon. Learners may change their own passwords. The creation of backup copies is supported.

TopClass fully supports Aviation Industry CBT Committee (AICC) standard to allow it to interact with the Centra virtual classroom solution. WBT systems have an agreement with Centra. Centra provides the interaction components, such as white boarding facilities, chat room facilities and audio conferencing, to TopClass. TopClass is currently advocating that it is also fully compliant with Sharable Content Object Reference Model (SCORM) standard.

TopClass can handle up to one thousand learners and may be run on network. Lessons may also be downloaded onto mobile units such as laptops for later reading or editing, in the case of the educators.

Although TopClass has a method of individualising learning, this methodology alone is not enough. TopClass does not make provision for a learner's previous knowledge, misconceptions or learning styles.

5.4 IN SUMMARY

The above-mentioned systems may be summarised in Table 5.1.

Even though all four systems are well-established and have many excellent features, their ability to help learners on an individualised basis is lacking. TopClass is the closest any of the systems comes to analysing and individualising learning. TopClass, however, does not cater for personal learning styles, misconceptions and possibly differing learning levels.

Another overriding factor that comes to the fore is the cost of purchase. With the exception of LearningSpace, none of the systems cost less than seven-hundred thousand Rand per year. The price of LearningSpace has yet to be published, but it may be assumed that it, too, will cost in the region of seven-hundred thousand Rand per year.

If a resource-base could be written, that can achieve all of the above factors, what would it look like? A possible model and prototype for this model will be presented in the following chapters.

LEGEND

SYMBOL	MEANING	SYMBOL	MEANING	SYMBOL	MEANING
(smiling face with graduation cap)	Well implemented	(neutral face)	Mediocre implementation	(frowning face)	Not well implemented or not implemented

TABLE 5.1: TABLE OF COMPARISONS

NO	REQUIREMENT	WEBCT	BLACK BOARD	TOP CLASS	LOTUS LEARNING SPACE
1	Educators should be able to create, edit and delete courses, syllabi, course objectives, sub-objectives and the links between them.	Mediocre implementation	Mediocre implementation	Well implemented	Well implemented
2	Educators and administrators should be able to create learner profiles and link them to course. It should be possible to link one learner profile to more than one course.	Well implemented	Well implemented	Well implemented	Not well implemented or not implemented
3	Educators and administrators should be able to link learner profiles to one or more misconceptions.	Not well implemented or not implemented	Not well implemented or not implemented	Not well implemented or not implemented	Not well implemented or not implemented
4	Educators should be able add resources to the resource-base.	Well implemented	Well implemented	Well implemented	Well implemented
5	Learners should be able to add resources to the resource-base.	Mediocre implementation	Not well implemented or not implemented	Not well implemented or not implemented	Well implemented
6	Educators should be able to identify possible misconceptions and link these misconceptions to the relevant objectives and resources.	Not well implemented or not implemented	Not well implemented or not implemented	Mediocre implementation	Not well implemented or not implemented
7	Educators should be able to create, edit and delete the links between course objectives and resources.	Not well implemented or not implemented	Not well implemented or not implemented	Well implemented	Well implemented
8	Educators should be able to create, edit and delete the links between course objectives, resources and misconceptions.	Not well implemented or not implemented	Not well implemented or not implemented	Not well implemented or not implemented	Not well implemented or not implemented
9	Educators should be able to critique the resources for quality.	Not well implemented or not implemented	Not well implemented or not implemented	Not well implemented or not implemented	Not well implemented or not implemented
10	Learners should be able to critique the resources for quality.	Not well implemented or not implemented	Not well implemented or not implemented	Not well implemented or not implemented	Not well implemented or not implemented

<table>
<tr><th>NO</th><th>REQUIREMENT</th><th>WEBCT</th><th>BLACK BOARD</th><th>TOP CLASS</th><th>LOTUS LEARNING SPACE</th></tr>
<tr><td>11</td><td>Advanced search facilities should be available.</td><td colspan="4"></td></tr>
<tr><td>12</td><td>The sharing of resources between users should be facilitated.</td><td colspan="4"></td></tr>
<tr><td>13</td><td>The resource-base should be cost effective and affordable.</td><td>$3300 USD (per year)</td><td>$5000 USD (per year)</td><td>R2 143 314 (3 yr total)</td><td>Not yet published</td></tr>
<tr><td>14</td><td>The automated list of suggested resources should be individualised according to course, misconceptions, back-ground and learning style.</td><td colspan="4"></td></tr>
<tr><td>15</td><td>Learners should be able to link their own resources into their profiles according to personal interest, learning style or misconceptions.</td><td colspan="4"></td></tr>
<tr><td>16</td><td>The resource-base should be easy to maintain.</td><td colspan="3"></td><td>External Maintenance</td></tr>
<tr><td>17</td><td>The resource-base should allow for at least three types of user profiles: learner, educator and administrator.</td><td colspan="4"></td></tr>
<tr><td>18</td><td>The resource-base should be user friendly and easy to navigate.</td><td colspan="4"></td></tr>
<tr><td>19</td><td>The resource-base should ideally be platform independent and be executable from a wide range of computers.</td><td colspan="4"></td></tr>
<tr><td>20</td><td>The resource-base should offer security in the form of authentication of users and audit logs.</td><td colspan="4"></td></tr>
<tr><td>21</td><td>The metadata should be compliant to one of the known standards.</td><td colspan="4"></td></tr>
<tr><td>22</td><td>The resource-base should run on a network (e.g. intranet) and be scalable.</td><td colspan="4"></td></tr>
</table>

Chapter 6

Resource Base Model: Concepts

6.1 BACKGROUND

As previously discussed, there is a need for a resource base that suggests resources to learners based on personal preferences and personal misconceptions. The following chapters introduce and detail the model of the suggested solution.

The resource base could be used as a stand-alone tool for the classroom; however, it is designed to work within a larger framework. This larger framework, called an integrated educational system, involves a group of learning and teaching tools that is focussed on improving educational standards and quality within tertiary educational institutions. The set of tools could be utilised within any educational situation, if correctly modified. Each computer-based tool has a specific function and each tool should interact with each other synergistically.

6.1.1 The Framework

The integrated educational system model is based on the concepts of Outcomes-Based Education. This is the standard for education at all levels within South Africa. The reasons for the development of this model have been multifaceted. Some of the reasons have been mentioned in Chapters 2 and 3 and include such challenges as larger number of learners in classes and the diversity of learners within these growing classes. Thus the need for a holistic educational tool that is both practical and applicable to the South African educational experience. The integrated educational system model has several distinctive characteristics. It does not replace the educator and the classroom; rather it includes the classroom as an integral part of the educational experience. Educators, too, are an essential part of the educational experience within the integrated educational system model. It is these two characteristics that distinguish the integrated educational system from the other educational systems (Harmse, 2002; El Saddik, Fischer & Steinmetz, 2000; Freedman, Ali & McRoy, 2000).

One of the primary concerns of the model is to ensure that the educator is not overburdened with the administration of these growing classes. The use of computer-aided technology has thus been considered to facilitate the easing of the administrative burden of the modern educator.

The integrated educational system model's components, thus, may be divided into several focus areas. The first is the theoretical component covering the educational aspects of outcomes-based education and the impact that this paradigm has on education and the implications of using computer technology within the outcomes-based paradigm. This component laid the foundation for the rest of the model. It was completed as a project by Rudi Harmse, a lecturer at the Port Elizabeth Technikon towards the completion of his Master's Degree. This Master's thesis goes under the title of "A Conceptual Object-orientated Model to Support Educators in an Outcomes-based Environment" and was completed in 2001 (Harmse, 2001).

The following figure (Figure 6.1) is an illustration of the model for the integrated educational system.

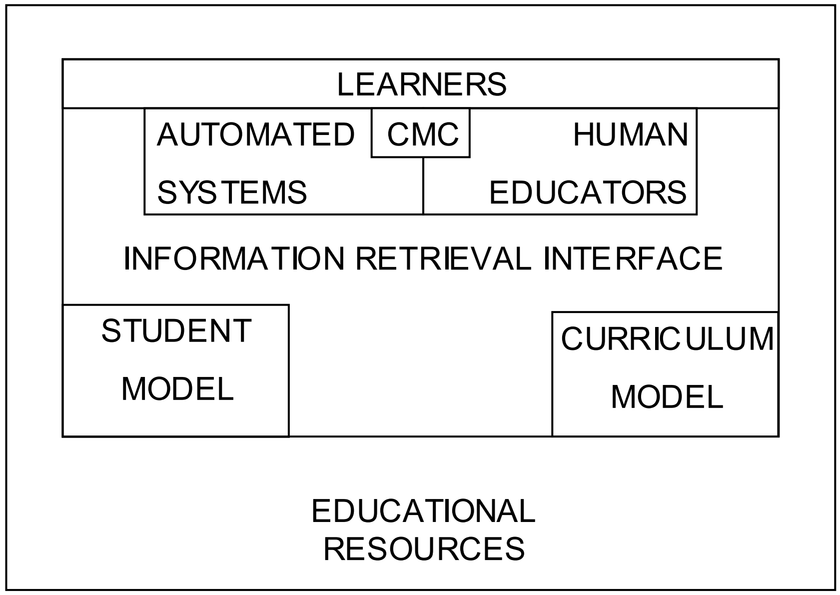


Figure 6.1: An Integrated Educational System Model

The general idea behind the integrated educational system model is to modularise the entities while still providing a means for communication between the modules. One of the important functions of this model is to provide for information sharing between the different elements of education (Harmse, 2001).

The modules or elements of the integrated education system may be divided into two basic categories: human and non-human. The human elements are simply the educators and the learners. The discussion and details roles and expectations of these users have, to some extent, already been discussed in Chapters 4 and 5. The further discussion of these users is beyond the scope of the current study. The non-human elements are those that may either be electronic and/or paper-based, such as the educational resources and the Computer Mediated Communication (CMC) module.

The CMC module is a component that provides communication between the learners and between the learners and the educators. CMC includes tools such as e-mail facilities, Internet Relay Chat (IRC) and the various conferencing facilities, such as video conferencing and white boarding. Automated Systems such as Computer-Based

Training (CBT) programs or ITS programs may also use CMC's to communicate with learners and educators by means of an automated e-mail response or prompting.

One such automated system was written and completed by one of the Master's Degree students, Grant Pullen, of the Port Elizabeth Technikon. Mr. Pullen's thesis, which is titled "The Development of a Model to Effectively Utilise Computer Mediated Communication to Support Assessment in a Virtual Learning Environment", was completed in 2001. The system developed by Mr. Pullen enabled learners to write tests and assignments electronically and upload them into the system. The niche area of this automated system was the computer-programming arena.

This means that provision was made to upload computer programs into the system for automated grading. The system would send, via e-mail, a receipt to the learner after the system had accepted an assignment. This receipt was proof of handing in and should be kept for further reference by the learner. The system also did a fair amount of automated grading for the educator, although it could not tackle some of the more complex issues. These complex issues, such the misinterpretation of questions or assignments, are noted by the system and passed onto the educator for further grading (Pullen, 2001).

Once the grading has been completed, the system passes data to the Student Model via the Information Retrieval Interface. This interface aids communication between all the components of the integrated educational system. Through the interface, educators are able to update and view the learner data stored in the administration database and the curriculum model. The interface also allows learners to access their own data for purposes of personal progress reporting (Harmse, 2001).

The Student Model component is the part of the system that stores the learner data. This data includes details of learner progress according to the curriculum goals. The curriculum goals (or objectives) are stored in the Curriculum Model component. The interaction between the Student Model and the Curriculum Model is a closely-knit one.

The Curriculum Model is the standard against which the learners are measured and assessed (Harmse, 2001).

The Curriculum Model's ideal contents include the curriculum goals for a course or subject. Each curriculum goal is associated with one or more misconceptions. A curriculum goal also consists of one or more outcomes (Harmse, 2001). A more detailed explanation of the contents of the Curriculum Model will be discussed later in the chapter and further in Chapter 7.

The Student Model contains a learner profile. This profile consists of four basic sub-profiles: report, achievement profile, misconception profile and the learning preference. Each of these sub-profiles play a role in determining the type of learning resource a learner will receive.

The final component of the integrated education system model is the educational resources component. The resource base forms a part of this component. As previously stated, the aim of the resource base is to provide learners with individual learning experiences based on personal misconceptions, learning preferences and their registered courses (Harmse, 2001).

To achieve this goal there are numerous factors that must be considered. The first factor is that of standards. As with all computer programs, interoperability is one of the major points of consideration and this is where standards play their role. The second factor is that of the database structure. The basic structure, which will form the foundation of the database, may eventually determine its overall success in terms of ease of use and ease of administration.

6.1.2 The Standards (Alphabet Soup)

There are many standards for describing educational resources on the Internet. These standards suggest the meta-data that should be included in educational resources for simpler and easier identification. There are several standards currently available. The Institute for Electrical and Electronic Engineers (IEEE) Learning Technology Standards Committee (LTSC) has developed the Learning Objects Meta-data (LOM). Educom is responsible for the Instructional Management Systems (IMS) project (El Saddik, Fischer & Steinmetz, 2001). There is also the Dublin Core (DCMI, 2002), the Sharable Content Object Reference Model (SCORM) (ADL, 2002) and the Aviation Industry CBT Committee (AICC) (AICC, 2002).

As previously mentioned, the IEEE has a developing standard called the LOM or Learning Object Meta-data, amongst a plethora of other standards, which range from Aerospace Electronics to Voting System Engineering. The group that is currently involved in the development of the Learning Technology standards is the IEEE Learning Technology Standards Committee (LTSC). This group has a number of working groups under its wide umbrella, ranging from Architecture and Reference Model Working Group to the Digital Rights Expression Language Study Group; of which the Learning Object Meta-data (LOM) Working Group is one (IEEE, n.d.). The LOM Working group has defined a Learning Object (LO) as "any entity, digital or non-digital, which can be used, re-used or referenced during technology-supported learning" (IEEE LTSC, n.d.). The IEEE is using the opportunity to consolidate the standards set by other institutions into their LOM model. The IEEE Standards Association homepage address is `http://standards.ieee.org/` (Anido-Rifón *et al.,* 2001).

The National Centre for Supercomputer Applications (NCSA) in collaboration with the Online Computer Library Center (OCLC) developed a list of meta-data elements called "The Dublin Meta-data Core Element Set". This is the Dublin Core that was first agreed upon at a Meta-data workshop in March 1995. The Dublin Core strives to develop a set of meta-data elements, which are universally acceptable to all parties who use and develop electronic media or resources. Thus, the Dublin Core covers a wide range of resources, from software to web pages. Dublin Core, therefore, is a much-generalised set of meta-data elements. It was found that these general elements were not necessarily suitable for all purposes and some specialist streams are currently under development. Amongst these specialist streams is the educational facet, which is being scrutinised and refined by what used to be known as the Dublin Core Education Working Group (DCEd). More information about the Dublin Core and their latest working draft may be found at the Dublin Core Meta-data Initiative Homepage, `http://dublincore.org/` (DCMI, 2002).

One of the standards bodies with which the DCEd work is the Instructional Management Systems (IMS) Working Group. The IMS may be found at `http://www.imsproject.org` and Educom (now called Educause), who are responsible for the IMS, may be found at `http://www.educause.edu`. The IMS working group consists of a number of software companies, training producers and educational institutions. The IMS's focus is solely on education. This allows the IMS to produce standards for resources as well as for learners. The IMS developed the IMS Learner Information Package (IMS LIP) that supports the storage of learner data and allows for interoperability between packages concerning learner data. The IMS have specifications that deal not only with learners and resources but also with interoperability, packaging and their latest addition, digital repositories (IMS, n.d.).

Another standard was developed in January, 2000 by Advanced Distributed Learning Network (ADLNet). This standard was named the Sharable Courseware Object Reference Model or SCORM 1.0. The focus of SCORM 1.0 was to empower training within the American Department of Defence (DoD). The web presence of ADLNet is `http://www.adlnet.org`. With the release of SCORM 1.1, the name, SCORM was changed to stand for Sharable Content Object Reference Model. ADL claim that this new name is a better description of the standard. According to ADL, SCORM is also trying to create "one unified 'reference model' of interrelated technical specifications and guidelines designed to meet DoD's high-level requirements for Web-based learning content" (ADL, 2002).

The Department of Defence is not the only industry to create a standard for describing media used within an educational genre. The American Aviation Industry also initiated a move to describe resources, called the AICC or the Aviation Industry CBT Committee. The objectives of the AICC are to aid the aviation industry, in particular, with the training of airplane operators, develop the guidelines necessary to ensure interoperability and provide a forum in which CBTs and other training technologies may be discussed. The AICC have developed their AGR, which stands for AICC Guidelines and Recommendations. These are recommendations for the technical aspects within specific areas. Although the AICC is focussed on the aviation industry, it does contribute and collaborate with the other standards, in particular, IMS, ADL and IEEE/LTSC. The AICC homepage is `http://www.aicc.org/` (AICC, 2002).

Each of the standards has a number of commonalities. The first is that although each professes to work with each other, they still remain separate. This is because, although the standards' area of interest is the same (educational resources), their goals and objectives remain disparate. The goals of the standards will, in turn, have an effect on the type of meta-data that will be prescribed. It follows that each of the standards has a number differences. To choose to follow a particular standard to the letter could mean a certain amount of inoperability with another standard. It has been suggested that one does not blindly follow one standard, but rather investigate the standards and glean the details to suit one's own needs (Dublin Core, 2002; AICC, 2002; SCORM, 2002; El Saddik, Fischer & Steinmetz, 2001; ADL, 2001).

Another commonality which all the standards (or Meta-data Schemas) have is that they are all in flux. The DC Ed calls their meta-data schema a "working draft", while the AICC has a number of versions of their AGRs available on their website. ADL also has a number of versions of SCORM available on their website and has a "latest developments" link that announces that the last update to SCORM was in November

2003. The last update on the IMS website regarding their Content Packaging Standard was on the 12th of June 2003 (Dublin Core, 2002; ADL, 2002; AICC, 2002; IMS, 2002). Thus, there is currently very little stability in the world of meta-data schemas.

As previously mentioned, the standard bodies do communicate and confer with each other. This is due to the common consensus that some sort of agreement on the standards is required. For example, SCORM is largely based on the AICC's guidelines and the IEEE's LOM. The board members for SCORM even include advisory members from the IEEE and AICC. Dublin Core also acknowledges the IEEE and has endorsed some of the components of the IEEE initiative (ADL, 2002; Dublin Core, 2002). The IMS standard is the basis of some of the SCORM components (IMS, n.d.).

The above-mentioned factors, i.e. that the standards are currently in a state of flux and that there is no consensus on standards, lead to the conclusion that although a standard should be adhered to, it might not be possible to fully comply to a particular standard. The IMS currently has one of the most comprehensive guidelines in the educational field. Thus, for the resource base, the IMS guidelines and meta-data schema will be adhered to as closely as possible. Some of the IMS guidelines are not entirely complete, nor are all topics covered, e.g. Curriculum. The initial prototype for the resource base will, therefore, not be completely standard-compliant but further developments on the prototype should adhere to one of the well-known standards, if not the IMS.

6.1.3 The Database Model

The decision to follow a particular standard runs concurrently with the designing of the database. One of the first steps in designing a database is to determine the basic processes that the database system will be expected to perform. From this analysis, a database structure is chosen. The role of the database structure is foundational, since it will affect the logical and physical view of the database. There are five basic database structures: hierarchical, network, relational, multidimensional and object-oriented. Each of the database structures has its own advantages and disadvantages (Elmasri &

Navathe, 1989, pp. 253–350). The remainder of the chapter will be devoted to the exploration of the database structure and the logical view of the resource base.

6.2 RESOURCE BASE MODEL: OVERALL VIEW

As previously mentioned, the first step in developing a database is the analysis of the processes it will be expected to perform. This, for the resource base, has been discussed in detail in the previous chapters.

6.2.1 A Brief Overview of Processes

There are numerous basic processes that are central to the resource base. Figure 6.2 illustrates the majority of these processes.

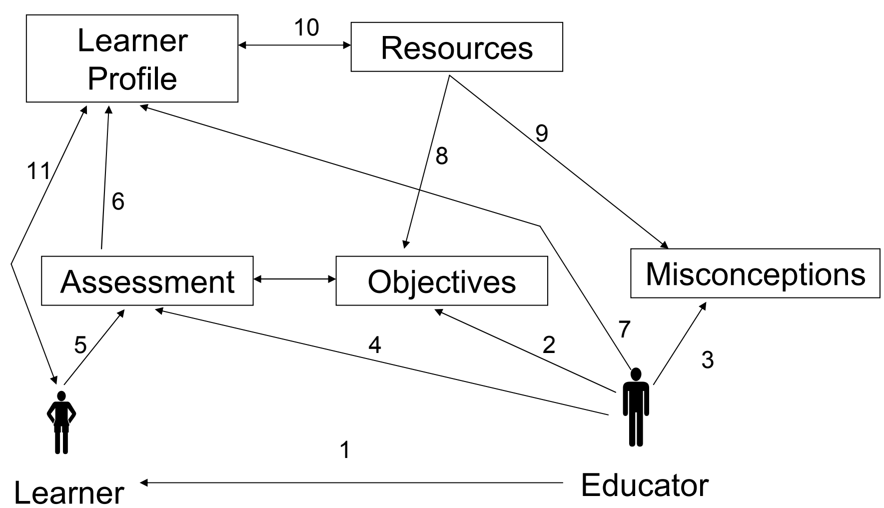


Figure 6.2: Basic Resource base Processes

Each of the processes has been labelled as a number. A brief overview of these processes and their function within the resource base is as follows:

Process 1: An educator teaches a learner. This process may be done without the aid of any electronic media or tool. It is the most fundamental of all the processes.

Process 2: An educator creates, modifies and removes objectives.

Process 3: An educator creates, modifies and removes misconceptions. These are all the misconceptions that learners might have regarding the objectives and the concepts of a course.

Process 4: An educator creates, modifies and utilises assessments. Although the assessment process is beyond the scope of the resource base, it should be noted that the assessment results have a dynamic role to play.

Process 5: The learner is assessed. This assessment may take on a variety of formats including assignments, practical and written tests, examinations and projects. The assessment, as mentioned in Process 4, is beyond the scope of the resource base.

Process 6: The learner profile is updated. This is the role of the assessment within the resource base. The assessment directly influences the learner's profile and updates the data on the learner's personal abilities (i.e. what the learner understands) according to the objectives of the course.

Process 7: The educator is able to view and edit the learner's profile.

Process 8: The relevant resources are linked to the appropriate objectives.

Process 9: The relevant resources are linked to the appropriate misconceptions.

Process 10: The resources are read from the learner profile according to the individual learner's misconceptions and learning objectives.

Process 11: The learner accesses his or her own learning profile to update personal details, individual learning styles and preferences as well as personal interests. The learner may also view his or her own learning profile to gauge personal progress.

Two processes which are not shown in Figure 6.2 are the searching processes. The learner should be able to search the resources and find resources relevant for his or her own studies or personal interests. The educator, too, should be able to do advanced search queries on the resources to find relevant resources to link to objectives and misconceptions.

For these processes, the most popular choice would be the normalised relational structure. The relational database, however popular, might not be the best choice for the task at hand (Elmasri & Navathe, 1989, pp. 349–350).

6.2.2 The Normalised Structure

The normalised, relational structure has a number of advantages. It can process an ad hoc query quickly and simply. The normalised, relational structure was developed to effectively store data. However, it has a limitation on the amount of transactions it can efficiently process and it cannot handle complex, high volume applications. The normalised structure is also a relatively mature data model. In previous years, especially when the normalised structure was developed, the size of databases was small in comparison to the databases currently available. As the size of the database increases, so the time and processing power required to perform queries containing joins increases. This increase is generally at an exponential rate (Elmasri & Navathe, 1989, p. 349; Kimball, 1996, p. 9). Therefore, the normalised structure is suited to a few of the processes required by the resource base, but not all of the processes.

It is envisaged that the normalised structure will support the functions and processes of the storage of the learner profile, the storage of the educator profile the storage of the course details (such as course name, objectives, sub-objectives and intended outcomes), the storage of the relationship between courses and objectives (and sub-objectives), the storage of the relationship between the objectives and misconceptions, the storage of the resource details, e.g. title, author, media type and date of creation and the assessment data should also be stored and accessed from a relational structure.

However, as previously mentioned, the assessment component is not truly a part of the resource base. The learner model component interacts with the assessment component to update each learner's profile.

The reason for choosing the normalised structure for these processes is simply that the relational structure is an excellent storage facility and is good at the ad hoc queries envisaged for the type and amount of data being stored. A further consideration is the probable low frequency in the number of queries and the anticipated ad hoc nature of the expected queries (Codd, 1990; Date, 1986, pp. 12–19). A further investigation on how the normalised structure will support the above-mentioned processes will be done in Chapter 7.

The normalised structure may be an excellent media for ad hoc queries; however, there is one drawback of the normalised structure in this area. The normalised structure becomes less efficient as the complexity of the queries increases. This phenomenon is directly related to the size and number of tables being used within any particular query. Increasing the size and number of tables within a query decreases the efficiency of the query. This leads many businesses to resort to other methodologies to increase the speed of complex queries. One of these methods is the use of data warehouse technologies (Connolly& Begg, 1998; McFadden, Hoffer & Prescott, 1999, pp. 529–531).

6.2.3 The Star Schema

Data warehouses, within a business context, are used to store enormous amounts of data. This data is largely historical in composition but may also contain operational data. The purposes of this repository are for the discovering of trends and patterns using Online Analytical Processing (OLAP) and other regression programs.

To discover trends and patterns, often a large number of tables need to be joined and totals and averages need to be calculated. Within a normalised relational structure, joining and aggregating these diverse tables take quite a bit of time and resources (i.e.

memory and CPU processing). For this reason, within a data warehouse, there is a reasonable amount of "non-normalisation". This is the large-scale use of the concepts of controlled redundancy. Tables are structured in such a way that totals and averages are stored as a field. Tables are also stored in a "joined" state. This improves the efficiency at which queries may be done, even if the data warehouse is created using a relational database management system (Connolly & Begg*,* 1998, p. 941; McFadden*,* Hoffer & Prescott, 1999*,* pp. 529–556; Kimball, 1996, pp. 8–9, 29–30).

The term "star schema" is given to the design of a data warehouse. In the same manner an Entity Relationship Diagram (ERD) describes a relational database; a star schema describes a data warehouse. Thus, it is envisaged that the data warehousing technologies should aid the resource base in advanced search functions and in the creation of individual learners' resource lists. A further study of the data warehousing technologies and the star schema used to create and streamline the prototype of the resource base follows in Chapter 8.

6.2.3 Interaction between Models

The effective melding of the two models (the normalised structure and the star schema) is a foundation of the resource base. The normalised structure and the star schema have to work together, in order to achieve some of the more complex functions needed by the resource base. These more complex functions include the access of the learner profile and the resource base in order to suggest resources for individual learners and the facilitating of advanced searches based on author details, key words, objectives, sub-objectives, misconceptions, media type or courses.

Further investigation into these interactions is done in Chapter 8.

6.3 CONCLUSION

There are numerous considerations when developing a resource base. The first consideration is that of standards. Standards ensure interoperability with other programs and databases. There are, however, various standards from which to choose and these standards are, at present, not all in agreement with one another. The standards are also in a state of flux and requirements are steadily changing to meet the needs of modern computing. The decision to follow a particular standard was thus not taken. The prototype will thus attempt to adhere to the general standards for describing educational resources and will perhaps require a unique meta-data schema.

The second consideration is that of database structures. Two database structures were chosen. These two databases will compensate for each other's weaknesses, i.e. where one is weak, the other is strong. The two structures chosen are the normalised, relational structure and the star schema. The details of these two structures and how they interact will be expounded on within the next two chapters.

Chapter 7

Normalised Database

7.1 INTRODUCTION

As mentioned previously, the resource base model consists of two components: the normalised structure and the star schema (denormalised structure). This chapter will include an in-depth study of the normalised component, including the design phases of the database, the conceptual model and the refining of the resource base schema. The normalised component has its basis in the Relational Database Model (RDB).

7.2 RELATIONAL DATABASE MODEL

The "father" of the relational model is widely acknowledged as Dr. E.F. Codd. He first introduced the model in the 1970's (Codd, 1970). The model's signature is its table format with rows and columns forming records and fields (Chen, 1976; Codd, 1990, pp. 1–3). Today, the relational model is popular with a majority of businesses. The model is typically used to support their daily transactions and keep record of these transactions for further analysis. There are numerous reasons behind this popularity. Codd (1990, pp. 431–440) cites fifteen advantages to the relational model (and the database management system).

One of the fifteen advantages that Codd (1990, pp. 431–440) mentions is the ability to perform ad hoc queries. In comparison to the older systems such as network databases or hierarchical databases, a relational database management system (RDBMS) does not require the prior setting of access paths. Early advocates of the RDBMS extol its ability to perform and optimise queries in "minimum time" (Codd, 1990, pp. 431–440; Date, 1986, pp. 533–535 & pp. 574–577).

Another advantage of the RDB is the ability to restrict users by applying user views. User views work on the principle of "what the eyes do not see; the heart does not grieve over". Users are given access to selected information on a need-to-know basis only. This gives a further level of security and privacy that previous database models did not offer (Date, 1986, pp. 533–535 & pp. 574–577; Codd, 1990, pp. 431–440). An implication of the restriction of user views is that a RDB has the ability to share data amongst users. A RDB allows for multiple users to connect to the database simultaneously. The feature that permits this simultaneous connection is the concurrency control (Elmasri & Navathe, 1989, p.13).

A further advantage is the flexibility of the RDB. Since there is separation between the rules of the database and the data itself, there is an ability to change those rules without affecting the existing data. This allows for the correction of those inevitable mistakes that are made either at the design phase or the implementation phase (Date, 1986, pp. 533–535 & pp. 574–577; Codd, 1990, pp. 431–440; Elmasri & Navathe, 1989, pp. 25–28). Codd (1990, p. 432) describes this feature as making the RDB a very "forgiving" database model.

The ability of the RDB to control data redundancy or unnecessary data duplication is seen as one of the more powerful applications. Data redundancy not only takes up valuable storage space but also potentially reduces the integrity of the data being stored (Codd, 1990, pp. 5–6; Elmasri & Navathe, 1989, pp. 12–13).

The other advantages to the RDB are interrelated with the above-mentioned positive aspects and may be read in Codd's "The Relational Model for Database Management (Version 2)", written in 1990.

To sum up, relational databases are excellent data-storage facilities. They are also relatively quick with simple ad hoc queries. Relational databases allow for security measures using the principles of user views and multiple user-interfaces. Relational databases are also flexible and allow for changes to the underlying structures while the daily transactions continue.

In order to make the most of the advantages of the relational model, proper design is imperative.

7.3 DESIGNING THE DATABASE

There are some authors who advocate four basic phases in the design of a relational database: the requirements analysis, the conceptual design, the logical design and the physical design. Other authors prefer to have six phases: requirements collection and analysis, conceptual database design, choice of a DBMS, data model mapping (logical design), physical design and database implementation (Elmasri & Navathe, 1989, pp. 457–460). Although there are slight differences in the structure each author gives to the design phases, the basic principles remain the same. Each of the phases marks an important stage in database development and should each produce a product (Elmasri & Navathe, 1989, pp.454–460). Although there are four or six phases in database design, these phases are not mutually exclusive and do not need to be processed in the order in which it has been given (Elmasri & Navathe, 1989, p. 458). For this study, the four phase design model will be used.

The first phase in the design is the requirements collection and analysis or the requirements analysis. This first stage determines the data needs of the organisation or the situation at hand (Elmasri & Navathe, 1989, pp. 460–461). For the resource base, this phase has already been completed in Chapters 2, 3 and 4.

The second phase is the conceptual database design which is the overall, high-level view of the database (database schema). It is independent of any data model and describes the scope of the database. A preliminary Entity-Relationship Diagram (ERD) is often used to describe a conceptual database design (Chen, 1976). The basic processes needed for the resource base have already been discussed in Chapter 6 and the ERD for the resource base will follow later in this chapter.

The third phase is the data model mapping or the logical design. The normalisation of the data model is one of the standard processes associated with this particular phase. Security needs and data integrity issues are also a consideration at this design level. The data model now becomes data-model dependent, since the database schema developed in the second phase is tailored to the abilities of the chosen DBMS. The tailoring to the abilities of the DBMS also includes the measuring of the efficiency of the database. The efficiency of the database, in this case, will depend on the ability of the resource base to perform complex queries relatively quickly (Elmasri & Navathe, 1989, pp. 472–473; McFadden, Hoffer & Prescott, 1999, pp. 46–48). The details to this phase will also be explained later in this chapter.

The fourth phase is the physical design. This design phase includes deciding how the data will be physically organised, i.e., it is within this stage that the fields and tables are defined from the entities and attributes which were identified from the previous phase (logical design). The processing programs and scripts that aid the database are also designed at this level (McFadden, Hoffer & Prescott, 1999, pp 46–48).

The last phase is the physical implementation of the database (Elmasri & Navathe, 1989, p. 474; McFadden, Hoffer & Prescott, 1999, pp. 46–48).

Since the first phase for the resource base has already been completed, it follows that the remaining phases need further discussion.

7.4 CONCEPTUAL MODEL

The second phase of database design involves expressing the future database as a schema. The methodology available for this is the ERD. The ERD is an expression of the relationships that exist between the entities of the database. At the highest level of abstraction, the ERD for the resource base is shown in Figure 7.1. The entities for the resource base are rather complex, e.g. the learner profile and the course information.

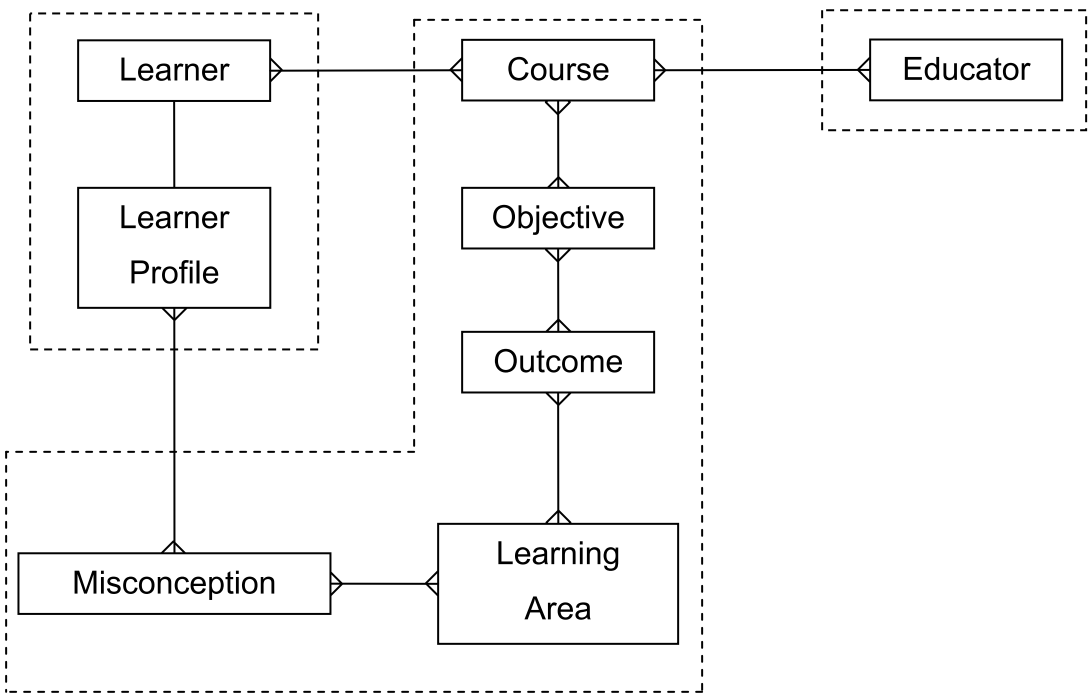


Figure 7.1: A Preliminary Entity-Relationship Diagram

7.4.1 The Learner Profile

The learner profile, as seen in Chapter 6, contains a large amount of data. This data allows for the personalisation of learning. In order for the resource base to be compatible with the integrated educational system model, a brief overview of the learner package for the integrated educational system model is required. The integrated educational system requires a record for each learner to be created. The progress of each learner is recorded within four separated profiles. Each learner should have an achievement profile, a misconception profile, a report profile and a learning preference profile (Harmse, 2001).

The achievement profile keeps a record of the learner's attainment of the assessment standards. The assessment standards are basically the "traditional" objectives of a course or module of a course. Thus, the achievement profile is used to determine what the learner already understands (Harmse, 2001).

The misconception profile tracks the problem areas experienced by the learner during the course of his or her learning. Therefore, the misconception profile is used to determine what the learner does not understand (Harmse, 2001).

The learning preference profile, as discussed in Chapters 2 and 3, should keep track of the learner's personal preferences in terms of type of learner (visual, audio, etc.); personal interests and learning disabilities.

The report is used to aggregate one or more profiles into a single report which may be utilised for any reporting/progress measurements required by the institution (Harmse, 2001).

Thus, for the learner profile, it is possible to move onto the third phase of database design (logical design) and create the refined version of the learner-profile segment of the ERD which is shown in Figure 7.2

The fourth stage of database design (physical design) entails the definition of the data fields into the identified data tables. Subsequently, to facilitate this, the finer details of the data fields have to be considered. These details include field names, data types and field sizes. In the physical design, foreign keys and associative tables also need attention. In order to simplify the intercommunication between the packages, the IMS project's suggestions will be adhered to as closely as possible. As mentioned in the previous chapter, the IMS project focuses mainly on the transfer of data between programs; it does not prescribe how the standard should be utilised within the resource base (IMS, n.d.). The IMS does, however, have several standards that may be utilised within the resource base, including its learner information standard. The configuration of the package will be discussed further later in the chapter.

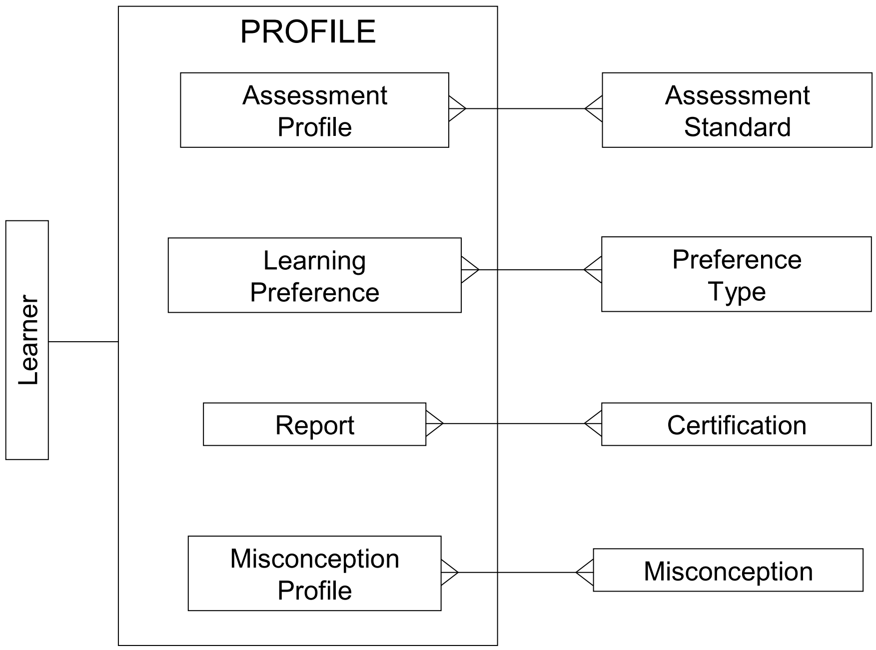


Figure 7. 2: Refined Learner-Profile ERD

The IMS Learner Information Packaging Information Model Specification is the very comprehensive learner information standard set by the IMS. The objectives of this model specification are to enable the recording of learning-related history, goals and accomplishments; facilitate the engagement of the learners in their own learning experiences and to aid the discovery of learning opportunities for learners (IMS, n.d.).

The IMS divides learner information into eleven main categories, which include identification, goal, qualifications, interest, competency, accessibility, security key and relationship. A brief explanation of the categories is as follows (IMS, n.d.):

- The identification category stores biographical information about the learner such as name, address and demographics.
- The goal category stores data that includes descriptions of personal aspirations and may be used to monitor personal progress.
- The qualifications, certifications and licenses (qcl) category includes data about the learner's prior learning experiences.
- The interest category encompasses the learner's personal interests, hobbies and other recreational activities.
- The competency category goes hand-in-hand with the qcl category in describing the learner's competence regarding specified objectives and skills.
- Accessibility contains the learner's preferences for learning as well as any other information that might be deemed necessary in determining a learner's accessibility to his or her learning. This other information includes disabilities and language skills.
- The security key (securitykey) category stores all the necessary security data such as passwords and user identities.
- The relationship category may be deemed as a type of meta-meta-data. It stores data about the relationship between the learner profile and the other data structures within the resource base, such as courses (IMS, n.d.).

The IMS Learner Information Packaging Information Model Specification, can be found on the IMS Specifications web page `http://imsproject.org/profiles/lipinfo01.html`.

The table below illustrates the fields needed to store the learner data within the learner profile as well as the IMS equivalents:

TABLE 7. 1: LEARNER PROFILE FIELDS

LEARNER				
Resource base Field Name	**IMS Equivalent**	**IMS Recommended Data types**	**Description**	**Purpose**
L_ID	uid (item 2.7.8)	String 1-32 characters	Learner Identity Number	Stores the primary key for a learner, e.g. Student number
L_Surname	name (item 2.4)	String	Learner Surname	Stores the learner's surname
L_Firstnames	name (item 2.4)	String	Learner First Names	Stores the learner's first names or given names
L_Title	name (item 2.4)	String	Learner Title	Stores the learner's title, e.g. Mr, Ms, Rev.
L_email	email (item 2.6.8)	Text and/or numerical 1-128 characters	Learner E-mail Address	Stores the learner's contact e-mail address
L_gender	gender (item 2.7.5)	Enumerated as 'male' or 'female'	Learner Gender	The gender of the learner (see Chapter 4.2.4)
L_dob	date (item 2.7.6)	date	Learner Date of Birth	The age of the learner may be determined from the date of birth (see Chapter 4.2.4)
L_password	Securitykey (item 11.1)	Text and/or numerical 1-128 characters	Learner password	The password the learner uses to access his or her profiles (see Chapter 4.3.2). Assuming that username is L_ID.

ASSESSMENT PROFILE				
Resource base Field Name	**IMS Equivalent**	**IMS Recommended Data types**	**Description**	**Purpose**
L_AC_ID	uid (item 2.7.8)	String 1-32 characters	Learner Assessment Criteria ID	Foreign key from the Learner entity (see Figure 7.2)
L_AC_Comp	Competency (item 7.1)	String	Learner Competence	Foreign key from the Assessment Criteria entity (see Figure 7.2) Field stores whether or not the learner has achieved competence within the Assessment Criteria
L_AC_Date	Competency (item 7.1)	Date	Date of completion	Date the learner demonstrated competence regarding the Assessment Criteria

LEARNING PREFERENCE

Resource base Field Name	IMS Equivalent	IMS Recommended Data types	Description	Purpose
L_LP_ID	uid (item 2.7.8)	String 1-32 characters	Learner identity Number	Foreign key from the Learner entity (see Figure 7.2)
L_LP_1stLang	language (item 3.3)	String 1-1024	Learner Home Language	The home language of the learner. (see Chapter 3.3). e.g. Xhosa
L_LP_2ndLand	language (item 3.3)	String 1-1024	Learner's second language	The second language of the learner. (see Chapter 3.3.). e.g. English
L_disability	disability (item 3.6)	Still under development	Learner learning disabilities. M:N relationship with Disability Types.	Any learning disabilities that the learner might have, e.g. attention deficit hyperactivity disorder (see Chapter 3.2.9).
L_disabcomm	comment (item 3.6)	String	Learner learning disabilities comment. Part of the Learner-Disability M:N relationship with Disability Types.	This field gives an indication as to the severity of the learning disability and any progress made, e.g. Learner is under professional medical treatment (Dr. J.M. Smith) – medication prescribed and great improvement seen in learner behaviour.
L_LearnPref	preference (item 3.4)	The domain will be defined by a cognitive-type vocabulary	Learner's learning preference	The learner's main learning style is stored to allow for more personalised learning (see Chapter 3.2.6), e.g. audio learner (who learns better from hearing than from any other sense).
L_LP_ID	Interest (item 8.1)	The domain type will be defined by an appropriate vocabulary	Learner's personal interest (M:N relationship with an Interest table)	Stores the learner's interest so that learners may have a personalised learning experience (see Chapter 3.2.5 and Table 4.1: requirement 13), e.g. F1 racing, aeroplanes, and marine ecology.

MISCONCEPTION PROFILE

Resource base Field Name	IMS Equivalent	IMS Recommended Data types	Description	Purpose
LMis_ID	uid (item 2.7.8)	String 1-32 characters	Learner ID	Foreign key from the Learner Entity (see Figure 7.2 & Chapter 3.2.5)
LMis_Comment	None defined		Misconception General comments	Any general comments regarding learner misconceptions in general, e.g. Learner has trouble understanding abstract concepts.
Mis_ID	None defined		Misconception ID (M:N relationship with misconception table)	Foreign key from Misconception Entity (see Figure 7.2 & Chapter 3.2.5)
Mis_Comment	None defined		Specific Misconception Comments (M:N relationship with misconception table)	Any comments regarding a learner's specific misconceptions, e.g. Learner has trouble understanding how a recursive procedure passes values.
Mis_Date	None defined		Date of Misconception discovery	The date the specific misconception was first diagnosed. (Part of the M:N relationship with misconception table)
Mis_Complete	None defined		The date of clarification of the misconception	The date when the learner demonstrated that the misconception is no longer a personal misconception. (Part of the M:N relationship with misconception table).

REPORT

Resource base Field Name	IMS Equivalent	IMS Recommended Data types	Description	Purpose
Rep_ID	uid (item 2.7.8)	String 1-32 characters	Report ID	Foreign key from Learner entity (see Figure 7.2)
Rep_Comment	None defined		A general learner report	This field is used for general comments regarding the learner and the learner's progress, e.g. Learner has potential but is not putting the effort that can be expended on the Mathematics.
Rep_ComDate	None defined		The date the above comment was made	This field is used to store the date of last update of the comments made.
Cert_ID	Affiliation (item 9.1) or competency (item 7.1)	The domain type will be defined by an appropriate vocabulary	Recognition of Prior Learning (M:N relationship between Report and Certification)	Foreign key from a certification entity that describes the certification, e.g. MCSE, or qualifications the learner has subsequently completed beyond the scope of the institution (see Chapter 3.3)
Rep_RecDate	Affiliation (item 9.1) or competency (item 7.1)	Date	The date of recognition of prior learning. (Part of M:N relationship between Report and Certification)	This field stores the date that the certificate, diploma or degree was recognised as a part of the learner's prior learning file.
Rep_comment			RPL comment. (Part of M:N relationship between Report and Certification)	This field stores any general comment concerning the recognition process of the certificate, e.g. RPL granted by Prof Black on condition that learner completes Database module.

As previously mentioned, the IMS has a very comprehensive standard. However, as seen in Table 7.1, this standard does not include Misconceptions. Other learner information that is included within the Learner Profile is that of the learner interests. This inclusion will aid the personalisation of resources and facilitate Table 4.1's requirement 14. Requirement 14 states that "The automated list of suggested resources should be individualised according to the course, misconceptions, background and learning style." The Preference Type will allow the learner to receive resources according to his or her individual learning style (Chapter 3.2.6; Table 4.1: requirement 14).

The learner information is not the only data that needs to be stored. The information about what courses the learners are registered for, is also important.

7.4.2 Course Information

The data being stored for each course within the resource base is relatively complex. It should not just include the name of the course, but also the course details. It seems as if the IMS does not, as yet, have any specifications on course details. Outcomes-Based Education (OBE) is the current educational paradigm within the South African context. OBE is also the paradigm within which the integrated educational system model is found (Harmse, 2001).

The integrated educational system model defines a curriculum goal package, which, in essence, holds the information needed for each course. The curriculum goal package includes details about each curriculum goal. A number of goals are set per subject or course. For each curriculum goal, many outcomes may be defined.

An outcome may be of two types: a critical outcome or a specific outcome. A critical outcome may span several learning arenas (or courses). An example of a critical outcome might be that the learner should be able to work effectively with others as a member of a team or group. This outcome requires interpersonal skills, communication skills and the knowledge required to complete the assignment or project. Thus, it may not be possible to assign a critical outcome to any particular learning area. Specific outcomes, on the other hand, may be described as broadly defined goals for certain learning areas (Harmse, 2001).

The structure of the course information component would suggest a structure as illustrated in Figure 7.3:

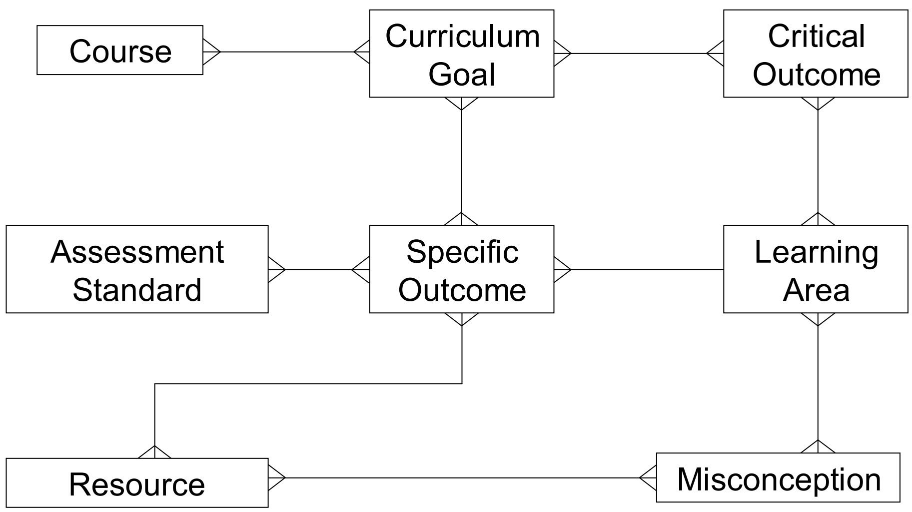


Figure 7.3: Refined Course Information ERD

As with the learner profile, the relevant fields have to be arranged into appropriate tables. This is the fourth stage of the design phase and because of the multiple M:N relationships, will be slightly more complex than the learner profile. The following table (Table 7.2) attempts to fulfil the requirements of the fourth design stage:

TABLE 7.2: COURSE INFORMATION TABLE

COURSE

Resource base Field Name	Description	Purpose	Relationship to other Entities
C_ID	Course ID or Course Code	Primary Key, e.g FIS1100	M:N with Curriculum Goal
C_Name	Course Name	Course Name, e.g. Financial Information Systems I	
C_Description	Course Description	This field stores the course description in order to market the course to prospective learners, e.g. Upon completion of this module, the student should demonstrate a high level of computer literacy, including an understanding of computer terminology, hardware and software and how to use and manage information technologies to produce meaningful information. In addition, the student should be able to answer discussion type questions in a satisfactory manner.	

CURRICULUM GOAL

Resource base Field Name	Description	Purpose	Relationship to other Entities
CG_ID	Curriculum Goal ID	Primary Key	M:N relationship with Course and M:N relationship with Critical Outcome and Specific Outcome
CG_Content	Curriculum Goal statement	This field stores the curriculum goal	

CRITICAL OUTCOME

Resource base Field Name	Description	Purpose	Relationship to other Entities
CO_ID	Critical Outcome ID	Primary Key	M:N relationship with Curriculum Goal and Learning Area
CO_Content	Critical Outcome statement	This field stores the critical outcome.	

SPECIFIC OUTCOME

Resource base Field Name	Description	Purpose	Relationship to other Entities
SO_ID	Specific Outcome ID	Primary Key	M:N relationship with Assessment Criteria, Resource and Learning Area
SO_Content	Specific Outcome statement	This field stores the specific outcome	

LEARNING AREA

Resource base Field Name	Description	Purpose	Relationship to other Entities
LA_ID	Learning Area ID	Primary Key	M:N relationships with Critical Outcome, Specific Outcome and Misconception
LA_Name	Name of Learning Area	The name or title of the learning area is stored in this field	
LA_Description	Description of Learning Area	The scope and a description of the learning area should be stored	

MISCONCEPTION

Resource base Field Name	Description	Purpose	Relationship to other Entities
MC_ID	Misconception ID	Primary key	M:N relationship with Learning Area and Resource
MC_Title	Misconception name or keyword	As an alternative means of identifying or remembering a misconception	
MC_Statement	Misconception Statement	The misconception itself, written out in full and contains an outline and description of the scope of the misconception.	

ASSESSMENT CRITERIA

Resource base Field Name	Description	Purpose	Relationship to other Entities
AC_ID	Assessment Criteria ID	Primary key	M:N relationships with Specific Outcome and Learner Assessment Profile (See Figure 7.2)
AC_Statement	Assessment Statement	Field holds the actual assessment criteria, e.g. Learner must be able to underline text in a word processing package.	
AC_Type	Assessment Type	The type of assessment that will take place, e.g. continuous evaluation.	
AC_Conditions	Assessment Conditions	The conditions under which the assessment should take place, e.g. project, formal test, examination	
AC_Description	Assessment Criteria Description	Any general comments that need to be included by that cannot be put under any of the other headings, e.g. The assessment level should be on a beginner's level and this skill is necessary to move onto the next level of learning.	

The Course Information, as discussed in Chapter 6, is but one component of the resource base. The information stored in both the Learner Profile and the Course Information needs to be utilised to glean a relevant set of educational resources for individual learners. This implies that a vast array of information about a resource needs to be included within the resource base.

7.4.3 Resource Information

The access of resources is one of the major focal points of the resource base. It follows that it, too, has at least one interesting issue that needs to be addressed.

A foundation issue is to consider if it is necessary to encapsulate the resource within the resource base. This particular issue then raises further questions, namely; copyright, storage methodology and the availability of physical hard drive space.

The physical hard drive space is a matter of economics; i.e. buying extra hard drives or installing a RAID system (Redundant Array of Inexpensive Disks). The issue of storage methodology includes the complexities of storing and accessing diverse types of media, including fully executable programs, such as educational games or virtual reality environments (Section 3.3).

The issue of copyright is a metaphorical "can of worms" for any institution. Educational institutions have to invest financial resources into the assurance that their materials (e.g. software, books, Internet web pages) are copyright compliant. To ensure that no one uses intellectual property without permission, institutions have to copyright and sometimes patent those intellectual properties, which is an additional financial concern (O'Hara & Peak, 2000).

However, if instead of storing the entire resource, only the link to the resource were stored, it would circumvent the majority of the above-mentioned problems. The issues of space and storage methodology are reduced or eliminated. The copyright concern is also reduced, since storing the link to the resource is considered acceptable use without infringing on copyrights (O'Hara & Peak, 2000). Therefore, for the resource base, the use of pointers or a uniform resource locator (URL) will be the method of storing the resource.

An ERD for the resource component is modelled in Figure 7.4.

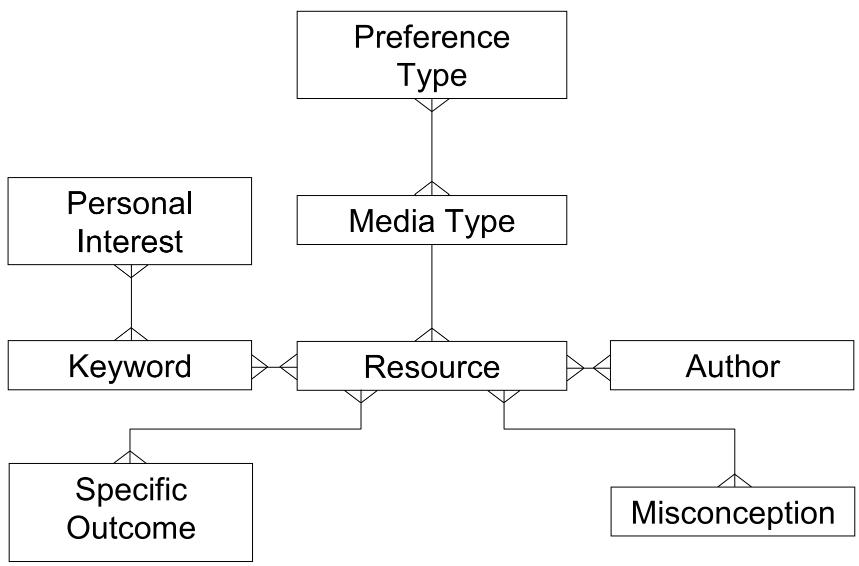


Figure 7.4: Resource Information

The links between Resource, Misconception and Specific Outcome are inherited from Figure 7.1. Application of the normalisation rules will divide the Resource from the Authors or creators (or programmers) of the resource. The normalisation rules will also apply to the Keyword entity, since one resource may have numerous keywords and keywords may be used for more than one Resource. Keywords are also linked to Personal Interest to allow for the inclusion of resources for learner hobbies and personal interests. This particular relationship facilitates point 14 of the criteria list established in Chapter 4 (Table 4.1).

A Resource may be of a particular media type, e.g. text or graphics or a video. These media types will help determine the resources given to a learner based on learning preferences. The learning preferences, as mentioned in Chapter 2.2.5, may be visual (e.g. graphics), audio (e.g. sound files) and a combination of audio and visual (e.g. video).

Table 7.3 describes the fields assigned to each of the entities illustrated in Figure 7.4 with the exception of Misconception and Specific Outcome. The details of Misconception and Specific Outcome were compiled in Table 7.2 under Content Information.

The IMS has a specification for resources available. Version 1.2.1 of the IMS Learning Resource Meta-Data Information Model is the latest version available from their website. Table 7.4 matches the IMS specifications with the fields introduced in Table 7.3.

The IMS Learning Resource Meta-Data Information Model includes the following fields: size, duration, difficulty level, version, copyright restrictions, annotator, learning resource type (e.g. exercise, simulation, questionnaire and diagram) and context. The field of difficulty level is an important inclusion, since this could influence the learner's approach to readdressing his or her misconceptions. The difficulty level basically states whether the learning material for a beginner, intermediate or advanced learner. The version field, which contains information on the version of the learning material, has been omitted. The reasons are two-fold: firstly, a new version of a webpage normally replaces the older version and the old version is no longer made available; secondly, should the older versions of learning materials be available, and relevant, they can be renamed. This means that the version number is included in the name and key identifier of the learning material.

TABLE 7.3: RESOURCE INFORMATION

RESOURCE

Resource base Field Name	Description	Purpose	Relationship to other Entities
R_ID	Resource Code or ID	Primary key	M:N relationship with Misconception and Specific Outcome
R_Title	Resource Title	The title of the resource	
R_EDate	Resource Date of last edit	To determine the age of the resource	
R_Link	Resource Link	A link (e.g. URL) to the resource	
R_CDate	Resource Check date	The date the link to the resource was last refreshed or checked	
R_Language	Resource Language	The language in which the content is presented, e.g. English, French	
R_Description	Resource Description	A brief description of the scope and content of the resource.	
R_size	Resource Size	An indication of the physical size of the resource in pages or in kilobytes.	
R_Duration	Resource Duration	An indication of the duration of the resource, measured in pages or in time.	
R_Difficulty Level	Resource Difficulty Level	An indication of the difficulty level of the resource, i.e. for a beginner, intermediate or advanced learner	
R_Copyright	Resource Copyright	The name of the copyright owner and any copyright restrictions.	
R_Annotator	Resource Annotator		
R_Context	Resource Context	The context in which the resource should be given or the type of the resource, e.g. questionnaire, group work materials, simulation, exercise or diagram.	

AUTHOR

Resource base Field Name	Description	Purpose	Relationship to other Entities
RA_Surname	Resource Author Surname	Who created/wrote the resource	M:N relationship with Resource
RA_FN	Resource Author First Names	The first names of the author	

MEDIA TYPE

Resource base Field Name	Description	Purpose	Relationship to other Entities
M_ID	Media Type ID	Primary Key	M:N relationship with Preference Type and a M:1 relationship with Resource
M_Name	Media Type Name	E.g. Video, picture	
M_Description	Media Type Description	A description of the scope of the media type	

KEYWORD

Resource base Field Name	Description	Purpose	Relationship to other Entities
KW_ID	Keyword ID	Primary Key	M:N relationship with Resource and Personal Interest
KW_Content	Keyword	The keyword facilitates searches (Table 4.1: Requirement 9)	

TABLE 7.4: IMS RESOURCE SPECIFICATION

RESOURCE

Resource base Field Name	IMS Equivalent	IMS Specification Item Number	IMS Recommended Data types	IMS Description
R_ID	Identifier	1.1	String	Globally unique label for learning object
R_Title	Title	1.2	LangStringType (1000 char)	Learning Object's name
R_EDate	Date	2.3.3	DateType	Date of contribution
R_Link	Location	4.3	String (1000 char)	A location or a method that resolves to a location of the resource. Preferable location first.
R_CDate	None Specific			
R_Language	Language	1.4	String (100 char)	Learning object's language; "None" is also acceptable.
R_Description	Description	1.5	LangStringType (2000 char)	Describes learning object's contents

AUTHOR

Resource base Field Name	IMS Equivalent	IMS Specification Item Number	IMS Recommended Data types	IMS Description
RA_Surname	Entity	2.3.2	String (1000 chars)	Entity or entities involved, most relevant first.
RA_FN	Entity	2.3.2	String (1000 chars)	Entity or entities involved, most relevant first.

MEDIA TYPE

Resource base Field Name	IMS Equivalent	IMS Specification Item Number	IMS Recommended Data types	IMS Description
M_ID				
M_Name	Format	4.1	Restricted: MIME type or 'non-digital'. String (500 char)	Technical data type of resource.
M_Description				

Keyword

Resource base Field Name	IMS Equivalent	IMS Specification Item Number	IMS Recommended Data types	IMS Description
KW_ID				
KW_Content	Keyword	1.6	LangStringType (1000 char)	Contains keyword description of the resource.

7.4.4 The Educator Profile

Although the educator is not the major focus of the resource base, the role of the educator within the system cannot be denied (Table 4.1). The educator has a large number of functions within the resource base and thus needs a profile through which to exercise those functions.

From Table 4.1, it can be derived that the educator is a user similar to the learner, but also has added rights and authority. However, an educator does not need all the personalisation functions of the learner. For example, an educator should not need to have the Misconception entity, nor the Assessment Profile. On the other hand, an educator is a person, who also has preferences: learning preferences and teaching preferences (Chapter 3.2.6). Thus, the educator profile should be dissimilar to that of the learners. Table 7.5 displays the fields necessary for the educator's profile within the resource base.

TABLE 7.5: EDUCATOR PROFILE

EDUCATOR

Resource base Field Name	Description	Purpose	Relationship to other Entities
E_ID	Educator ID	Primary Key	M:N relationship with course, personal interest and learning preferences
E_Surname	Educator Surname		
E_Firstnames	Educator First names		
E_Title	Educator Title, e.g. Mr, Prof, Dr		
E_email	Educator's E-mail address	For communication purposes	
E_Interest	Educator's personal interests or hobbies	For personalisation purposes	
E_TP	Educator's teaching preferences	For personalisation purposes	
E_LP	Educator's learning preferences	For personalisation purposes	

Thus, the educator profile is not as complex as the learner profile, although, the educator rights to the resource base will be a lot more extensive.

All the components within the resource base have been detailed in this section; the next section takes a look at the resource base as a whole. Thus, the third stage of the database design (the logical design) has been partially completed. Most of the fourth stage of the database design (the physical design) has also been addressed. The part of the third stage which still needs attention is the issue of efficiency within the resource base.

7.5 REFINING THE RESOURCE BASE SCHEMA

Before discussing the efficiency of the resource base, a complete picture of the resource base is necessary. Figure 7.5 is the culmination of all the previous figures.

In Figure 7.5, some of the entities are connected with dashed lines to clarify their relationship since their pathway intersects another relationship.

Figure 7.5 displays the plethora of many-to-many relationships that exists between the various entities. This could have some repercussions on the efficiency of the queries that need to be carried out by the resource base.

The most common queries that will be performed on the resource base will be those of creating the suggested resource list for each individual learner. This would involve joining the following tables: Learning Preference; Preference Type; Media Type; Personal Interest; Keyword; Assessment Profile; Assessment Standard; Specific Outcome; Misconception; Misconception Profile and Resource.

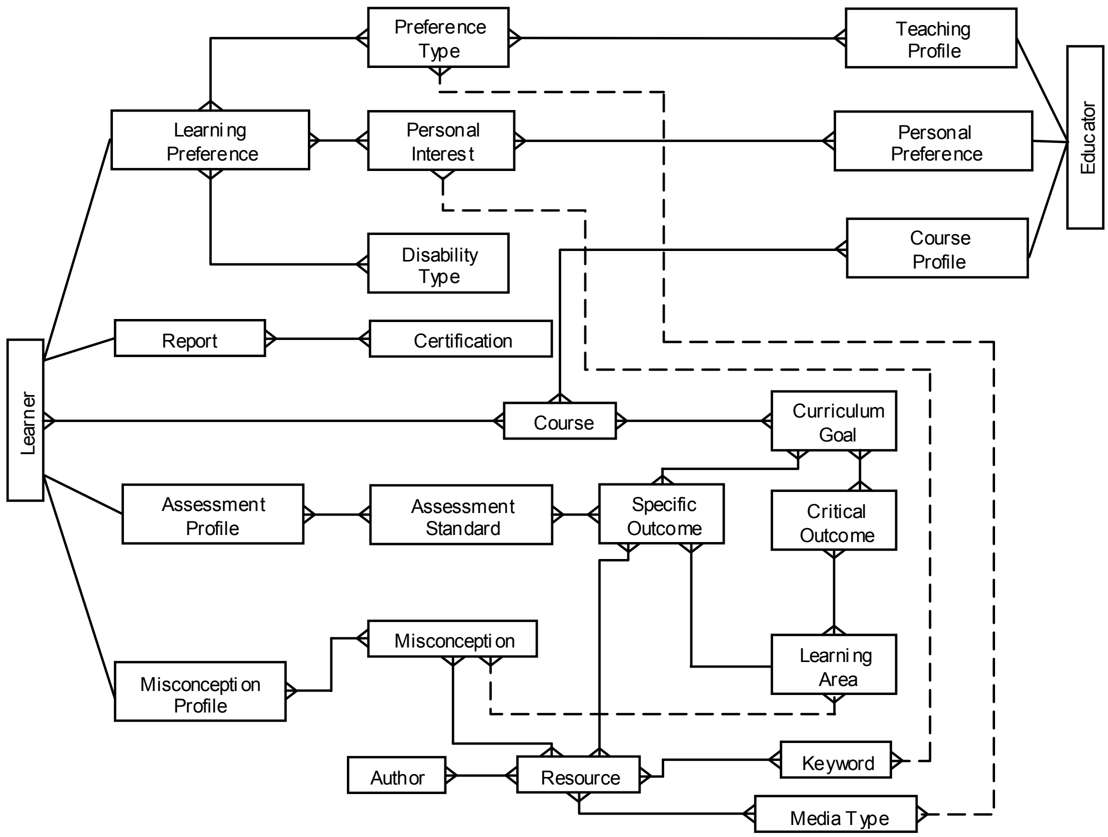


Figure 7.5: Refined Resource base ERD

None of the other envisaged queries are as join-intensive as the abovementioned suggested resource list query. However, the resource list query is one of the main objectives of the resource base. Such a query would be very processor and memory intensive if the resource base is implemented exactly as illustrated in Figure 7.5. As the number of joins within a query increases, so the time it takes to process that query escalates. Another factor which negatively affects the speed of a query is the positive growth in the size of each table (Connolly & Begg, 1998, pp. 626; McFadden, Hoffer & Prescott, 1999, pp. 261–262; Ramakrishnan & Gehrke, 2000, pp. 689–693).

Thus, to increase the efficiency of queries within the resource base, a measure of controlled redundancy needs to be introduced. Controlled redundancy means that some of the entities will be stored in a merged or joined state. Increased query efficiency is the domain of the data warehouse. In essence, a data warehouse stores data in a state of controlled redundancy to facilitate complex queries in an efficient manner (Connolly & Begg, 1998, pp. 913–916, 938; McFadden, Hoffer & Prescott, 1999, pp. 529–556; Ramakrishnan & Gehrke, 2000, pp. 689–670).

7.6 CONCLUSION

As seen, the resource base is a relatively complex structure. A pure and completely normalised structure would not be entirely efficient in executing the envisaged queries. This is due to the nature of the normalised database, which requires joins to be completed when queries involve more than one related table. An increased number of joins decreases the speed of the query.

In order to make the more complex queries more efficient, it is thus necessary to introduce a degree of controlled redundancy. The next chapter will investigate the implications of controlled redundancy and data warehousing techniques.

Chapter 8

Star Schema

8.1 INTRODUCTION

In Chapter 7, the normalised structure of the resource base was explored. It was noted that although the normalised structure is an excellent storage facility, it is not the most efficient when it comes to queries. The problem associated with the normalised database structure is that queries would require an excessive number of joins. This leads to processor capacity being utilised. If the database is being utilised more frequently for queries than for storing transactional data, then the processor could be overtaxed. This is especially true for queries requiring the joining of numerous tables containing a multitude of records. The suggested solution to this quandary is to utilise a star schema.

As mentioned in the previous chapters, the star schema is the technique used to describe a denormalised database. The star schema component has its roots in the arena of data warehousing. The denormalisation technique found in data warehousing will make the resource base's rapid search facility possible. Thus, this chapter will describe star schemas in general and then apply the star schema and data warehousing principles to the resource base.

8.2 DATA WAREHOUSING

Data warehousing is a tool used by an increasing number of businesses today. The data warehouse's main function is to store data from differing sources in a uniform and easy-to-access manner. Data warehouses, in the business world, are usually very large data repositories. Data warehouse sizes are typically measured in terabytes (Kimball, 1996,

p. xxvi, pp. 187–189; Connolly & Begg, 1998, p. 930). The 'father of data warehousing', Bill Inmon (1996), defines a data warehouse as "A subject-orientated, integrated, time-variant, and non-volatile collection of data in support of management's decision-making process".

The differences between a data warehouse and a normalised database are found in their function, form and the type of data stored.

A normalised operational database has its main function in storing operational (transactional) data. Its tables and fields are organised around the applications of a business, e.g. invoices and product sales. A data warehouse, on the other hand, is organised around the subject areas of a business, e.g. customers and sales. This is the *subject-orientated* characteristic of a data warehouse (Inmon, 1996; Connolly & Begg, 1998, pp. 914–915; McFadden, Hoffer & Prescott, 1999, pp. 530–531).

A normalised database stores detailed data stemming from the daily operations of an institution. A data warehouse stores summarised data originating from a smorgasbord of internal, operational databases and external databases. In Inmon's definition of the data warehouse, this is the *integrated* characteristic (Inmon, 1996; Connolly & Begg, 1998, pp. 914–915; McFadden, Hoffer & Prescott, 1999, pp. 530–531).

A normalised, operational database will typically store up to five years worth of data. A data warehouse, conversely, may store a few decades' worth of historical data. An operational database should always be up-to-date and accurate. The characteristic of currency implies that an operational database is a database into which users enter data as transactions are being completed. This transactional data is entered directly into the normalised database by the users, which is in contrast to the data warehouse. A data warehouse, on the contrary, is a "snapshot" of the business data. The current information of the operational database might not be available in the data warehouse until the next data warehouse update. This is the *time-variant* characteristic of the data warehouse (Inmon, 1996; Connolly & Begg, 1998, pp. 914–915; McFadden, Hoffer & Prescott, 1999, pp. 530–531; Oracle Corporation, 2002).

The issue of currency also influences the last data warehouse characteristic: *non-volatility.* A traditional data warehouse is not updated as every transaction occurs; instead, it is updated at regular intervals, e.g. once a month or once a week. Another issue of non-volatility means that new data does not replace the data that already resides within the data warehouse. Instead, the new data is simply added to and integrated into the existing data. A further aspect of non-volatility is that users can only view the data, they cannot edit the data within the data warehouse (Inmon, 1996; Connolly & Begg, 1998, pp. 914–915; Kimball, 1996, pp. 1– 12; McFadden, Hoffer & Prescott, 1999, pp. 530–531; Oracle Corporation, 2002).

Form follows function. The data warehouse exists to offer businesses competitive advantage in decision-making by allowing for ad hoc, complex queries to done in a shorter timeframe than an operational database. This means that the data warehouse, because of its different reason for existence, differs in the way that it looks at a logical level (Inmon, 1996; Connolly & Begg, 1998, pp. 913–914, 937–943; Kimball, 1996, p. 1).

With a normalised database, an Entity Relationship Diagram (ERD) is utilised to design and model the normalised database. Since the data warehouse is essentially different to a normalised database, it follows that a dissimilar schema should be employed in order to both design and model the data warehouse on a logical level. This schema is called the star schema (Inmon, 1996; Kimball, 1996, p. 1; Oracle Corporation, 2002).

8.3 DEFINING A STAR SCHEMA

8.3.1 What is a Star Schema?

In the same way that an ERD describes a normalised relational database on a logical level, a star schema describes a data warehouse on a logical level (Connolly & Begg, 1998, p. 938). Another name for the star schema is a dimension model (McFadden, Hoffer & Prescott, 1999, p. 552). The reason for the name, star schema, is that once the drawing is complete, it should take on a star-like shape. This means that a star schema should have a single table in the middle, with other tables connected to it, radiating out in a star (or snowflake) formation. Figure 8.1 illustrates the "star" formation of the star schema (Kimball, 1996, pp. 10–14).

8.3.2 Star Schema Components

As seen in Figure 8.1, the star schema consists of two types of tables: the fact table and dimension tables. The fact table is the "centre" of the star. The dimension tables are the "rays" or "arms" of the star schema.

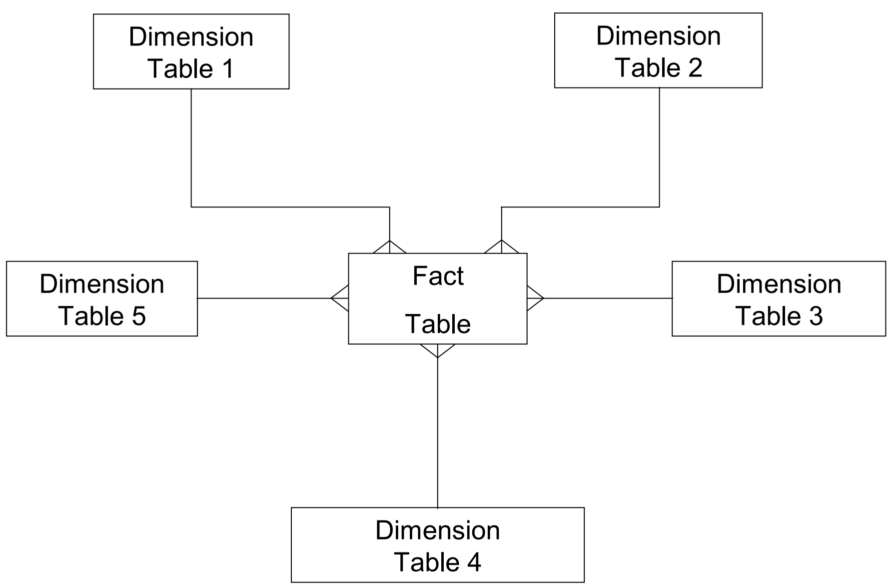


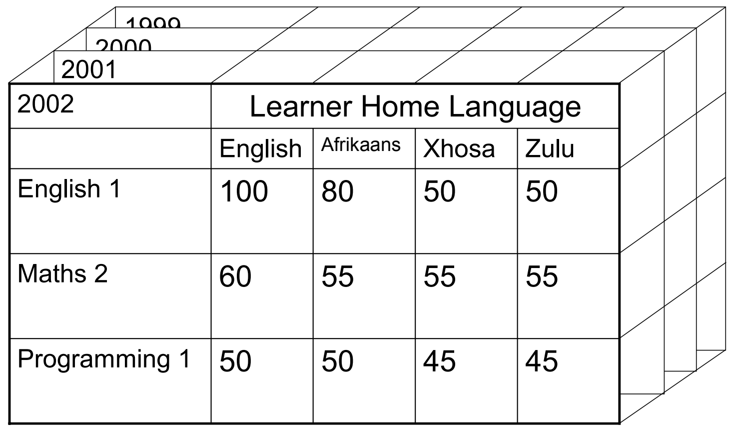
Figure 8.1: Star Schema Structure

A fact table represents one of the subjects of the data warehouse and contains facts or quantitative data about the subject. For example, a fact table could hold data about the number of learners enrolled, or the percentage of learners who passed or failed (Connolly & Begg, 1998, pp. 938–941; Kimball, 1996, pp. 10–14). The amount of detail being stored within the data warehouse will directly affect the size of the data warehouse. The more detail required, the larger the data warehouse. Determining the level of detail for the data warehouse is also known as deciding on the *grain* of the fact table. In the business world, a grain could be monthly sales or weekly sales. The smaller the grain, i.e. the shorter the time frame, the more data is stored (McFadden, Hoffer & Prescott, 1999, pp. 554–556; Kimball, 1996, p. 11). Thus, deciding on the size of the grain (or the level of detail being stored) is one of the most fundamental decisions in designing and implementing a data warehouse (McFadden, Hoffer & Prescott, 1999, p. 554; Connolly & Begg, 1998, pp. 938–941).

If the data could be represented in a cube, the titles along the side of the cube, such as years or courses, would be the dimensions of the star schema. The dimension tables, in essence, hold the descriptions of the facts or the reference data to the facts in the star schema (Connolly & Begg, 1998, 938–941; McFadden, Hoffer & Prescott, 1999, pp. 552–554).

The dimension tables are not usually normalised. The reasons for this are twofold. Firstly, the data in a data warehouse is static and the anomalies associated with controlled data redundancy are not important. Secondly, the space-saving that would occur with the normalisation of the dimension tables is negligible (Kimball, 1996, p. 32).

For example, an institution could keep a data warehouse about the courses and learners that are in its operational system. An educator could ask the question "What is the language trend of the learner enrolments?" A typical answer, in diagrammatic format, might look similar to Figure 8.2. The year, home language and course all describe the data in the centre of the table. The star schema used to model this particular data warehouse would look similar to Figure 8.3.



Learner Enrolments by Year
and by Home Language

Figure 8.2: Example Data Cube

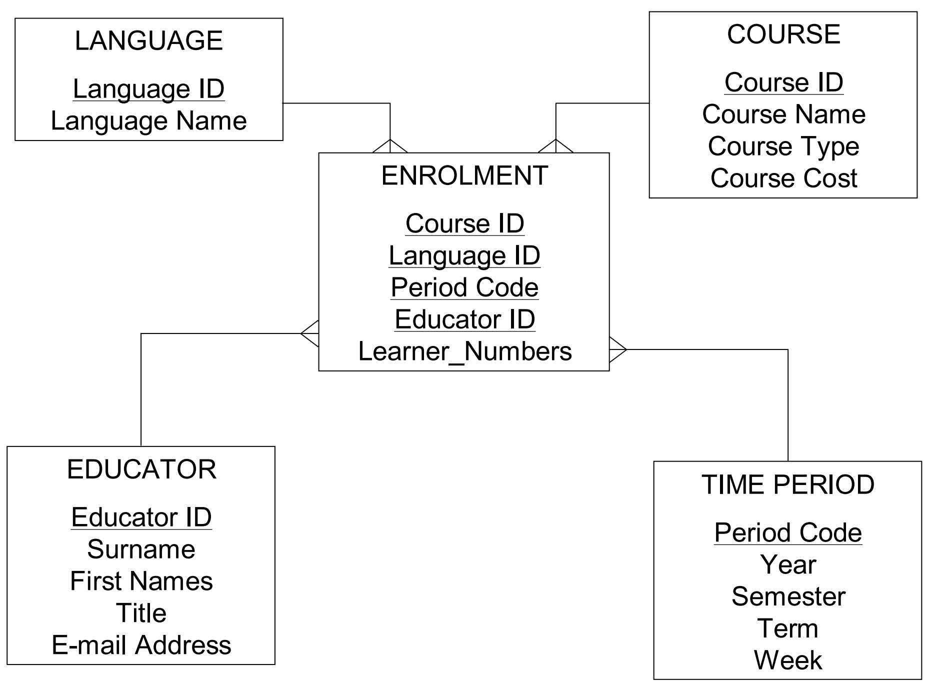


Figure 8.3: Example Star Schema

With the use of tables, a star schema may be implemented within a Relational Database Management System (McFadden, Hoffer & Prescott, 1999, p. 564; Kimball, 1996, pp. xxi–xxiii).

8.4 THE MODEL

As mentioned in Chapter 6, there are two major components to the resource base: the normalised component of the resource base and the star schema (data warehouse component). In order to achieve the more complex functions of the resource base, these two components need to work together in close association.

In Chapter 7, the ERD for the resource base was developed (Figure 7.5, here duplicated as Figure 8.4 for convenience).

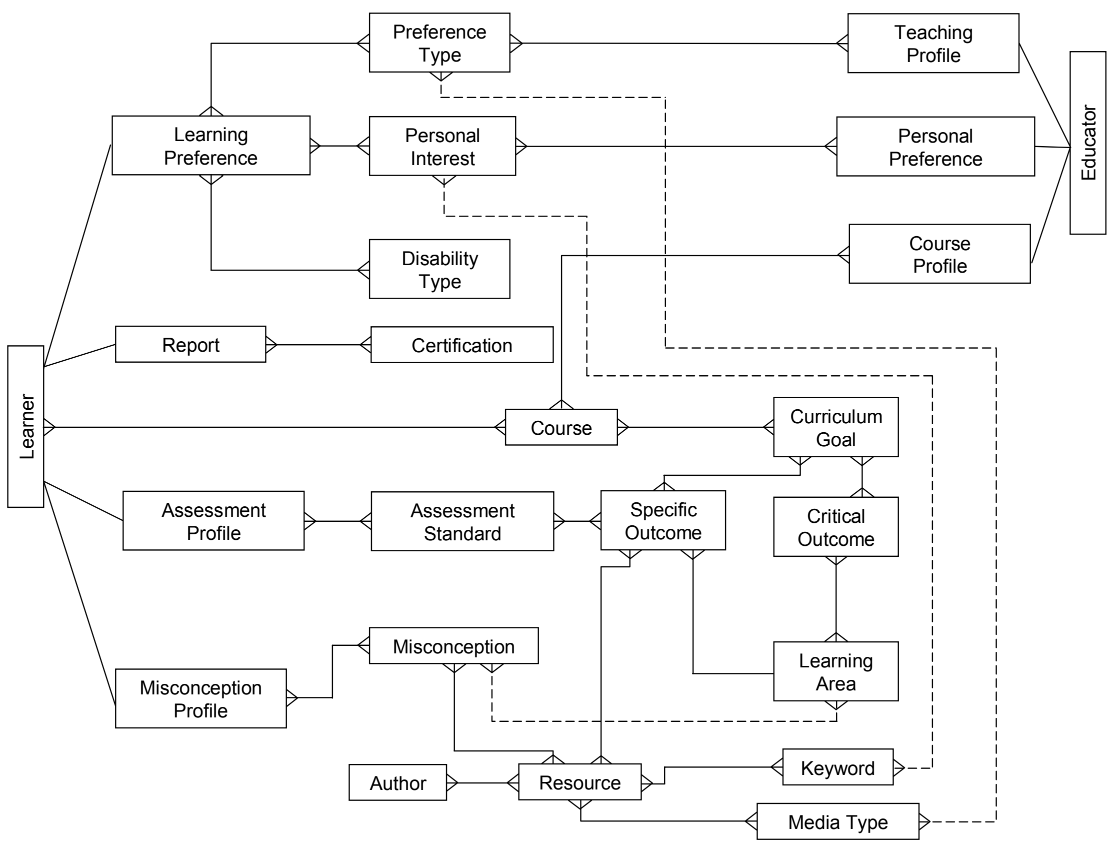


Figure 8.4: Refined Resource Base ERD

It is from this structure (Figure 8.4) that the star schema should be developed.

The question as to why the star schema is necessary for the resource base was introduced in Section 6.3.3. To briefly recap, a normalised database schema is an excellent tool for ad hoc queries. However, to create queries that require the multiple joining of tables, especially if the tables have M:N relationships, is resource intensive and take time to complete. Thus for queries that are commonplace and require a multitude of tables to be joined on a regular basis, a normalised database schema is not efficient. The solution to this dilemma has come in the format of a star schema. Within this schema, the tables are not normalised: data is stored in a redundant fashion. This redundancy reduces the number of M:N joins needed within the database and reduces the response-time for common queries.

It follows that only a part or a portion of the resource base should be developed into a star schema.

8.4.1 Defining the Star Schema

In developing a star schema, the queries that will be most common are the queries on which the star schema should be centred. These queries, in the case of the resource base, were briefly explored in Chapter 6. In Chapter 6, the processes within the resource base were identified. From these processes, it implies that learners will access the resource base in order to discover where their individual conceptual weak points are and what resources should be read or understood in order to correct their misconceptions. Thus the most common query posed to the resource base will be the learners asking "What resources do I need?" (Section 6.3.1, process 10). Other frequently posed queries would include searches for resources based on keywords, course, specific outcome and misconceptions. Thus, it is around these searches that the star schema needs to be created.

From Figure 8.4, the tables involved with each of these queries are the resource, the misconception, the keyword, the course, the specific outcome and the learner misconception profile. The next step in defining the star schema would be to identify the fact table. Since all the queries revolve around the resource, it would thus be a logical conclusion that the resource table would be the basis of the fact table. The other tables, i.e. misconception, course, specific outcome, keyword, would then be the foundation of the dimension tables. The learner profile is omitted, since only one of the queries involves the learner profile and each learner would receive a different set of resources according to that profile. Figure 8.5 represents the above-mentioned considerations in diagrammatic format.

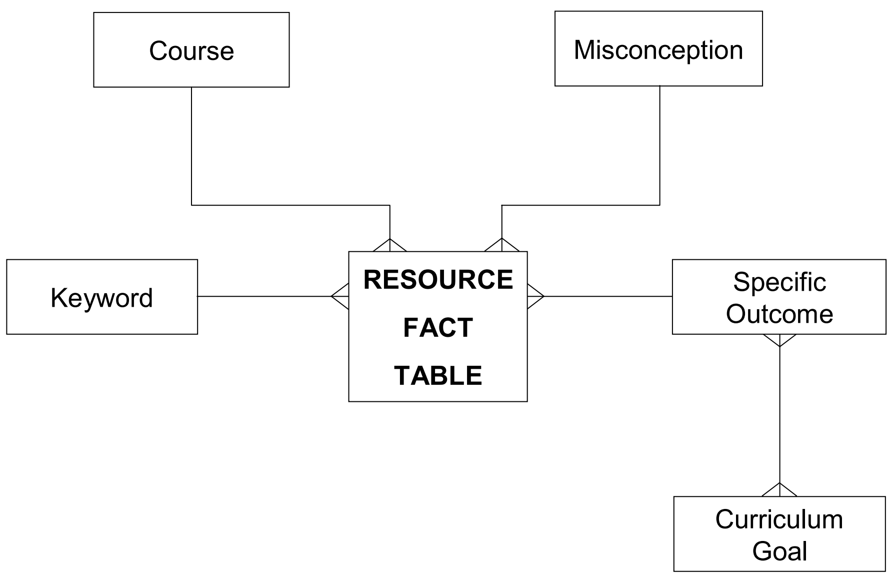


Figure 8.5: Preliminary Star Schema

The star schema represented in Figure 8.5 is by no means the end-product. This is merely a guide on the road to refinement. The various fields involved and the exact configuration of the star schema are yet to be developed.

In order to further develop the star schema, a closer inspection of the tables involved needs to be done. The tables involved in the star schema were described in Chapter 7.

These tables (shown in Figure 8.5) are Course, Keyword, Specific Outcome, Curriculum Goal, Misconception and Resource. These are the necessary tables to successfully complete the learners' queries of "What resources do I need?" The misconception profile (Table 7.1) is additional to the star schema and is necessary to keep a record of the misconceptions of each learner. Thus, the misconception profile will lend the individuality necessary to the resource base (Table 4.1, Criteria 14).

Within the normalised database structure, the SQL query for "What resources do I need?" would involve joining the tables Misconception Profile, Misconception, and Resource. The Course table could be included, since it could be used to categorise the resources when presenting the individualised resource list to the learner in question. Typically, an individualised list of resources, based on personal misconceptions would generate the following SQL query:

```
SELECT DISTINCT
      RESOURCE_DETAILS.R_ID AS RID,
      RESOURCE_DETAILS.R_TITLE AS TITLE,
      RESOURCE_DETAILS.R_LINK AS URL
FROM
      RESOURCE_DETAILS,
      Learner_Misconception,
      Misconception,
      Course
WHERE
      (Learner.L_ID = @StudentNumber)
      AND
      (Learner.L_ID = Learner_Misconception.LMis_ID)
      AND
      (Learner_Misconception.LMis_ID = Misconception.MC_ID)
      AND
      (Misconception.MC_ID = RESOURCE_DETAILS_Misconception.MC_ID)
      AND
      (RESOURCE_DETAILS_Misconception.R_ID = RESOURCE_DETAILS.R_ID)
      AND
```

```
        (Learner_Course.L_ID = Learner.L_ID)
        AND
        (Learner_Course.C_ID = Course.C_ID)
        AND
        (COURSE.C_ID = COURSE_CURRICULUM_GOAL.C_ID)
        AND
        (COURSE_CURRICULUM_GOAL.CG_ID = CURRICULUM_GOAL.CG_ID)
        AND
        (CURRICULUM_GOAL.SO_ID = CURRICULUM_GOAL_SPECIFIC_OUTCOME.SO_ID)
        AND
        (CURRICULUM_GOAL_SPECIFIC_OUTCOME.SO_ID = SPECIFIC_OUTCOME.SO_ID)
        AND
        (SPECIFIC_OUTCOME.SO_ID = SPECIFIC_OUTCOME_RESOURCE.SO_ID)
        AND
        (SPECIFIC_OUTCOME_RESOURCE.R_ID = RESOURCE.R_ID)
GROUP BY [COURSE NAME]
```

Within the query, the table Learner_Misconception is the table in which each learner's misconceptions are stored. In order to organise the resources according to course or find all the resources for a particular course, the number of joins amounts to twelve in total. It is here that the star schema comes into its own. There are only two inner joins in the star schema query. This implies that the time it takes to complete a query in a star schema is less than a normalised database (Kimball, 1996, pp. 95–97).

8.4.2 Refining the Star Schema

Figure 8.5 was previously identified as a rough star schema for the resource base. According to Ralph Kimball (1996, pp. 95–97), this type of schema is known as a snowflake structure. This is due to the Specific Outcome being linked to a further dimension, Curriculum Goal. Kimball remarks that a snowflake structure slows queries and does little to save data storage space. Thus, a refined star schema (Figure 8.6) combines the Specific Outcome and Curriculum Goal into a single dimension.

A star schema is used in order to develop a data warehouse. A data warehouse is a sizeable database that contains predominantly historical data. This data is frequently utilised in making informed business decisions (i.e. a decision support tool). In the resource base, however, another set of circumstances exists.

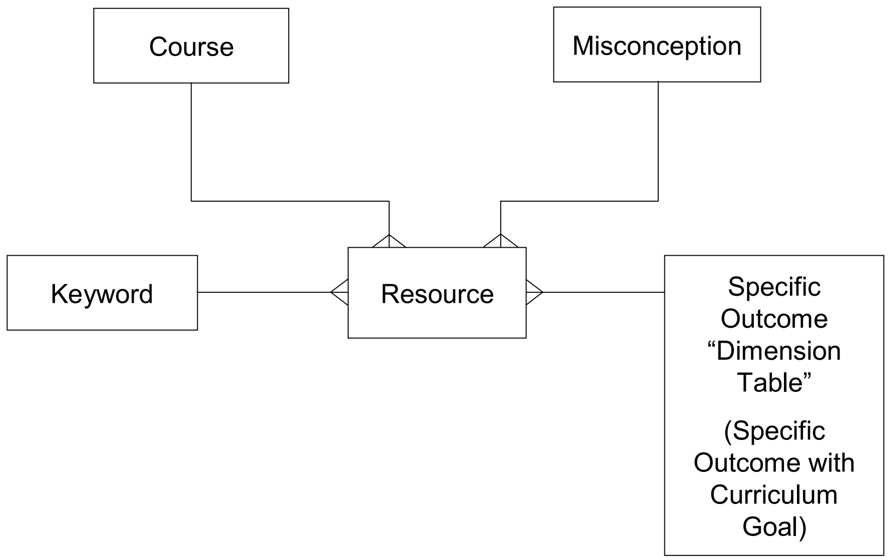


Figure 8.6: Refined Star Schema

The resource base contains a majority of historical data, with a little data that might be considered "operational" or transactional data. The motivation for putting "operational" in inverted commas is the fact that assessment does not take place on a daily basis for each learner. This implies that the data input will not be as extensive as the daily input in a business environment with daily transactions. The "operational" data mainly consists of the misconceptions, which should be a dynamic factor if the learner is growing and progressing academically. The historical data includes the learner and educator details, the course details, the resource details and objectives. By these definitions, the resource base is not truly a historical database nor is it a true operational database.

8.5 "OPERATIONAL" DATA WAREHOUSE

Since the resource base is a hybrid of both a historical and operational database, it stands to reason that its function is two-fold. The resource base is a database whose primary function is not to hold or store data but to transact queries. The secondary function (on which the primary function relies) is the storage of data. As previously stated, the normalised data schema is an excellent storage facility and the star schema is an excellent querying facility. The intermarriage of the two vastly differing data schemas poses some challenges in itself. The greatest challenge is the implementation of these two data schemas. As shown in Figure 8.6 and Figure 8.7, only a portion of the normalised database structure is implemented into the star schema. To create an entire data warehouse solely for these few tables does not seem to be economical, or practical. One possible solution is to allow the resource base to retain its hybrid nature and allow both schemas to be an integral part of each other.

8.5.1 A Hybrid Database

The star schema, although a different type of database, may reside together with the normalised schema within the same database. Kimball (1996, pp. 5–18), suggests that a relational database management system be used to create data warehouses. A normalised database is generally realised within a relational database management system. Thus the two types of schemas may be implemented using the same SQL package. This, for the resource base, implies that a very different type of schema may exist (Figure 8.7). Figure 8.7 shows the star schema within the normalised schema, as it should be implemented within the prototype. It illustrates all of the entities that play a role in the star schema component in a light grey, i.e. Misconception, Keyword and Course. The tables in black are the tables which are solely utilised within the star schema. These tables are the Resource Fact Table and the Specific Outcomes Dimension Table. The Specific Outcomes Dimension Table is linked to the two tables that determine its content: the Specific Outcome Table and the Critical Goal Table.

The Specific Outcomes Dimension Table contains data which has been generated, rather than inserted by means of a form. When an educator or an administrator creates new Specific Outcomes or Critical Goals, a script or trigger would be initiated to put the outcomes and goals into the Specific Outcomes Dimension Table. The Specific Outcomes Dimension Table's fields are the Specific Outcomes Dimension ID (key field), the Specific Outcomes ID (foreign key from the Specific Outcomes Table), the Specific Outcome, the Critical Goals ID (foreign key from the Critical Goals Table) and the Critical Goal. Thus, the Specific Outcomes Dimension Table is, in essence, the join of the Specific Outcomes Table and the Critical Goal Table. The Specific Outcomes Dimension Table is, in turn, connected to the Resource Fact Table.

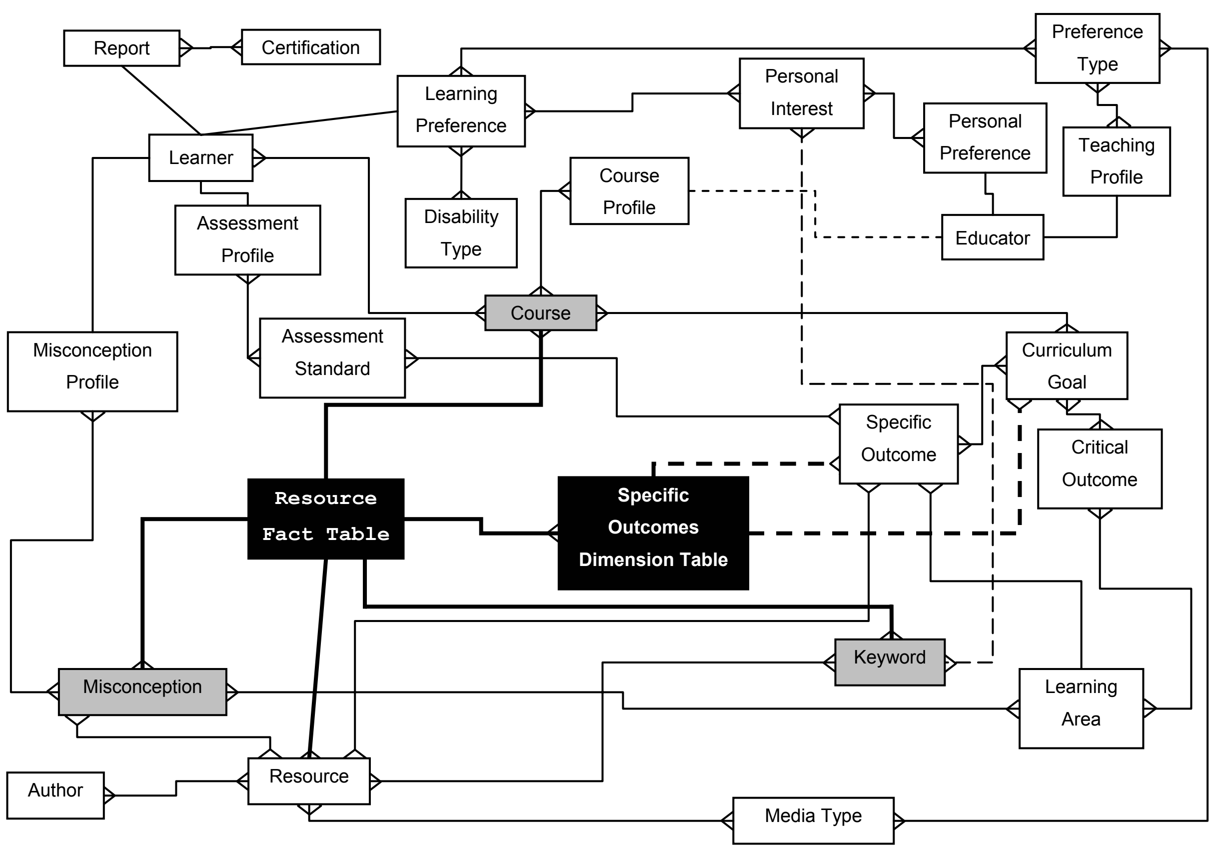


Figure 8.7: The Resource Base Schema

8.5.2 The Resource Fact Table

The Resource Fact Table is the centre of the star schema. Although this table stores the details of the resources, is different from the Resource Table in a few facets. The first of these is the way in which this table is created. The Resource Table would be populated from a form that an educator, administrator or learner will complete. The Resource Fact Table (Table 8.1) would essentially be populated using a trigger or a script, utilising the "rays" or the dimension tables to which it is connected.

TABLE 8.1: STAR SCHEMA'S RESOURCE FACT TABLE

RESOURCE FACT TABLE

Resource Base Field Name	Description	Purpose	Source
R_ID	Resource ID	Unique Key/Part of compound key	Resource Table
C_ID	Course ID	Unique Key/Part of compound key	Course Table
MC_ID	Misconception ID	Unique Key/Part of compound key	Misconception Table
KW_ID	Keyword ID	Unique Key/Part of compound key	Keyword Table
SOCG_ID	Specific Outcome and Critical Goal ID	Unique Key/Part of compound key	Specific Outcome Dimension Table
R_Title	Resource Title	The title of the resource	Resource Table
R_Link	Resource Link	A link (e.g. URL) to the resource	Resource Table
R_Language	Resource Language	The language in which the content is presented, e.g. English, French	Resource Table
R_Description	Resource Description	A brief description of the scope and content of the resource	Resource Table
R_size	Resource Size	An indication of the physical size of the resource in pages or in kilobytes	Resource Table
R_Duration	Resource Duration	An indication of the duration of the resource, measured in pages or in time	Resource Table
R_Difficulty Level	Resource Difficulty Level	An indication of the difficulty level of the resource, i.e. for a beginner, intermediate or advanced learner	Resource Table
R_Copyright	Resource Copyright	The name of the copyright owner and any copyright restrictions	Resource Table
R_EDate	Resource Date of last edit	To determine the age of the resource	Resource Table
R_CDate	Resource Check date	The date the link to the resource was last refreshed or checked	Resource Table
R_Annotator	Resource Annotator		Resource Table
R_Context	Resource Context	The context in which the resource should be given or the type of resource, e.g. questionnaire, group work materials, simulation, exercise or diagram	Resource Table

As seen in Table 8.1, the biggest difference between the Resource Fact Table and the Resource Table (illustrated in Section 7. 4.3, Table 7.3), is the number of foreign keys in the Resource Fact Table. All of these foreign keys are a part of the Resource Fact Table compound key. It is this compound key that acts as the catalyst for the other differences between the Resource Fact Table and the Resource Table.

The compound key implies that each resource appears *at least* once within the Resource Fact Table. The norm for each resource would be multiple occurrences within the Resource Fact Table. A resource would have a record for each keyword associated with it, a record for every misconception with which it is linked and a record apiece for the related courses. This is unlike the normalised Resource Table, where each resource appears only once.

As previously mentioned, the role of the star schema is to ensure quick and efficient queries. The compound key plays the pivotal task in fulfilling this function. For example, should a learner want to see all the resources for which he or she has misconceptions and see the courses for which these misconceptions occur, the query would utilise the course code and table containing the learner's misconceptions (Learner_Misconception) and the table containing the learner's course registrations as well as the Misconception table and the Resource_Fact_Table.

```
SELECT DISTINCT
      RESOURCE_FACT_TABLE.R_ID AS RID,
      RESOURCE_FACT_TABLE.R_TITLE AS TITLE,
      RESOURCE_FACT_TABLE.R_LINK AS URL
      Course.C_Name AS [Course Name],
      Misconception.MC_Title AS [Misconception Title]
FROM
      RESOURCE_FACT_TABLE,
      Course,
      Learner2Course,
      Learner_Misconception,
      Misconception
WHERE
      (Learner2Course.C_ID = Course.C_ID)
      AND
```

```
(Course.C_ID = RESOURCE_FACT_TABLE.C_ID)
AND
(Learner_Misconception.MC_ID = Misconception.MC_ID)
AND
(Learner_Misconception.MC_ID = RESOURCE_FACT_TABLE.MC_ID)
AND
(Learner_Misconception.L_ID = @StudentNumber)
```

If the Course Name and the Misconception details were not required, then the query would not need the Course and Misconception tables. The same query done without the aid of the star schema would need twelve joins to satisfactorily complete the query. Counting the number of joins done in an SQL query does not, however, prove that the star schema reduces the number of operations done by the database management system. In order to better understand the power of the star schema, a brief study was undertaken.

8.6 SOME THOUGHTS ON PERFORMANCE

The power of the star schema is its ability to retrieve data quickly and efficiently. Appendix 1 contains a brief study which illustrates the differences, in terms of workload placed on a computer processor, between the normalised schema and the star schema. In essence, the star schema is not only different to the normalised schema in its design but also in its implementation and application. It therefore stands to reason that a variety of indexing techniques have been developed exclusively for a data warehouse. These indexing techniques retrieve data at a faster and more efficient rate than those utilised within an operational database. However, it is not only the efficiency of the indexing techniques that allow a data warehouse to be more efficient in the retrieval of data, it is also the reduced calculation load that the data warehouse places on the computer processor.

An optimally designed star schema would result in fewer joins between tables than a normalised schema. This implies that the number of operations (i.e. each join or each selection) performed by the computer processor would be reduced within the data warehouse. A brief calculation is presented in Appendix 1. These calculations were performed on three sizes of databases. The first is a small database, the second is larger than the first and the third has more data than the second database. The results of this calculation may be summarised in a chart (Figure A1.3 here reproduced as Figure 8.8).

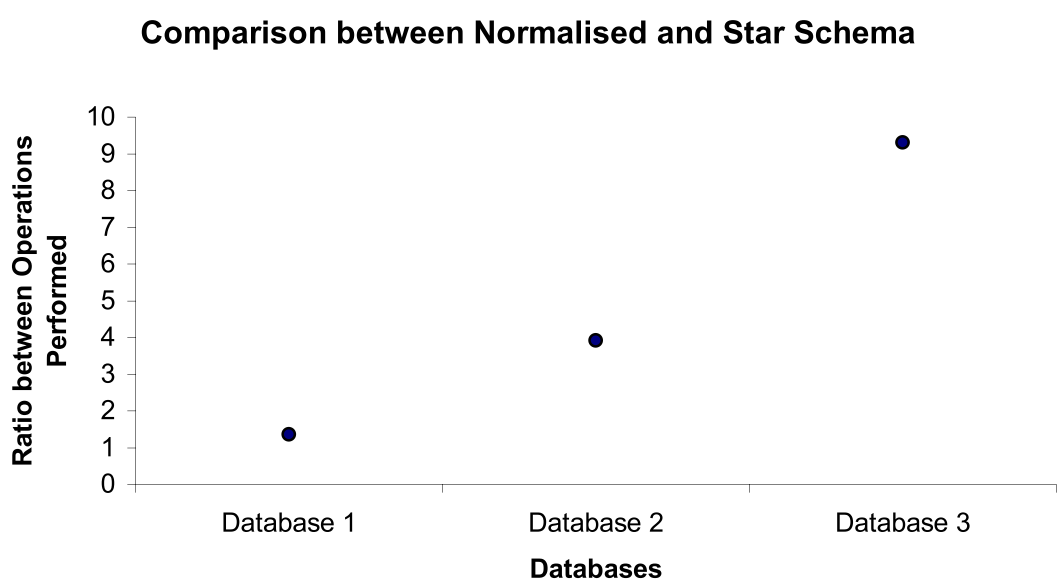


Figure 8.8: Comparison Chart

The ratio was determined by the number of operations performed by each of the schemas: number of operations performed by the normalised schema divided by the number of operations performed by the star schema. As seen from Figure 8.8, the star/normalised schema ratio tends in the favour of the star schema. This means that as the size of the database increases, the star schema becomes progressively more efficient in comparison to the normalised schema.

In each of the cases, the star schema outperformed the normalised schema by an escalating factor. Thus, once implemented as a data warehouse, the star schema would outperform the normalised schema (or operational database) in two areas: the number of operations performed and the speed of data retrieval, due to the available data warehousing indexing techniques.

8.7 CONCLUSION

Star schemas are usually utilised to facilitate the designing of data warehouses. These data warehouses are valued by businesses to aid the making of informed decisions and the discovery of hidden patterns and correlations within the business and its environment. This is because star schemas assist the speedy and efficient querying of data.

Within the resource base context, the normalised database will be used to access data more than it will be used to store data. This implies that a means to make its repetitive queries more efficient is needed. Implementing an entire data warehouse from the normalised database has enormous implications as far as computing power; storage space and administration are concerned. This, coupled with the fact that the data being stored within the resource base, is mostly static or historic data which is not refreshed or updated very regularly does not warrant the need for a completely separate system.

The proposed prototype (designed in Figure 8.7), therefore, is a hybrid of the two types of databases: normalised and star schema. The star schema components of the resource base should be generated using the data stored within the normalised structure with the aid of triggers and scripts.

The following chapter describes the prototype and includes a "walk-through" of the student interface.

Chapter 9

Prototype Production

9.1 INTRODUCTION

This chapter describes how the model was translated into a prototype. The prototype description will include the data queries required to extract the information about the resources as well as some screenshots of the prototype. Furthermore, a short analysis on the lessons learned while creating the prototype will conclude this chapter.

9.2 DEVELOPMENT ENVIRONMENT

The purpose of the prototypes is to test the model being developed. Since the prototype is a working model, a considerable amount of development packages have to be chosen in order to code the model into electronic format. There are two packages that are foremost on the selection list. The first is the database management system for the creation and storage of the underlying data structures. The second is the web authoring tool for the creation and management of the user interface.

There are numerous issues that need consideration when selecting a database management system. The first is the ability of the database management system to handle the implementation of the star schema, i.e. the data warehouse component. The second issue is one of scalability, i.e. the ability of the database management system to handle growth in data and in number of users. Ease-of-use was also one of the criteria, although not a critical one.

Although packages such as *Microsoft Access™* were created for ease-of-use, they were not created to manage data warehouses. This is since these packages were created for the end-user. Therefore, the database management systems that are particularly enterprise orientated were considered. Two of these database management systems are *Oracle9i™* and *Microsoft's SQL Server™*. *Oracle9i™*, according to its developers, has data warehousing facilities. *Oracle9i™* also has a number of built-in security features, along with scalability. Oracle claims that *9i™* is capable of handling several terabytes of data (Oracle, 2003). *Microsoft SQL Server™* offers its clients identical features as Oracle. It also has data warehousing facilities and is scalable. It also has a number of built-in security features (Microsoft, 2003).

Thus, the criteria for a database management system are met with both products. The decision to use *Microsoft SQL Server™* was two-fold. Firstly, a stable, operable environment was readily available at the institution. Secondly, being a Microsoft product, it should be compatible with the chosen web authoring tool.

When deciding upon the web authoring tool to create the user interface, a number of options arose. First was *Microsoft FrontPage™*, which was used in an earlier prototype. Second was *Dreamweaver™*, developed by Macromedia. The last option was *Visual Studio .Net™*, a part of Microsoft's .NET™ strategy. These above-mentioned three options are not the only software which could have been used. The choice of the three out of the large variety of web authoring/application development tools was based largely on personal exposure, availability and, inevitably, cost.

Microsoft FrontPage™ was, at first, the web authoring tool of choice. However, since the earlier prototype (which used *FrontPage 95™*) and the resource base prototype, Microsoft had released a new version of *FrontPage* (i.e. *FrontPage XP™*). This newer version had a different approach to database integration and the learning curve to master this approach would the equivalent of learning a totally new package.

Macromedia's *Dreamweaver*™ was also considered. *Dreamweaver*™ was recommended on the basis of its web features. Some of these features include an excellent tool to allow for complex web layouts and an editor for Macromedia's animation technology, *Flash*™, as well as an editor for *Fireworks*. *Fireworks*™ is a tool that enables designers to create their own graphics and allows for user interactivity with the created graphics (Sawyer McFarland, 2000; Calore, 2001; Macromedia, 2003). At the commencement of development, only *Dreamweaver 4* ™ was available. In the *Dreamweaver 4* ™ critiques the reviewers mentioned nothing or very little about *Dreamweaver*™'s abilities to connect to a database. Nevertheless, the major deterrent for using *Dreamweaver*™ was a financial one, if *Dreamweaver*™ was to be used, it had to be bought. Microsoft products, however, were readily available and licensing had already been done by the Port Elizabeth Technikon.

Microsoft's .Net™ Strategy uses eXtensible Markup Language (XML) web services in order to connect a large variety of services together. The appeal of .NET™ was that it not only handled web applications but was a software development tool. This puts .NET™ in a different class to both *MS FrontPage*™ and *Dreamweaver*™. The marketing materials for .NET™ and the numerous official Microsoft articles available from the Microsoft website confirm that *Visual Studio .Net*™ is more than a web authoring tool (Microsoft, 2003).

Microsoft touts .NET as "software for connecting information, people, systems and devices" (Microsoft, 2003). The .NET™ path was chosen for its visual programming capabilities. *Visual Studio* .NET™ allows one to simply drag and drop objects onto a form to create a web page. The objects are then given properties (such as colour, size, and font). The attraction of *Visual Studio* .NET™ is that the code for the web pages is separated from the web pages. The appeal of this separation is that it allows the developer to concentrate on one issue at a time. Another advantage to the separation approach is that a change in either the user interface (i.e. the web pages) very seldom interferes with the code and vice versa.

Within *Visual Studio* .NET™*,* there are four different language choices: *Visual Basic* .NET, *Visual C++* .NET™, *Visual C#* .NET™ and *Visual J#* .NET™. According to Microsoft, C#™ is the bridge between *Visual Basic*™ and *C++*™. Microsoft claims that C#™ holds the best of both *Visual Basic*™ and C++™. The idea is that *Visual Basic*™, while being easy to code, was never as flexible as C++™. C++™, while being flexible, was never as productive as *Visual Basic*™. C#™, Microsoft proclaims, has the flexibility of C++™ while enjoying the productivity and ease of coding of *Visual Basic* (Sridharan, 2003).

While *FrontPage*™ and *Dreamweaver*™ are both easier to use, the choice fell upon C#™. One of the reasons, as previously mentioned, was that of cost. C#™ is one of the languages currently being utilised by the institution for teaching purposes, therefore, it was readily available. Support services for the package were also available. This last issue proved to be an extremely important concern at the very beginning of the creation of the prototype as well as towards the end of the development. Since the support services knew the package, the facility manager could give the necessary technical support needed to complete the project with understanding, advice and speed. The last reason for the choice of C#™ was that of versatility. The language itself provided the flexibility needed to access the database. The learning of a new language and the learning of object-orientation and visual programming also provided the researcher with the much needed professional versatility and sense of achievement.

The rest of the chapter is devoted to the prototype. This includes a “walk through” of the prototype and the issues that surround the implementation of the prototype.

9.3 A TOUR OF THE RESOURCE BASE PROTOTYPE

This tour is a brief explanation of the prototype and will include a number of screenshots of the prototype which is available on http://www.petech.ac.za/resourcebase.

The first screen (Figure 9.1) that a user will see when entering the resource base is the homepage.

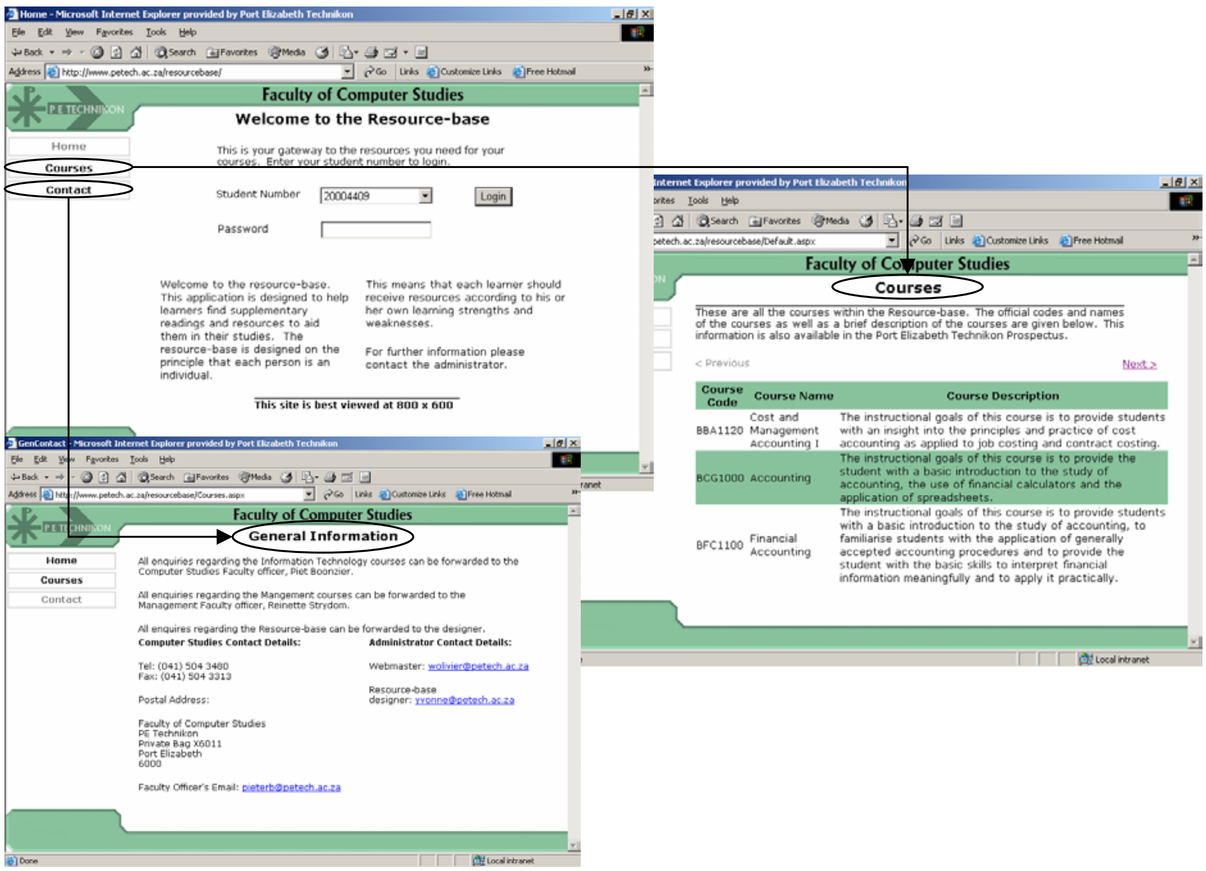


Figure 9.1: General Pages

Besides the option for logging in, any person visiting the site has two more options: *Courses* and *Contact*. The first of these two, *Courses* (Figure 9.1) contains a list of all the courses that are available on the resource base. The second, *General Information*, gives the visitor information about who to contact regarding the courses available, as well as the contact details for various administrators. These two pages serve as the "Marketing Model" component of the resource base, mentioned in Chapter 3.1. The purpose of these three pages is to orient any visitor or learner to the resource base and give relevant general-purpose information. Any user may navigate freely amongst these three pages.

To fully appreciate the resource base, and for the sake of continuity, one learner's path through the resource base will be shown. This learner (K Mukwevho) may only enter the resource base through the homepage (Figure 9.1). For the protection of privacy, the learner should enter a username and password. Not only does the username and password provide a measure of privacy but it also is the fulfilment of the 20th requirement of the Requirements Table (Table 4.1), described in full in Chapter 4. The username also serves as a basis for the next web page: *All Your Courses* (Figure 9.2)

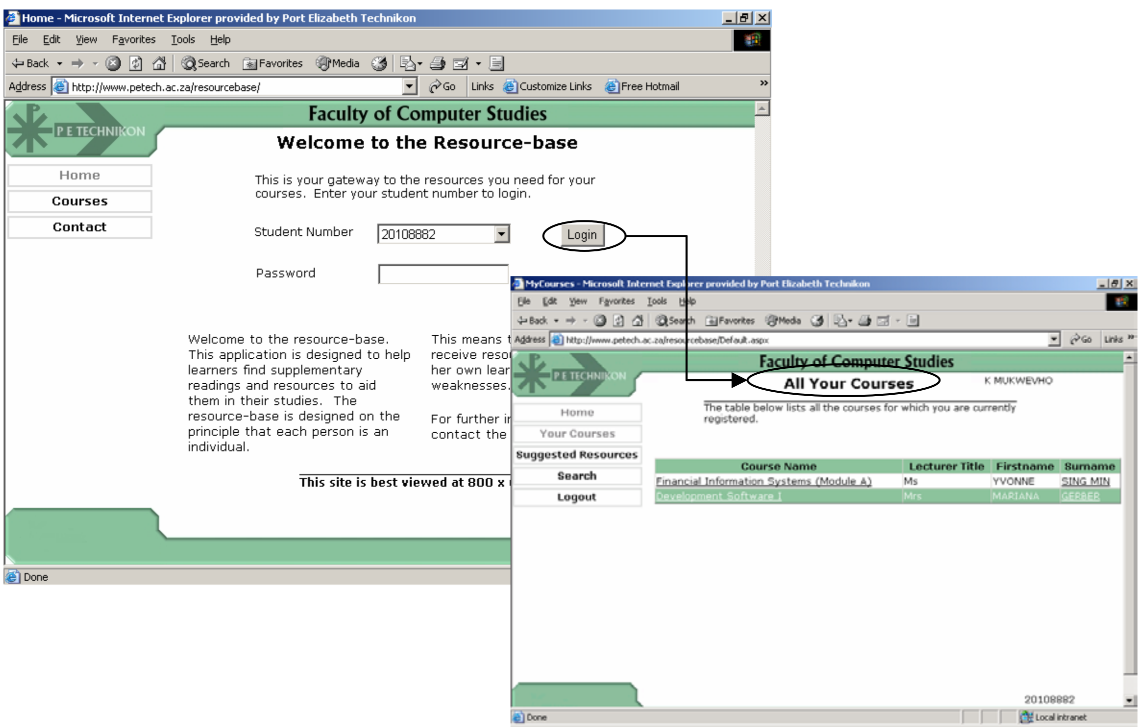


Figure 9.2: All Your Courses

This page is the learner's "home" inside the resource base. It gives a list of all the courses for which the learner is enrolled. The *All Your Courses* page also gives a means to contact the relevant educators via e-mail (Figure 9.3). The facility to e-mail the lecturer facilitates requirement 5 and 10 of the Resource base requirements compiled in Chapter 4 (Table 4.1).

Requirement 5 states that the learner should be able to add resources to the resource base. This requirement has a number of implications for the integrity and the quality of the resources that the learners could prescribe. The issues surrounding this requirement will be further discussed in Chapter 10. Requirement 10 states that the learner should be able to critique the resources available on the resource base. This also has a number of concerns which include that of personal bias and honesty. For the prototype, feedback from the learner regarding the resources needs to be done via e-mail. The e-mail route has a number of advantages and disadvantages in regard to Requirements 5 and 10. These points will be further elaborated upon in Chapter 10.

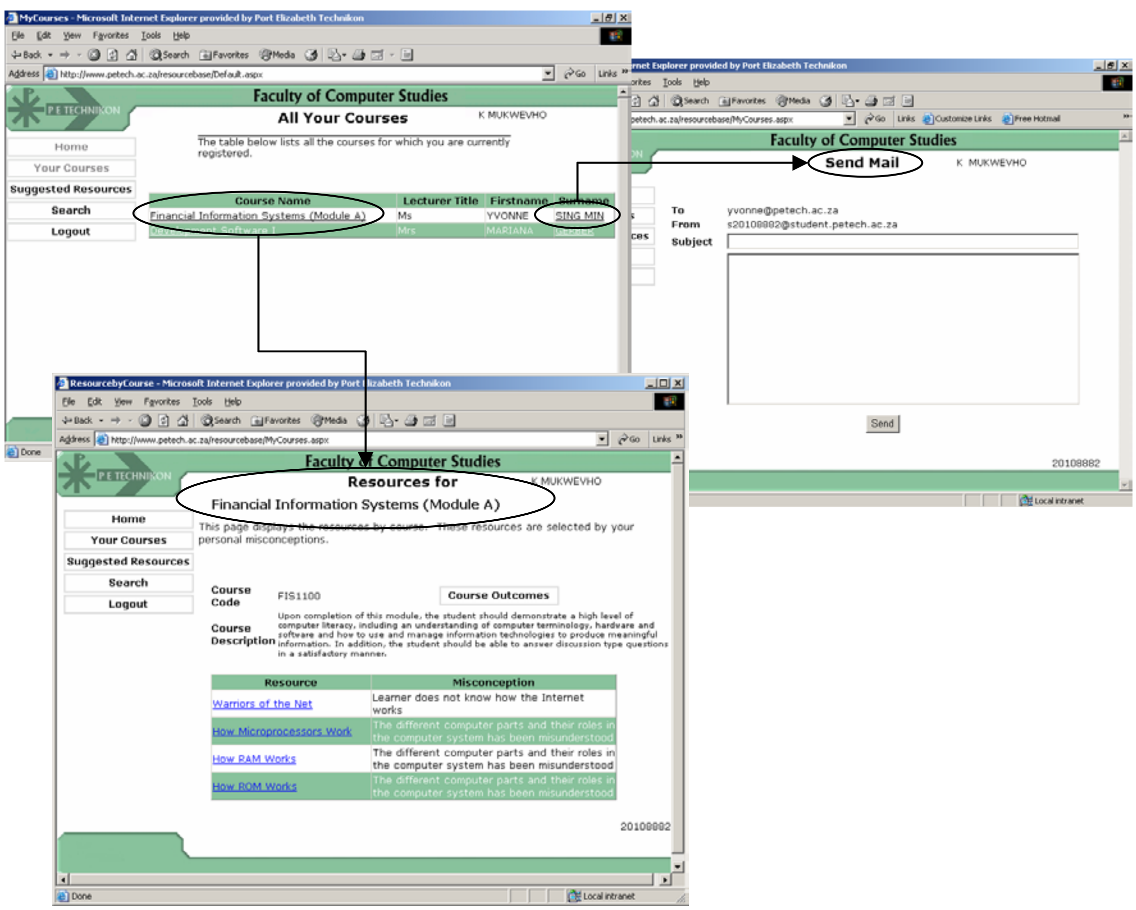


Figure 9.3: All Your Courses Links

The grid on the *All Your Courses* page not only contains educator contact details but also a link to a page that contains course information: *Resources for Course.* The *Resources for Course* page displays the course description and the course code. It also has a grid that presents the learner with the misconceptions that he or she has for that particular course. This misconceptions grid gives a link to the resources as well as informs the learner as to what he or she did not understand, i.e. states the misconception. In the case of Ms Mukwevho, there are four resources available for her attention. These four resources were retrieved from the Resource base utilising the star schema.

This particular query asks for the learner's resources according to misconception for a particular course. In the star schema, the query is relatively simple:

```
SELECT DISTINCT
      RESOURCE_FACT_TABLE.R_ID AS RID,
      RESOURCE_FACT_TABLE.R_TITLE AS TITLE,
      RESOURCE_FACT_TABLE.R_LINK AS URL,
      Misconception.MC_Statement AS Misconception
FROM
      RESOURCE_FACT_TABLE,
      Learner_Misconception,
      Misconception,
      Learner_Course,
WHERE
      (Learner_Misconception.L_ID = @StudentNumber)
      AND
      (Learner_Course.L_ID = @StudentNumber)
      AND
      (Learner_Misconception.Mis_ID = Misconception.MC_ID)
      AND
      (Learner_Course.C_ID = Course.C_ID)
      AND
      (Course.C_ID = RESOURCE_FACT_TABLE.C_ID)
      AND
      (Misconception.MC_ID = RESOURCE_FACT_TABLE.Mis_ID)
```

To underline the star schema's power, the same query done in the normalised schema is more complex:

```
SELECT DISTINCT
      Resource.R_ID AS RID,
      Resource.R_TITLE AS TITLE,
      Resource.R_LINK AS URL,
      Misconception.MC_Statement AS Misconception
FROM
      Resource,
      Learner_Misconception,
      Misconception,
      Resource_Misconception,
      Learner_Course,
      Course,
      Course_Curriculum_Goal,
      Curriculum_Goal,
      Curriculum_Goal_Specific_Outcome,
      Specific_Outcome,
      Specific_Outcome_Resource
WHERE
      (Learner_Misconception.L_ID = @StudentNumber)
      AND
      (Learner_Course.L_ID = @StudentNumber)
      AND
      (Learner_Misconception.Mis_ID = Misconception.MC_ID)
      AND
      (Resource_Misconception.R_ID = Resource.R_ID)
      AND
      (Learner_Course.C_ID = Course.C_ID)
      AND
      (Course.C_ID = Course_Curriculum_Goal.C_ID)
      AND
      (Curriculum_Goal.CG_ID = Curriculum_Goal_Specific_Outcome.CG_ID)
      AND
      (Curriculum_Goal_Specific_Outcome.SO_ID = Specific_Outcome.SO_ID)
      AND
```

```
(Specific_Outcome.SO_ID = Specific_Outcome_Resource.SO_ID)
AND
(Specific_Outcome.Resource.R_ID = Resource.R_ID)
```

The normalised schema, therefore, has to perform twice as many joins as the star schema (four joins for the star schema in opposition to the eight joins required by the normalised schema). Although this screen shows only the misconceptions for the learner and not the curriculum goals or the specific outcomes, there is a button (*Outcomes*) that leads the learner to the *Curriculum Goals* page (Figure 9.4).

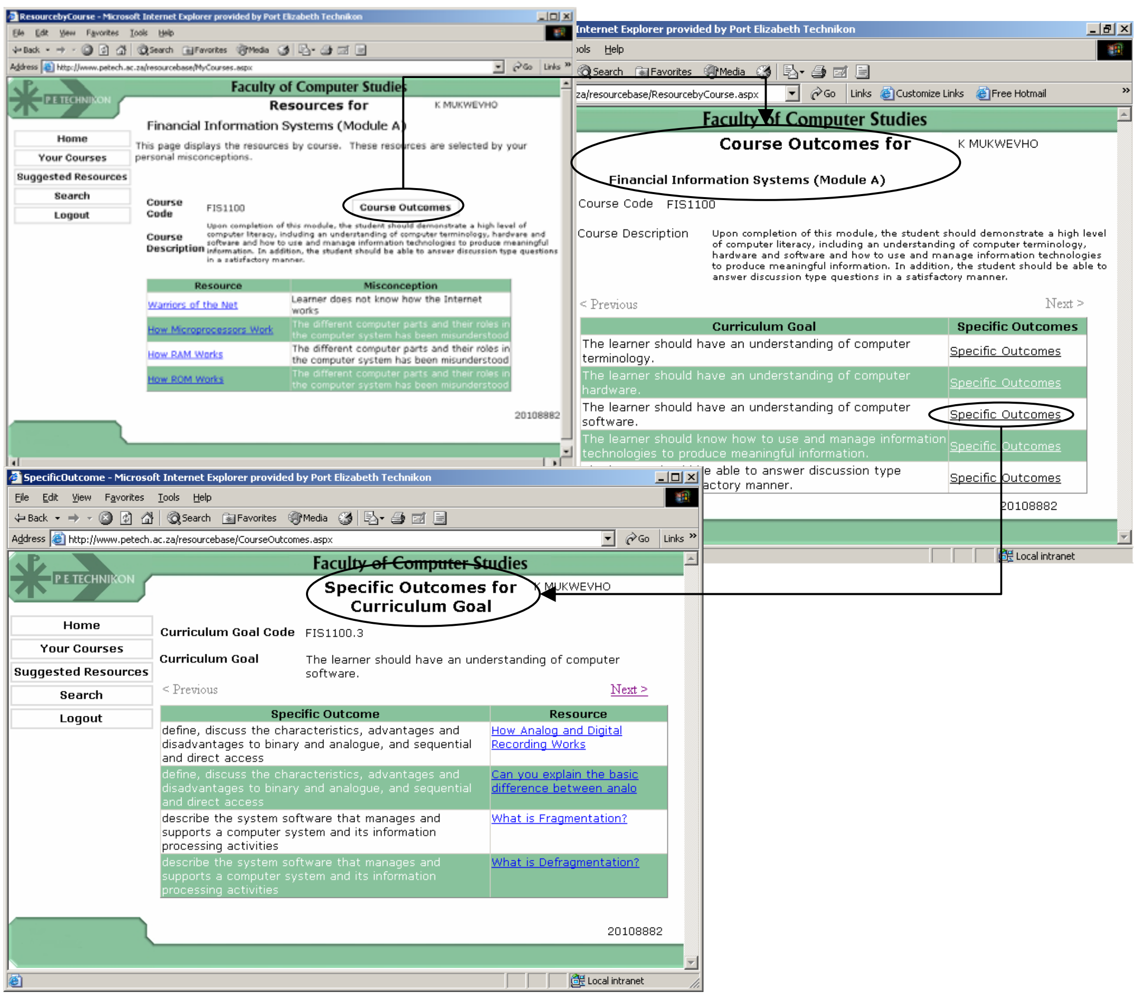


Figure 9.4: Curriculum Goals and Specific Outcomes

The reason for including the misconceptions at this point and not the outcomes is that of "Just-In-Time" learning and the criteria, specified in Section 4.3.2, which states that the number of links or levels should be reduced and simplified.

As previously mentioned, to fulfil the criteria for course outcomes, the *Outcomes* button on the *Resources by Course* page will lead the learner to the outcomes. Figure 9.4 illustrates the course outcomes for Financial Information Systems (Module A). These are the Curriculum Goals for the course.

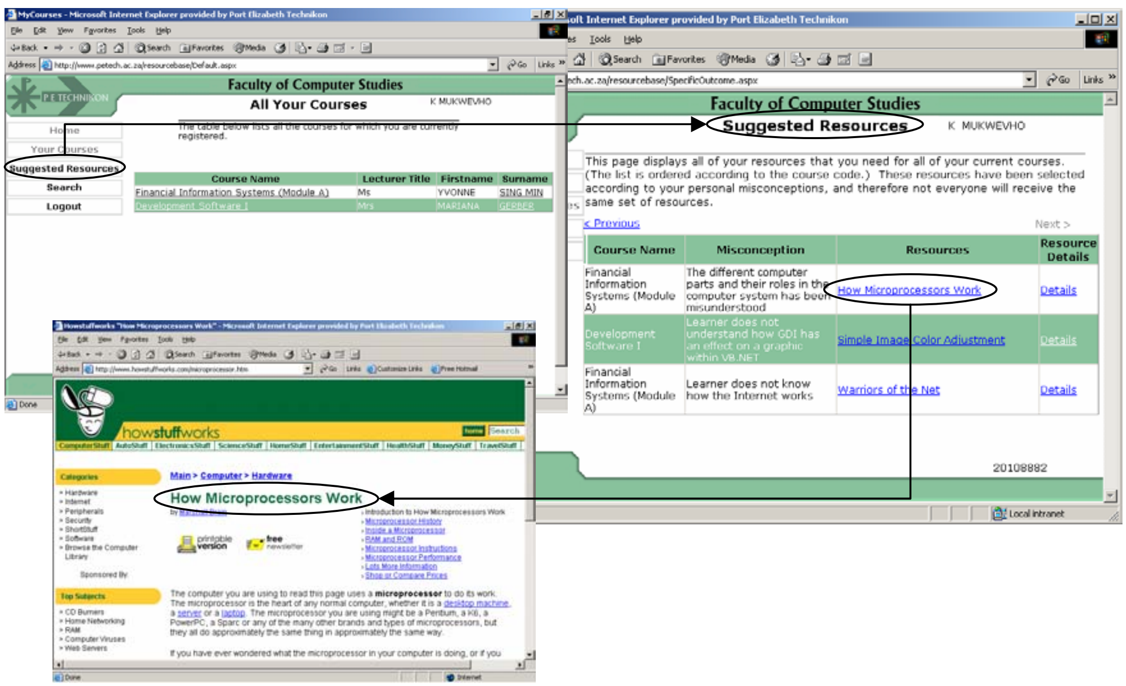


Figure 9.5: Suggested Resources Links

The two levels of the outcomes (Curriculum Goals and Specific Outcomes) are displayed on two pages. The *Curriculum Goals* page displays a grid containing the curriculum goals for a particular course (in this case, Financial Information Systems I). The grid also has a link to a *Specific Outcomes* page. The *Specific Outcomes* page also has a table with the specific outcomes for that particular curriculum goal, the name of the relevant resources as well as an active link which will open the resource in question. The *Specific Outcomes* catalogue with an active link allows learners to view resources associated with specific outcomes. This means that learners may look at resources before the material is presented in class. It also allows learners to identify and rectify misconceptions independently of the educator's intervention. Allowing learners to prevent larger problems by tackling small misconceptions on their own meets the criteria specified in Chapter 4 of self-directed learning (page 55)

Should the learner want to view all his or her misconceptions, regardless of course, the page that should be accessed is the *Suggested Resources* page (Figure 9.6)

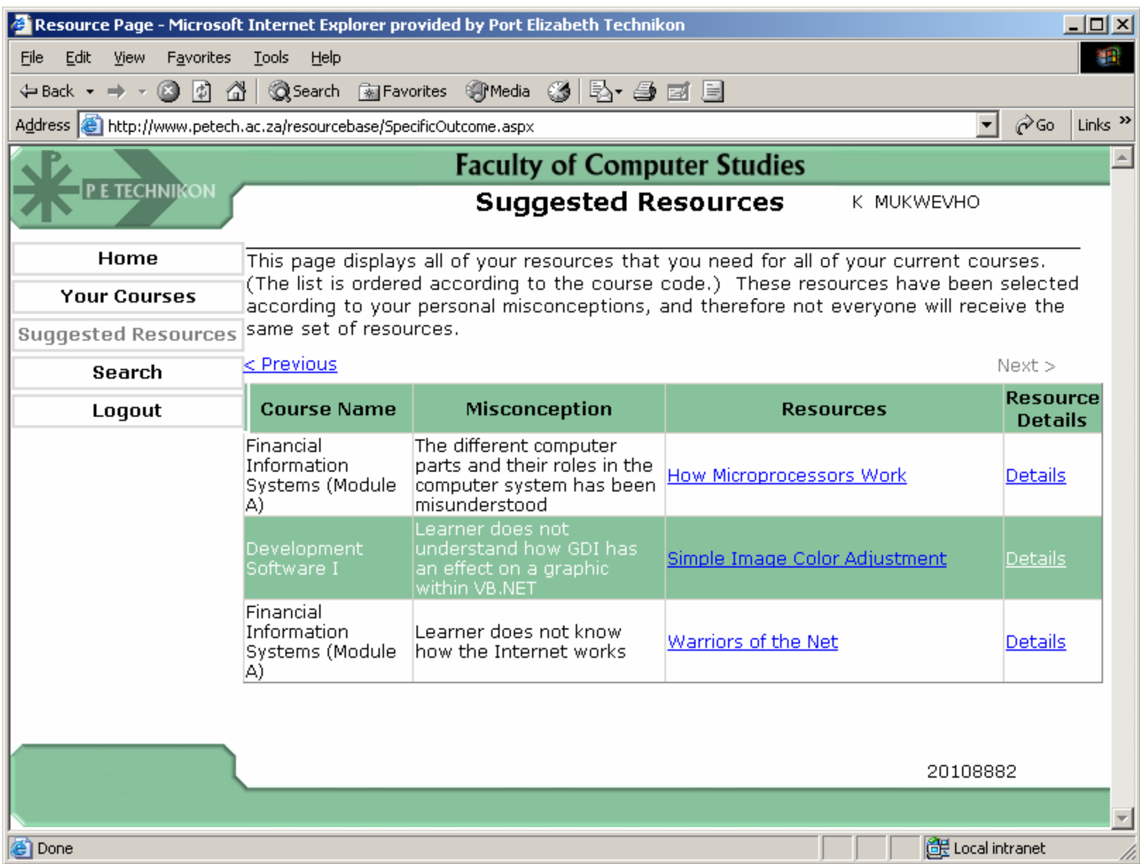


Figure 9.6: Suggested Resources

The *Suggested Resources* page is the focal point of the resource base. It shows individual learners what resources they need in order to resolve their particular set of misconceptions. Figure 9.6 is the same "My Resources" page, enlarged for better viewing. As seen in Figure 9.6, the various fields shown in the table are Course Name, Misconception, Resources and Resource Details. The misconception column, although embarrassing to some learners, has the main function of offering feedback to the learner. These are the areas in which the learner is weakest and thus needs more attention. As discussed in Chapter 3, providing feedback to learners is important, not only for the correction of misconceptions, but to give the learners reassurance and orientation within their learning.

The resource column contains the name and resource URL that opens the resource in the browser. The resource details column takes the learner to the *Resource Details* page. The *Resource Details* page displays the details for the chosen resource (Figure 9.7).

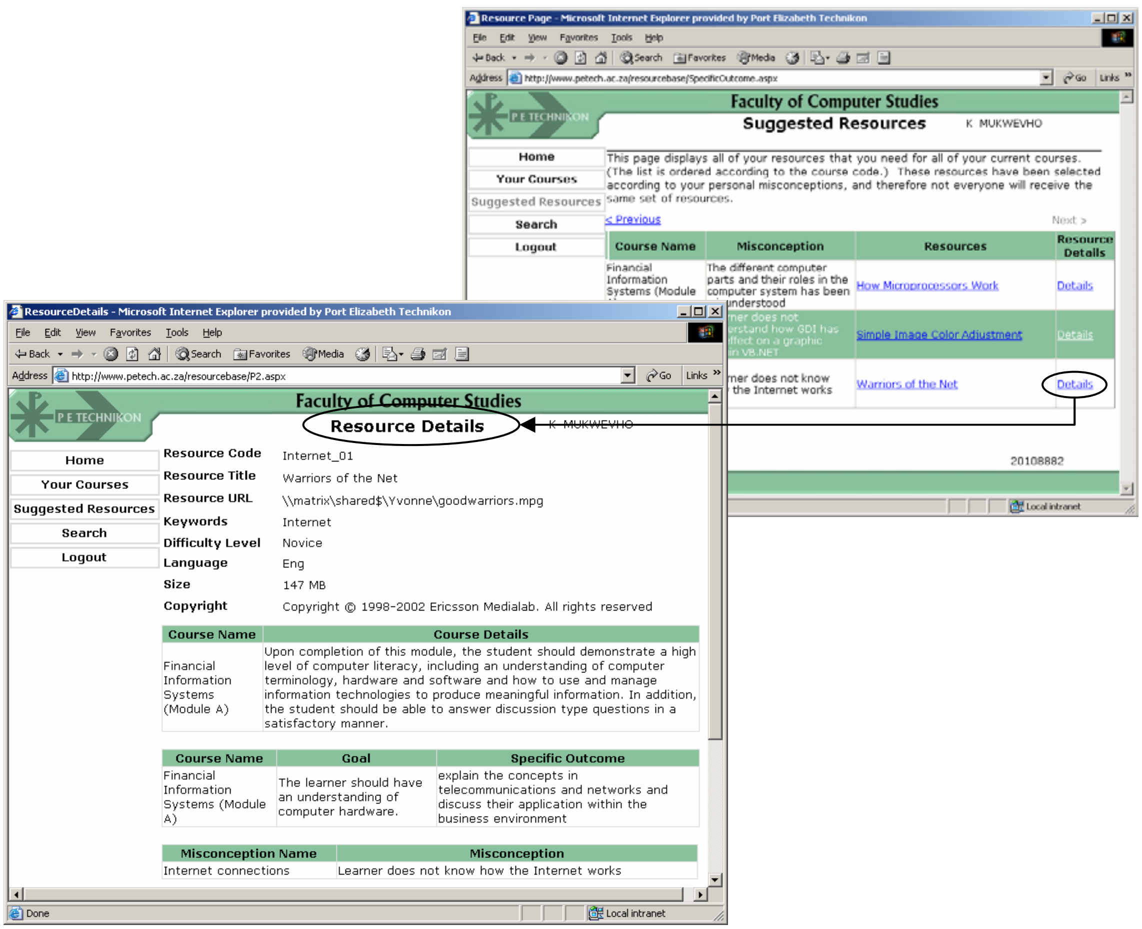


Figure 9.7: Resource Details

As implied in Figure 9.7, clicking on a resource title takes the user to the resource. The *Resource Details* page allows the learner to view some of the other data concerning the resource in question. An enlarged view of the *Resource Details* page is given in Figure 9.8. As suggested by the name, the *Resource Details* page offers some of the details from the Star Schema to the learner. These details could start as a starting point for the learner in his or her quest to find alternative resources on the Internet or in the library. The *Resource Details* page also serves another purpose, to show the power of the Star Schema. To create the *Resource Details* page, the following SQL stored procedure was used:

```
SELECT
      ResourceStar.ResourceTitle AS [Resource Title],
      ResourceStar.ResourceLink AS [Resource Link],
      ResourceStar.ResourceLang AS Language,
      ResourceDetails.Description AS Description,
      ResourceDetails.Size AS Size,
      ResourceDetails.Difficulty_Level AS [Difficulty Level],
      ResourceDetails.Copyright AS Copyright,
      Misconception.MC_Title AS [Misconception Name],
      Misconception.MC_Statement AS Misconception,
      SpecificOutcomeStar.SO_Statement AS [Specific Outcome],
      SpecificOutcomeStar.CG_Statement AS Goal,
      Keyword.KW_Content AS [Keyword Dfn],
      Keyword.KW_ID AS Keyword,
      Course.C_Name AS [Course Name],
      Course.C_Description AS [Course Description]
FROM
      RESOURCE_FACT_TABLE,
      Resource Details,
      Misconception,
      SPECIFIC_OUTCOMES_DIMENSION_TABLE,
      Keyword,
      Course
WHERE
      (RESOURCE_FACT_TABLE.R_ID = @ResourceID)
      AND
```

```
        (RESOURCE_FACT_TABLE.R_ID = ResourceDetails.R_ID)
        AND
        (RESOURCE_FACT_TABLE.MC_ID = Misconception.MC_ID)
        AND
        (RESOURCE_FACT_TABLE.SOFT_ID =
SPECIFIC_OUTCOMES_DIMENSION_TALBE.SOFT_ID)
        AND
        (RESOURCE_FACT_TABLE.KW_ID = Keyword.KW_ID)
        AND
        (RESOURCE_FACT_TABLE.C_ID = Course.C_ID)
```

As seen from the above procedure, there are five inner joins. If the star schema had not been utilised, the number of inner joins would amount to eleven.

The *Search* page (Figure 9.8) is accessible from the side menu. There are five searches available to the learner: Keyword, Course, Misconception, Keyword within a Course and Course Outcomes.

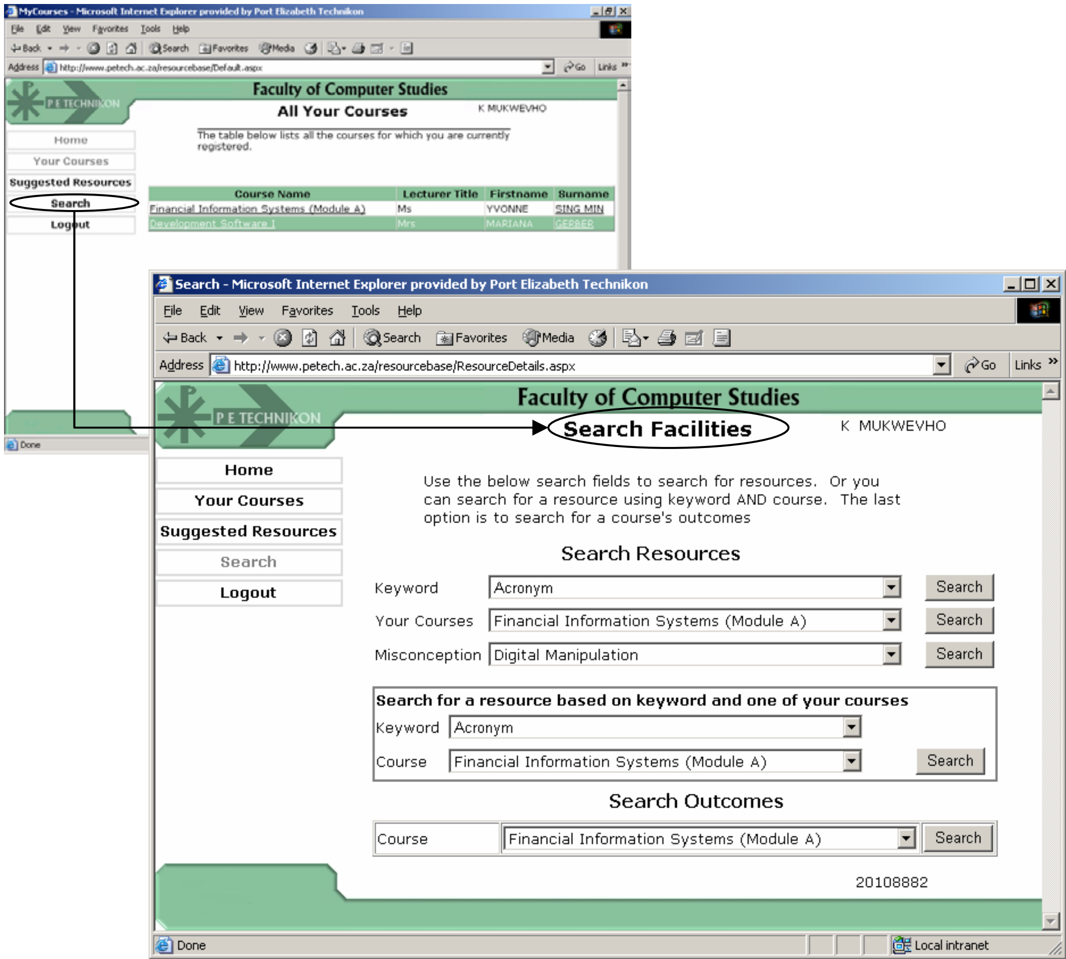


Figure 9.8: The Search Page

The *Search* page fulfils requirement 11 of the resource base requirements (Table 4.1, Chapter 4). Requirement 11 states that advanced search facilities should be available. This will facilitate learners in finding the resources pertaining to particular topics.

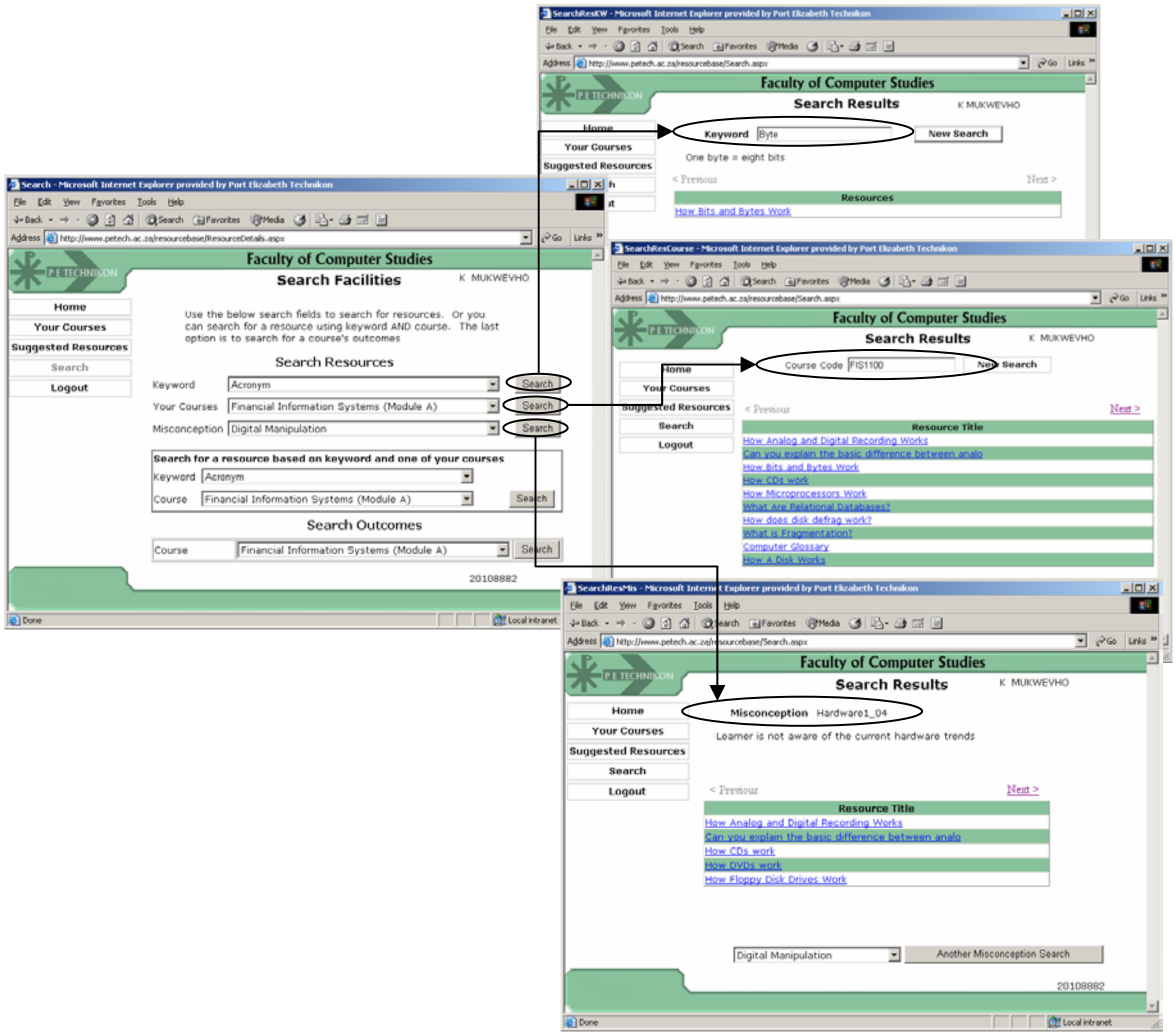


Figure 9.9: Keyword, Course and Misconception Search Results

As seen in Figure 9.9 and Figure 9.10, the results are expressed on five separate pages, depending on the query. Each of these results is displayed in a data table. Normally a data table would only be able to show results on one page. Thus a user could be faced with information overload. In C#, however, the data tables can be programmed in such a way that a maximum of ten results appear at one time. In order to access the following ten results, "Next" and "Previous" link buttons are created and programmed.

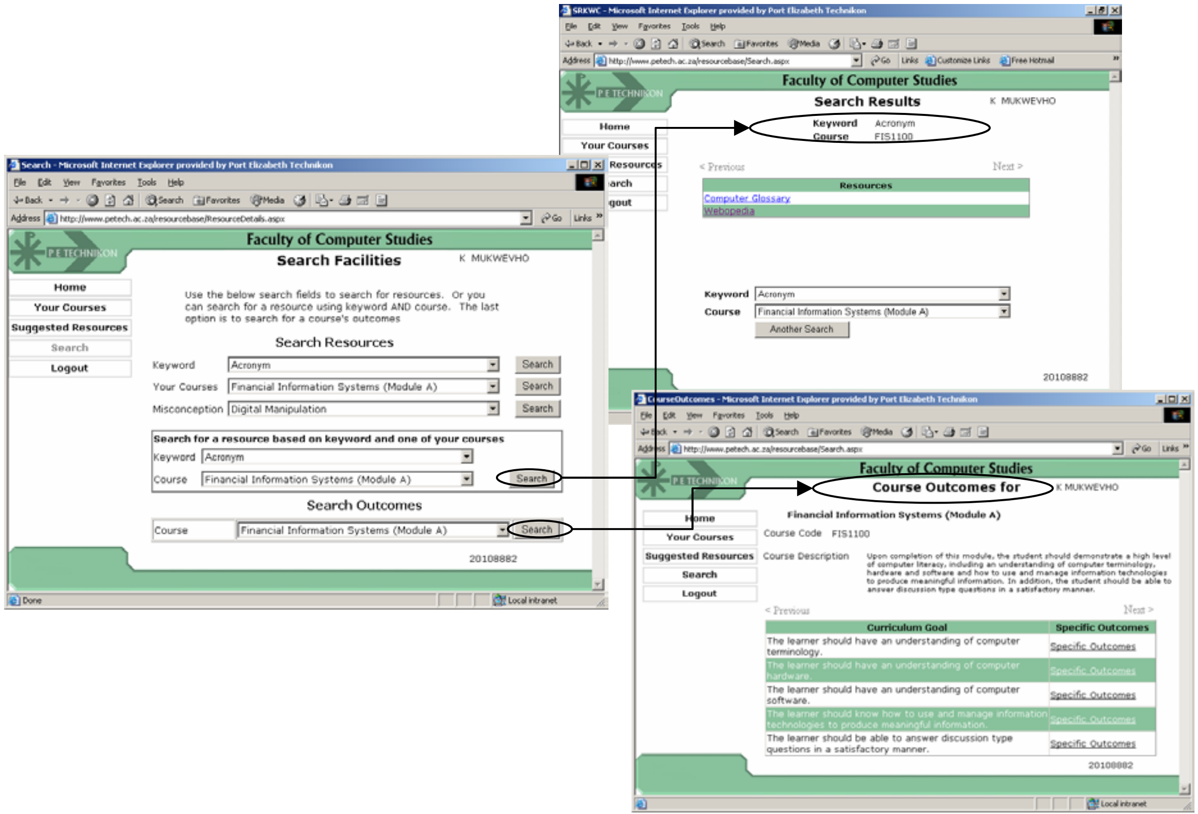


Figure 9.10: Outcomes Search and Keyword within Course Search

Figure 9.10 illustrates the result to the Search Outcomes for each course. This link takes the learner to the *Course Outcomes* page first illustrated in Figure 9.4. As previously mentioned, the learner may then view the specific outcomes associated with each curriculum goal for the course.

The last button available on the learner's menu is the logout button. This button takes the learner back to the first screen (Figure 9.1). The learner may, from this page, login again or may enter another URL in the browser's navigation bar.

9.4 OVERCOMING THE TRIALS

The beauty of a prototype is that it not only serves as a test bed, it also serves as a classroom. Several challenges in terms of both software and technical support were posed and overcome.

The software, *Visual Studio* .NET™ is, at the time of writing, a relatively new language. The challenge here was the syntax which was conquered by some tenacious sifting through the Microsoft help files.

The technical trials were resource-related. *Visual Studio* .NET™ requires an immense amount of computing power, from both the server and the programmer's personal computer. Being a relatively new language, new patches and updates were required from Microsoft in order to run the compiled interface on the web servers. On a more mundane note, the SQL server had a motherboard malfunction, the motherboard was hastily replaced. The Faculty of Computer Studies has, thankfully, been blessed with an extremely competent, and efficient, facilities manager. This facilities manager ensured that all the technical challenges were met with haste, professionalism and always with a smile.

On the side of the prototype, it is not as flexible and as user-orientated as first intended. A number of facilities that were envisaged were not implemented. One of these facilities is the user personalisation facilities which allow users to adjust the user-interface to suit their personal learning style and sense of fashion.

Since this is a prototype, the user interface for the educator components was also not created. Included in the educator components would be the server-side scripts which insert the data into the star schema when the educator updates or adds a resource. Furthermore, a script to check the availability and updating of resource websites and other resources was not implemented as first envisaged.

On the user-interface side, the resource-base pages were first developed for a 1024 x 768 resolution screen. This had to be altered once the prototype had been completed, to facilitate an 800 x 600 resolution screen. The motive for this alteration is that of compatibility and flexibility. Hardware is downwards compatible but not upwards compatible.

9.5 LEARNER APPRAISAL

Learners do not necessarily view the world in the same manner an educator might. Therefore, an interesting study regarding the learners' opinion on the resource-base was informally conducted. The questions asked to the learners were:

1. What I would change about the resource-base and how I would change it?
2. What I would keep the same?
3. Would I use this facility if it were made available for use?

To facilitate the answering of the questions, the educator selected a semester test which the learners had written in the last half of the year. The educator allocated misconceptions to each learner according to the individual's answers to the questions posed in the test.

User Interface

A number of learners responded to the survey and several intriguing results were observed. The results were intriguing from the respect that they were not the reaction that was anticipated. The anticipated responses included the concerns about security and privacy issues and the ability of the resource-base to provide the resources in sufficient quantity and quality. The greatest complaint by the learners about the system, however, was that the interface was too boring, too business-like and too formal. The learners wanted animated pictures and more colour in each of the screens.

Remaining on the topic of user interface, the learners mentioned that they would like the "Back" and "Previous" buttons removed. It seems as though the learners would like everything on one page, regardless of how untidy it might seem to the developer.

The learners also requested a help page or an explanation page that gives the background of the resource-base and answers the question of "What is this site about?"

Security

The majority of the responses were security concerns. The learners also wanted the security option (password on the login screen) to be activated. The learners did not like the dropdown box for the username either. It seems that privacy is a large concern amongst the learners.

Courses and Materials Available

Only one of the courses was made available to the learners to peruse, since the developer/educator had immediate access to that particular course's materials and outcomes. A majority of the learners indicated that they would appreciate all of their courses to be made available in the future.

There was a request for memorandums to tests that had been written in class. There was also an interesting request regarding previous years' examination papers. The learner requested that he would like to see the misconceptions linked to examination questions. He claimed that this would improve a learner's ability of correctly interpreting the questions so that the correct answers may be given.

Facilities Available

A few of the learners also indicated that they did not appreciate the course outcomes search and that the search was not necessary. A small percentage of the learners did admit that they were not sure how the *Search* page works and requested some form of help when dealing with the searches.

A few learners compared the resource-base to their student portal (available on http://extreme.petech.ac.za). This portal has facilities that allow learners to view their year marks (or progress reports) and has links to a variety of popular search engines such as Google (http://www.google.com). The student portal also gives learners access to exam timetables and exam results. The learners' comments were that they would like the same facilities to be available on the resource-base.

Numerous learners mentioned that they would appreciate additional information on the resource-base. This includes job opportunities per diploma or "Who hires people like me?"

Three learners requested that the educator for each subject write a short message to the learners regarding how the learner should go about learning the concepts in the subject and what issues or problems might cause learners to fail. This same learner requested a peer forum where learners of the same class may interact and share their frustrations and victories with each other.

Several learners mentioned that they would like the resource-base to point to library books available to aid with their assignments. The learners, who wrote this as a response, were all from the extended programme group. The extended programme is a learning programme which allows disadvantaged learners or learners who did not meet the entrance criteria by a marginal amount (using the Swedish rating scale). The extended programme learners are given a reduced studying load (only half of their subjects) for their first and second years. This means that an extended programme learner will complete his or her studies in four years instead of three years. It is interesting to note that the learners who wrote this request did not do well in their last assignment due to plagiarism. It is also noted that these self-same learners did not do well in tests, either.

One learner requested links to self-tests and another learner requested educational games.

General

Learners complained that the majority of the sites available were on the Internet. At the Port Elizabeth Technikon, learners have to pay for the excessive use of Internet access. The majority of learners see this as the chief drawback of the resource-base.

On the Positive Note

All of the learners, who responded to the survey, concluded that they would most certainly use the resource-base. Each of the participating learners emphasised the value of knowing their individual pitfalls. Several learners even expressed disappointment in the fact that the resource-base had not been made available to them at the beginning of the year.

9.6 CONCLUSION

The resource base prototype was developed using the Microsoft products: *Microsoft SQL Server*™ and *Visual Studio* .NET™ (C#). Both the star schema and normalised schema were implemented on the SQL server. The database is indirectly accessed by the user (learner) via the user interface. This interface was coded in C#™ as active server pages.

The user interface was implemented for the learner's view. The educator's components were not implemented. All educator functions were done directly in the database. This included creation of learner profiles, insertion of resources and the linking of all the interrelated information.

Once the prototype had been completed, the learners of the Financial Information Systems I class of 2003 were given access. This would allow the learners to respond to a survey which was conducted on an informal basis.

Overall, the learner response to the resource base was positive, with a few user-interface complaints. The interesting findings from the survey included the view of the learners towards outcomes in general. A few of the learners did not appreciate or perhaps did not understand the purpose of course outcomes. The majority of the learners' comments were directed towards the colour scheme and look of the web pages. The learners maintain that the web pages were too business-like and professional. The learners wanted the web pages to be exciting and youth-orientated with animated pictures and wilder colour schemes.

Aside from the learner expectations, the resource base has to be measured up to the original standards and criteria set out in Chapter 4. The purpose will be to determine whether or not the resource base has met the necessary needs originally specified. This comparison will be covered in the next chapter.

Chapter 10

Conclusions and Deliberations

> "The basic principle of the new education is to be that dunces and idlers must not be made to feel inferior to intelligent and industrious pupils. That would be 'undemocratic'. These differences between the pupils – for they are obviously and nakedly *individual* differences – must be disguised…
>
> …Children who are fit to proceed to a higher class may be artificially kept back, because the others would get a *trauma* – Beelzebub, what a useful word! – by being left behind. The bright pupil thus remains democratically fettered to his own age-group throughout his school career, and a boy who would be capable of tackling Aeschylus or Dante sits listening to his coaeval's attempts to spell out A CAT SAT ON THE MAT."

Screwtape
"The Screwtape Letters" by C.S. Lewis

10.1 THE PREAMBLE

C.S. Lewis (1898–1963) was a Fellow and Tutor in English Literature at Oxford University and also elected to the Chair of Medieval and Renaissance English at Cambridge University. In his novel, "The Screwtape Letters" which was published in 1942, he outlines several evils of society, including the above extract regarding the educational system of his day. His scathing criticism was aimed at Traditional Education.

In the time of C.S. Lewis, Traditional Education sought to "paint" all learners with the "same brush", thereby removing their individuality and personal identity. Conversely, the current paradigm in education, constructivism, seeks to empower the learner's individuality (Section 2.3).

As seen from the previous chapters, the resource base has sought to enable individual learning and differentiated learning facilities into the classroom. The resource base strives to create a technique which will allow educators to organise their educational resources. This technique should facilitate the quick and efficient search and retrieval of these resources. These searches should allow educators and learners to find resources based on keywords, outcomes and misconceptions. Learners should be able to receive their educational resources on an individual basis where the criteria for customisation are based on the learners' unique misconceptions (Section 1.4). These were the objectives that were introduced in Chapter 1.

The objectives identified in Chapter 1 will be used in this chapter to determine the success of the resource base and discover new and further avenues for continued research.

The objectives discussed in Section 1.4 were expounded further in Chapter 4. This resulted in a table of requirements (Table 4.1) which was utilised as a basis to evaluate several products in Chapter 5. The table of requirements is thus the basis of the evaluation of the resource base.

Before continuing with the evaluation, there is a point on which to dwell. A distinction should be made between the abilities of the model and that of the prototype. The prototype, although a test bed for the model, does not reveal all of the model's capabilities. The evaluation, therefore, will take place on a dual basis: the capacity of the prototype and the potential of the model.

10.2 RESOURCE BASE REQUIREMENTS

As previously mentioned, Chapter 4 concluded with a table of requirements (Table 4.1) for the resource base. For the sake of convenience, the requirements of Table 4.1 have been reproduced in Table 10.1. These requirements are now used to evaluate the resource base.

In the prototype, the educator interface was not implemented. The evaluation of the educator interface and educator components will therefore be based on the model only.

Requirement 1, based on the model, is possible. Most database management systems also facilitate the straightforward importing of data from spreadsheets and other databases. It is therefore feasible to implement a script to allow the mass importation of courses, outcomes, courses, learners and the links between these entities.

Requirement 2 is facilitated because the model permits learners to be linked to multiple courses over numerous years. It is also possible for the learners to take the same course over several years. Modern database management systems also allow for a variety of users with dissimilar profiles and access rights. It should therefore be permissible to allow educators the rights to create and edit learner profiles.

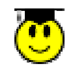
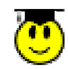
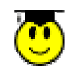
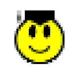
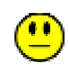
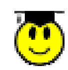
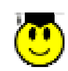
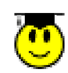
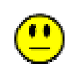
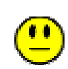
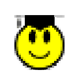
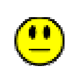
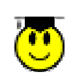
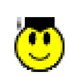
Requirement 3 has been met, since both the model and prototype allow for the linking of all learner profiles to multiple misconceptions.

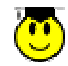
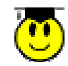
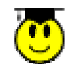
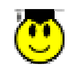
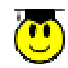
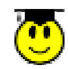
Requirement 4 is a matter of implementation since a future developer could choose to limit this facility to the administrator profile. The model, however, caters for this facility and the database management system chosen should permit the necessary access rights to be given to the educator profiles.

LEGEND

SYMBOL	MEANING	SYMBOL	MEANING	SYMBOL	MEANING
	Well implemented		Mediocre implementation		Not well implemented or not implemented

TABLE 10.1: TABLE OF ASSESSMENT

NO	REQUIREMENT	RESOURCE BASE
1	Educators should be able to create, edit and delete courses, syllabi, course outcomes, sub-outcomes and the links between them.	
2	Educators and administrators should be able to create learner profiles and link them to course. It should be possible to link one learner profile to more than one course.	
3	Educators and administrators should be able to link learner profiles to one or more misconceptions.	
4	Educators should be able add resources to the resource base.	
5	Learners should be able to add resources to the resource base.	
6	Educators should be able to identify possible misconceptions and link these misconceptions to the relevant objectives and resources.	
7	Educators should be able to create, edit and delete the links between course objectives and resources.	
8	Educators should be able to create, edit and delete the links between course objectives, resources and misconceptions.	
9	Educators should be able to critique the resources for quality.	
10	Learners should be able to critique the resources for quality.	
11	Advanced search facilities should be available.	
12	The sharing of resources between users should be facilitated.	
13	The resource base should be cost effective and affordable.	
14	The automated list of suggested resources should be individualised according to course, misconceptions, back-ground and learning style.	

NO	REQUIREMENT	RESOURCE BASE
15	Learners should be able to link their own resources into their profiles according to personal interest, learning style or misconceptions.	
16	The resource base should be easy to maintain.	
17	The resource base should allow for at least three types of user profiles: learner, educator and administrator.	
18	The resource base should be user friendly and easy to navigate.	
19	The resource base should ideally be platform independent and be executable from a wide range of computers.	
20	The resource base should offer security in the form of authentication of users and audit logs.	
21	The metadata should be compliant to one of the known standards.	
22	The resource base should run on a network (e.g. intranet) and be scalable.	

Requirement 5 is achievable. The model is broad enough to facilitate this particular requirement. As discussed in Section 3.3, the quality of the resources is an important issue. This is just one of the considerations when implementing this requirement. There are numerous arguments for and against learners adding resources into the resource base. A debate about whether or not learners will abuse this facility could be countered by a system of accountability. The learners should be accountable for the resources added to the resource base. Another solution would be a temporary holding facility for resources added by learners. This facility would not allow learners to view the resources until they are approved by an educator. This temporary holding facility can be added by the addition of one or two entities in the resource base.

Requirement 6 has been facilitated. The model allows for misconceptions and the association of these misconceptions to the necessary outcomes and resources. The educator profiles within the database management system should allow educators the rights to the necessary tables.

Requirement 7 is provided for within the model. It is a matter of implementation and user rights to ensure that educators have this facility available to them.

Requirement 8 states that the educator should be able to create, edit and delete the links between course objectives, resources and misconceptions. Thus, Requirement 8, as with Requirement 7, has been incorporated within the model but the implementation thereof is a matter of user rights.

Requirement 9 was not implemented within the prototype, however, the model does allow for an annotator for each resource. A more comprehensive quality check and criticism is possible by adding an associative entity between the educator profile and resource entity.

Requirement 10 is possible by adding an associative entity between the learner profile and the resource entity. As with the adding of resources, the learners should be accountable for their comments, if not to the educators, then certainly their peers.

Requirement 11 has been facilitated through the star schema (Chapter 8). The star schema caters for the searches for misconceptions, outcomes and keywords. The normalised schema may be utilised to search for authors and media types. If necessary, the star schema may be adapted by the addition of a media dimension to allow for faster searches on the media types.

Requirement 12 is facilitated through the model. The learners have access to all the resources through the keyword search in the prototype. The model allows all users to access all the resources through the avenues of searches and resource delivery.

Requirement 13 is based on the cost of the resource base. This cost is a function of the licensing of the database management system (in this case, *Microsoft SQL Server™*), the database server, the web server and the development tool (*Microsoft Visual Studio™*). In the development of the prototype, the cost of development was reduced by several factors. Firstly, the institution has a blanket agreement with *Microsoft*, which decreases the cost of licensing of all *Microsoft* products. The second is that the institution uses these *Microsoft* products in their courses, which further defrays the cost of use. The servers (web and database) were also shared amongst concurrent projects and developments within the institution. There is another point of consideration: although *Microsoft SQL Server*™ has been utilised for the development of the prototype, any other SQL database management system may suffice. After the compilation of the interface in *Visual Studio* .NET™**,** the programming package will only be needed to perform interface maintenance issues. The other requirements of the resource base would be that of services and hardware. A web server to provide the "middleware" for the resource base should be available (this allows the learners to log in). An SQL server should also be available for the learners. For the maintenance of the resource base, the costs should be nominal due to the sharing of both the hardware and software with other applications. The administration is a duty that is shared, hence once the resource base has been installed, the upkeep thereof should be relatively stable. An obvious addition is that of an intranet or network and a means for the learners and educators to access the intranet or network.

Requirement 14 has been met. Chapter 9 describes in detail the individualisation capabilities of the resource base. On both the database schema level (model) and within the prototype, the resource base gives the learners their resources according to their personal misconceptions. No two learners should receive the same set of resources unless they are equally matched on an academic level.

Requirement 15 is possible within the model through the misconceptions. Should a level of learner (and possibly educator) accountability be required, a new field in the associative entity between the misconceptions and learner profile needs to be introduced. This field should indicate the identity of the person who suggested the resources. A further field could indicate the identity of the person who removes a misconception from a learner profile. This would prevent the ad hoc addition and removal of misconceptions by both learners and educators.

Requirement 16 mentions that the resource base should be easy to maintain. This goal is achievable. The database and the interface are separated and thus it is simple to isolate a problem or glitch. The interface, as mentioned in Chapter 9, was created in *Visual Studio* .NET™**.** *Visual Studio* .NET™ allows the user to see the web pages separately to the code. *Visual Studio* .NET™ is not only a visual programming language, but also an object-orientated language. Each element has methods and properties. Therefore, debugging in *Visual Studio* .NET™ becomes a simpler task. In the database segment, the redundancy within the star schema makes updates and insertions more complex than those within a normalised schema. The creation of database scripts should, on the other hand, ease the complexity of updates and insertions.

Requirement 17 requires that at least three user profiles be developed: the learner, the educator and the administrator. The model provides for the learner and educator profiles. The database management system utilised should also cater for at least three types of users.

Requirement 18 requires that the resource base be user friendly and easy to navigate. The feedback from the learners, expounded in Chapter 9, seems to suggest that the learner component of the resource base is simple to navigate. The only criticism that the learners had was that they did not entirely understand the purpose of the resource base. The individualisation of the user interface is possible through the database schema. The educator and learner profiles may be extended by means of user-interface table which could store the user's unique preference for colour schemes, navigation and home pages.

Requirement 19 states that the resource base should be platform independent and executable from a wide range of computers. Since the resource base prototype utilises a web-based interface, it is possible for most machines to access the resource base. The only possible problems would be the extremely outdated computers with the earliest web browsers. Requirement 19 has thus been satisfied.

Requirement 20 states that security is an issue. Provision has been made for this particular requirement in the form of authentication when the learner logs into the resource base. The learners, from the survey discussed in Chapter 9, emphasised the importance of security. A learner does not want his or her colleagues to discover what learning weaknesses he or she possesses. The security facilities of the resource base were not activated for the prototype, since it is not the main focus of the prototype. It also was not activated to allow for the easy debugging and evaluation of the prototype.

Requirement 21 implies that one of the known meta-data standards should be utilised. In Section 6.2.2, it was decided that the Instructional Management Systems (IMS) standard would be the basis of the resource base meta-data. It may thus be concluded that Requirement 21 has been met.

Requirement 22 requires the resource base to be scalable and run over a network. It was for this particular requirement that *Microsoft SQL Server*™ was chosen as the database management system. *Microsoft SQL Server*™ is scalable, more so than *Microsoft Access*™. Since the interface of the resource base is web-based, it is possible not only to run the resource base over a local intranet but also to run it over the Internet.

10.3 CONSIDERING THE RESOURCE BASE

10.3.1 The Limitations

Within both the model of the resource base and the prototype, there are a variety of limitations. The model does not prescribe its application and is open to several interpretations. The model is certainly not a cure-all for every classroom malady and should not be utilised as such.

Security and privacy issues have not been fully addressed within the model. With the learner feedback in mind, it is imperative that these issues be addressed.

The model only presents guidelines for the user interface. These guidelines included the balancing of the number of hyperlinks on the site and navigational considerations. The finer details of the user interface are certainly not prescribed by model. A future developer could opt to alter the user interface, which may not be an adverse proposal considering the learner feedback.

The prototype also has its own limitations. The prototype demonstrated the learner component but not the educator component. This educator component therefore needs to be added to the prototype to evaluate the true usefulness of the resource base within a live educational environment. Although the survey described in Chapter 9 was useful, it was a very brief and subjective look at the resource base.

An obvious limitation is that the resource base is technology-reliant. In educational institutions with limited or antiquated computer facilities, it will be difficult to implement a resource base.

It is said that obstacles may be viewed in two lights, either as stumbling blocks or as stepping stones. The obstacles or limitations of the resource base may be seen as stepping stones when they present further research opportunities.

10.3.2 Further Research

As previously mentioned, the learner survey conducted was informal, subjective and brief. It would be of value to quantitatively measure the effect of the source base on individual academic performance. A question to ask would be "Would the learners actually use this facility?" This question can only be answered if the learners are given the resource base for a full course and the educator continually updates the learners' profiles within the resource base. A further question which could be answered by the previously mentioned study would be the true value that the resource base adds to the learners' academic life and success.

The accountability of both learners and educators needs to be more comprehensively explored. Should the learners be allowed to enter resources directly into the resource base? What type of accountability should be implemented and what penalties should be in place? These questions are not necessarily technical in its focus but perhaps more human in nature and tend towards the computer security arena.

In the search for resources for the resource base prototype, very few African resources were discovered. The lack of these resources could have an impact on the context of teaching (Section 2.2.5). The source of the majority of the resources is America and some of the resources are exceedingly patriotic and biased towards an American audience. The impact of these American resources on South African learners, especially the Xhosa and Zulu learners, is an area of personal interest to the researcher. Are these resources "Americanising" the African learners and denying them their own culture? What impact would this "Americanisation" have on the African Renaissance? What would it take to create resources for the African educational context and what are the implications?

10.4 FINALE

In this Knowledge Age, educators have to prepare learners to face the multi-faceted demands of the modern workplace. The Knowledge Age has also brought new educational paradigms, in the form of constructivism and Outcomes-Based Education (OBE). The paradigm of constructivism advocates the building of knowledge on the foundations of previous experiences and prior education. Constructivism also acknowledges that each learner is an individual with a unique set of abilities and needs. In today's teaching and learning situations, this places the educator in an environment filled with opportunity and challenges. These challenges include multi-cultural classes, larger learner numbers in classrooms, financial restrictions and diverse demands from businesses and governing bodies.

Electronic educational resources may go some way in aiding educators providing individual learning to learners. Although there are a multitude of resources available on the Internet, it is both time-consuming and difficult to find quality resources. The quality of resources is judged on both educational and technical criteria. Storing these quality resources (or the links to these resources) is one of the aims of the resource base. The second aim of the resource base is to provide search facilities. These search facilities enable the user to find resources based on key words, course, course outcomes and misconceptions. The final aim of the resource base is to allow the educator to individualise the collection of resources that each learner receives according to the learner's unique set of misconceptions.

This chapter had a look at the resource base's abilities to meet those aims. It is hoped that the resource base goes some way in providing differentiated learning to the learners. It is also hoped that the frustration that some of the academically challenged learners harbour against educators and the "educational system" will be alleviated with the aid of the resource base. The resource base, admittedly, is not the perfect solution to all the challenges posed to modern education. It is, however, a step in the right direction.

On a personal note, this study has given the researcher a deeper look into education and the mind of the learner. Confucius once wrote in "The Confucian Analects", "Learning without thought is labour lost; thought without learning is perilous". Educators certainly have a duty towards the learners entrusted into their care. This duty is to incite them to learn and be involved in their own learning. The learners, too, have a duty. This duty is unto themselves: to learn, to improve, to live.

"Teaching should be such that what is offered is perceived as a valuable gift
and not as a hard duty."

Albert Einstein

Appendices

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Appendix A

Performance Pondering

A.1 INTRODUCTION

The star schema differs from the normalised schema on almost every level, including logical and physical design as well as implementation and application (Kimball, 1996, p. 1; Oracle Corporation, 2002). The logical design and application differences were introduced in Chapter 8. This Appendix concentrates on the disparity between the normalised schema and the star schema in the area of query performance. Query performance is especially important to the resource base, since the majority of the operations executed are envisaged to be queries.

Since the resource base will need to query a large amount of data quickly, it is imperative that the schema chosen facilitates the necessary queries. The normalised schema, as mentioned in Section 8.1, is an efficient storage facility. It is said, in the world of engineering, that form follows function. It is therefore not unreasonable to expect a normalised database's abilities to retrieve data to be restricted to its customary function. A normalised schema usually represents an operational database, which as a rule requires searches involving a small number of concise tables and is expected to return a handful of records. A star schema, however, is expected to traverse tables of gargantuan size and return a sizeable answer set (Kimball, 1996, p. 1–12; Oracle Corporation, 2002).

Consequently, each schema should have a differing approach to the execution of queries. Indexing may be utilised in order to expedite queries in both schemas. There are various indexing techniques available, including the B-tree index. The B-tree index is the most efficient for the type and number of queries performed by operational databases. Within a data warehouse, on the other hand, the use of B-tree indexing is considered inadequate. One of the reasons for the B-tree's inadequacy is that the index is often larger than the actual data warehouse table, thereby taking up additional hard drive space. A B-tree index being utilised for unique keys within a data warehouse fact table is normally not efficient for the type of queries posed to a data warehouse. For a data warehouse, the use of a bitmap index is strongly suggested (Kimball, 1996, p. 97; Oracle Corporation, 2002).

The two schemas are therefore quite disparate in the area of querying techniques. The indexing utilised to optimise queries for the schemas are different and it would thus be a challenging task to compare the two schemas on the grounds of their indexing techniques. In an evaluation regarding performance, it is does not seem to be correct to compare two schemas utilising certain differences as the measure of performance. These differences might adversely influence the outcome of the exploration. As the saying goes, it is similar to comparing apples with oranges. The trick is to find those characteristics which the two items share and use these commonalities to begin the evaluation. Therefore, at least one common denominator, by which one may begin to evaluate the two schemas, is needed. Since the evaluation is a performance evaluation, the average cost of executing a typical query is the normal modus operandi in determining query performance. Therefore, the two schemas will need to be appraised in terms of their queries.

A.2 DETERMINING THE COST OF A QUERY

Database specialists tend to calculate the cost of executing a query in terms of disk accesses. The number of disk accesses has a direct impact on the speed of the query. A query's execution time is reduced each time the DBMS has to access the disk in order to access further data. Therefore, for these queries, a variety of facts needs to be known or estimated. These facts include the time it takes for a disk to read a page of data into memory, the processing capabilities of the Central Processing Unit (CPU) and the number of pages that can be stored in memory (Ramakrishnan & Gehrke, 2000, pp. 230–231; Elmasri & Navathe, 1989, pp. 525–527).

The formal cost-of-query calculations are also highly dependent on the type of database management system (DBMS) being utilised, since each DBMS uses differing algorithms for search and retrieval. Oracle, for example, claims that their search facilities in their DBMS are far superior to other DBMSs due to the advanced algorithms being utilised (Oracle Corporation, 2003). Oracle's competitor vendors, however, make similar claims regarding their own products.

Not only does each DBMS use different sets of algorithms, but each DMBS may have several algorithms at disposal for each type of operation. For example, a select query may be done as a straight (brute force) search, a binary search or it may use a hash index or a clustering index, or the primary index. Each of these techniques influences the formulas utilised in calculating the cost of query execution.

Therefore, one of the facts that needs to be known is the DBMS that will ultimately be utilised in the final resource base.

Another fact that needs to be considered is the "blocking factor". This is the number of records (in a particular table) in each physical piece of disk space (a block). A block might also be equated to a page (or the page size). The number of pages that can fit into memory for processing also has an effect on the number of reads done by the hard disk. However, computer memory may be increased to decrease the number of reads performed, thereby reducing the time it takes to execute a query (Ramakrishnan & Gehrke, 2000, pp. 230–231; Elmasri & Navathe, 1989, pp. 525–527).

A further consideration is the number of records in each of the tables being used. The cost of the query escalates in relation to the increase in the number of records (or tuples)

in each table (Connolly & Begg, 1998, pp. 605, 618–635; Elmasri & Navathe, 1989, pp. 501–511).
All of the above information should be available from the DBMS. However, since the current resource base is a prototype, a few of the necessary facts for the calculations are either not available or will not truly reflect the final implementation. Any calculation based on these inaccurate figures will therefore be a rough estimate.

For these reasons, a simplified version of calculating the cost of queries will be utilised to determine the effectiveness of the resource base's star schema.

Since joins are the most expensive of DBMS operations, the simplified version will concentrate on the number of joins that is necessary to successfully execute the queries (Connolly & Begg, 1998, p.626; Elmasri & Navathe, 1989, pp. 506–510).

A.3 REDUCING DATABASE OPERATIONS

The resource base's star schema will thus be compared to the normalised structure utilising queries that have identical resultant data primarily on the basis of the number of joins. The next three sections will compare differing sizes of databases, starting with a small database and ending with a larger database. All of the calculations are based on the algorithms presented in Connolly and Begg (1998) from pages 618–635 and Elmasri and Navathe (1989) from pages 501–511.

These three databases will utilise the same query to provide consistent results. This simple query is "What are the resources for my courses?" This query has to find the courses for which the learner is registered and then find all the resources for those courses. The number of calculations completed to successfully execute this query in both schemas will is computed for three databases of differing magnitudes. The first database is a small database, the second database is a larger (or medium-sized) database and the last database is a relatively large database. There are a number of variables that remain constant to reduce their influence on the calculations. These variables are the number of keywords and the number of misconception records. These tables do not feature in the normalised schema in the query chosen for this performance evaluation. They do, however, influence the star schema's RESOURCE FACT TABLE. It was decided to keep the number of keywords associated to each resource to five. The number of misconceptions per resource is constant at five per resource.

A.3.1 The First Database

The first database is a relatively small database, with ten learners in the LEARNER table, each of these learners taking a maximum of one course each. There are two courses in the COURSE table, each having five curriculum goals. The CURRICULUM GOAL table has ten records, each associated with two specific outcomes. The SPECIFIC OUTCOME table has twenty tuples and each specific outcome is associated with two resources. There are thirty resources in the RESOURCE table.

The Normalised Schema

Within the normalised schema, the number of tables involved in this query would be nine (including associative tables) (Figure 8.8).

```
SELECT DISTINCT
      R_ID AS [Resource ID],
      R_Title AS [Resource Title],
      R_Link AS [Resource URL],
      C_Name AS [Course Name]
FROM
      LEARNER,
      LEARNER_COURSE,
      COURSE,
      COURSE_CURRICULUM_GOAL,
      CURRICULUM_GOAL,
      CURRICULUM_GOAL_SPECIFIC_OUTCOME,
      SPECIFIC_OUTCOME,
```

```
        SPECIFIC_OUTCOME_RESOURCE,
        RESOURCE
WHERE
        (LEARNER.L_ID = @StudentNumber)
        AND
        (LEARNER.L_ID = LEARNER_COURSE.L_ID)
        AND
        (LEARNER_COURSE.C_ID = COURSE.C_ID)
        AND
        (COURSE.C_ID = COURSE_CURRICULUM_GOAL.C_ID)
        AND
        (COURSE_CURRICULUM_GOAL.CG_ID = CURRICULUM_GOAL.CG_ID)
        AND
        (CURRICULUM_GOAL.SO_ID = CURRICULUM_GOAL_SPECIFIC_OUTCOME.SO_ID)
        AND
        (CURRICULUM_GOAL_SPECIFIC_OUTCOME.SO_ID = SPECIFIC_OUTCOME.SO_ID)
        AND
        (SPECIFIC_OUTCOME.SO_ID = SPECIFIC_OUTCOME_RESOURCE.SO_ID)
        AND
        (SPECIFIC_OUTCOME_RESOURCE.R_ID = RESOURCE.R_ID)
GROUP BY [COURSE NAME]
```

The first component of the query would be that of selecting the learner (@StudentNumber). This would be a maximum of ten operations. The number of operations is ten because for each record, the DBMS has to loop through all of them once to determine whether or not it is a match. This is assuming that there are no indexes on the key fields. To be impartial to both of the database schemas, the worst case scenario and the lack of indexing is assumed. With this assumption in mind, the first resultant (and temporary) table would have one record (the learner's student number).

This resultant table is then joined with the associative entity (LEARNER_COURSE), which is a maximum of ten operations. The DBMS has to perform a nested loop for joins, the first table forms the outer loop and the second table forms the inner loop.

Therefore, for any join, the number of operations performed is usually the number of records in the first table multiplied by the number of operations in the second table. In this case, it is one multiplied by ten. The second resultant table contains one record (each student takes one course).

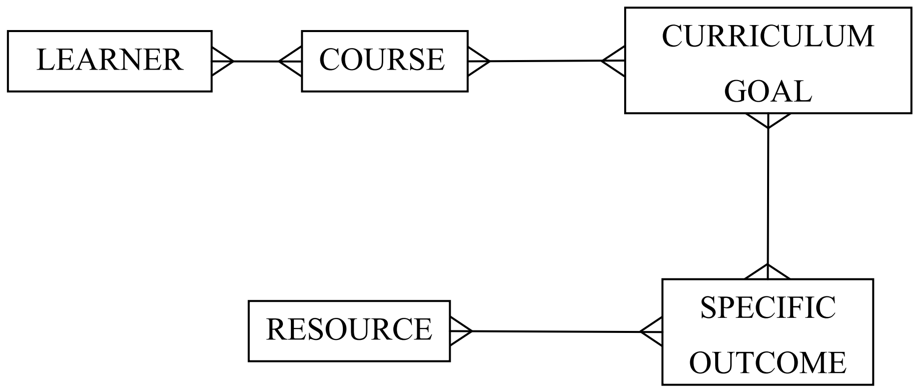

Figure A.1: Normalised Schema for Learner-Resource Query

The third component of the query is the join between the resultant table (one record) and the COURSE table. Since there are two records in the COURSE table and one in the resultant table, the total number of operations is two (one multiplied by two). The new (and third) resultant table has one record (containing the learner details and the course details).

The fourth component of the query is the join between the third resultant table (one record) and the associative table, COURSE_CURRICULUM_GOAL (ten records). The number of operations performed to execute this component of the query is ten (one multiplied by ten). The fourth resultant table has five records.

The fifth component of the query is the retrieval of the curriculum goal details. The number of operations performed to join the fourth resultant table and the CURRICULUM GOAL table (ten records) is fifty. The new and fifth resultant table has five records.

The sixth component of the query is the join between the fifth resultant table and the associative table, CURRICULUM_GOAL_SPECIFIC_OUTCOME (twenty records). The number of operations to complete this sixth component is one hundred (five multiplied by twenty). The sixth resultant table contains ten records.

The seventh component is the retrieval of the specific outcomes details. This joins the sixth resultant table (ten records) with the SPECIFIC_OUTCOME table (twenty records). The number of operations is two hundred, giving a seventh resultant table of ten records.

The eighth component is the joining of the seventh resultant table and the associative table SPECIFIC_OUTCOME_RESOURCE (forty records). The number of operations, which produces the eighth resultant table, is four hundred operations yielding twenty records.

The final and ninth component is the joining of the eighth resultant table (twenty records) to the RESOURCE table (thirty records). The number of operations is six hundred, subsequently producing the final answer of twenty records.

The total number of operations performed to successfully execute this query is one thousand, three hundred and eighty-two (1382).

The Star Schema

Within the star schema, the number of tables involved in the query is less (Figure 8.9). However, the number of records within the table will be significantly greater in the fact table (RESOURCE_FACT_TABLE).

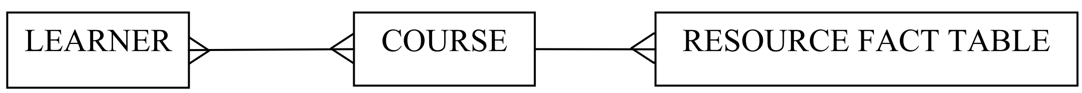

Figure A.2: Star Schema for Student-Resource Query

Since a fact table is a "joined" table which is stored, its size is dependant on the number of records in each of its dimension tables. In the case of the RESOURCE FACT TABLE, its dimensions include keywords, specific outcomes and misconceptions. Determining the number of keywords or misconceptions for each resource is a difficult task since each resource will have a dissimilar number of keywords and misconceptions with which it is associated. Therefore, the number of keywords and misconceptions per resource for the purpose of this calculation is merely an estimation.

Assuming that there are five keywords associated with each resource. This implies that there will be a total of one hundred keywords. The misconceptions estimate is five misconceptions per resource which implies that there will be a total of one hundred misconceptions. Since the keywords and the misconceptions are not a part of the query being performed, it was decided to keep the number of keywords and misconceptions per resource constant. This will allow for an unbiased calculation and trend analysis. The size of the RESOURCE FACT TABLE may be calculated as the product of:

- the number of curriculum goals,
- the number of specific outcomes per curriculum goal,
- the number of resources per specific outcome,
- the number of misconceptions per resource and
- the number of keywords per resource.

Therefore, for this example, the number of records in the RESOURCE FACT TABLE is 10 x 2 x 2 x 5 x 5 = 1000. One thousand records in the RESOURCE FACT TABLE.

The calculation for the cost of query would differ from that of the normalised schema, although the number of records in the other tables remains the same.

```
SELECT
      R_Link AS [Resource URL],
      R_Title AS [Resource Title],
```

```
      C_Name as [Course Name]
FROM
      LEARNER,
      LEARNER_COURSE,
      COURSE,
      RESOURCE_FACT_TABLE
WHERE
      (LEARNER.L_ID = @StudentNumber)
      AND
      (LEARNER.L_ID = LEARNER_COURSE.L_ID)
      AND
      (LEARNER_COURSE.C_ID = COURSE.C_ID)
      AND
      (COURSE.C_ID = RESOURCE_FACT_TABLE.C_ID)
```

The first component of the star schema query is the selection of the learner from the LEARNER table. This, as seen in the normalised schema, is ten operations. The first resultant table has one record.

The second component of the query is the joining of the first resultant record with the associative table, LEARNER_COURSE (ten records). This gives a second resultant table of one record, needing ten operations to complete.

The third component is the retrieval of the course details. This gives the third resultant table, which has one record. The number of operations done to complete this component is two.

The last component is the retrieval of the resources. This means joining the third resultant table of one record with the larger fact table, RESOURCE_FACT_TABLE (one thousand). This component requires one thousand operations, yielding the final result of twenty records.

The total number of operations performed, utilising the star schema, is one thousand and two.

To summarise, the above calculations and comparisons are given in Table A.1 and Table A.2.

TABLE A.1: OPERATIONS FOR THE NORMALISED SCHEMA

NORMALISED SCHEMA OPERATIONS						
Query Component	**Table 1**		**Table 2**		**Resultant Table**	**Number of Operations**
	Name	Size	Name	Size		
First (Select)	LEARNER	10			1	10
Second (Join)	1st Result	1	LEARNER_COURSE	10	1	10
Third (Join)	2nd Result	1	COURSE	2	1	2
Fourth (Join)	3rd Result	1	COURSE_CURRICULUM_GOAL	10	5	10
Fifth (Join)	4th Result	5	CURRICULUM_GOAL	10	5	50
Sixth (Join)	5th Result	5	CURRICULUM_GOAL_ SPECIFIC_OUTCOME	20	10	100
Seventh (Join)	6th Result	10	SPECIFIC_OUTCOME	20	10	200
Eighth (Join)	7th Result	10	SPECIFIC_OUTCOME_RESOURCE	40	20	400
Ninth (Join)	8th Result	20	RESOURCE	30	20	600
			Total Number of Operations for the query			1382

TABLE A.2: OPERATIONS FOR THE STAR SCHEMA

STAR SCHEMA OPERATIONS						
Query Component	**Table 1**		**Table 2**		**Resultant Table**	**Number of Operations**
	Name	Size	Name	Size		
First (Select)	LEARNER	10			1	10
Second (Join)	1st Result	1	LEARNER_COURSE	10	1	10
Third (Join)	2nd Result	1	COURSE	2	1	2
Fourth (Join)	3rd Result	1	RESOURCE_FACT_TABLE	100	20	1000
			Total Number of Operations for the query			1022

The normalised schema needed one thousand, three hundred and eighty-two operations to complete the same query.

$$1382 \div 1022 = 1.35$$

Therefore, the star schema is, for this query, 1.35 times better than the normalised schema.

A.3.2 The Second Database

As seen in the previous calculation, the star schema only has a slight advantage over the normalised database when dealing with a relatively small database. To determine whether or not a trend exists, a few more calculations need to be done using different size databases.

The second database is larger than the first, with fifty learners in the LEARNER table, each of these learners taking a maximum of three courses each. There are ten courses in the COURSE table, each having ten curriculum goals. The CURRICULUM GOAL table has ninety records, each associated with five specific outcomes. The SPECIFIC OUTCOME table has three hundred tuples and each specific outcome is associated with five resources. There are five hundred resources in the RESOURCE table. There are five resources per misconception and five keywords per resource. This means that the RESOURCE_FACT_TABLE contains fifty-six thousand, two hundred and fifty records.

Using the queries specified in Section A.2, Tables A.3 and A.4 may be computed.

The difference between the number of operations executed for the larger database is a factor of 3.92. The star schema is about four times more efficient than the normalised schema.

TABLE A.3: OPERATIONS FOR THE NORMALISED SCHEMA

NORMALISED SCHEMA OPERATIONS						
Query Component	**Table 1**		**Table 2**		**Resultant Table**	**Number of Operations**
	Name	Size	Name	Size		
First (Select)	LEARNER	50			1	50
Second (Join)	1st Result	1	LEARNER_COURSE	150	3	150
Third (Join)	2nd Result	3	COURSE	10	3	30
Fourth (Join)	3rd Result	3	COURSE_CURRICULUM_GOAL	100	30	300
Fifth (Join)	4th Result	30	CURRICULUM_GOAL	90	30	2700
Sixth (Join)	5th Result	30	CURRICULUM_GOAL_ SPECIFIC_OUTCOME	450	150	13500
Seventh (Join)	6th Result	150	SPECIFIC_OUTCOME	300	150	45000
Eighth (Join)	7th Result	150	SPECIFIC_OUTCOME_RESOURCE	1500	750	225000
Ninth (Join)	8th Result	750	RESOURCE	500	750	375000
			Total Number of Operations for the query			661730

TABLE A.4: OPERATIONS FOR THE STAR SCHEMA

STAR SCHEMA OPERATIONS						
Query Component	**Table 1**		**Table 2**		**Resultant Table**	**Number of Operations**
	Name	Size	Name	Size		
First (Select)	LEARNER	50			1	50
Second (Join)	1st Result	1	LEARNER_COURSE	150	3	150
Third (Join)	2nd Result	3	COURSE	10	3	30
Fourth (Join)	3rd Result	3	RESOURCE_FACT_TABLE	56250	750	168750
			Total Number of Operations for the query			168980

Therefore, for two cases, the star schema is the more cost-effective model. However, in the second case, the factor by which the star schema outperforms the normalised schema is a much smaller number. To determine if this is a trend or if there are other factors involved, a third database will be investigated.

A.3.3 The Third Database

The previous query of the resources for each course for which a learner is registered, is utilised. The third database is larger than the first two, with one hundred and fifty learners in the LEARNER table, each of these learners taking a maximum of eight courses each. There are forty courses in the COURSE table, each having fifteen curriculum goals. The CURRICULUM GOAL table has three hundred records, each associated with ten specific outcomes. The SPECIFIC OUTCOME table has two thousand tuples and each specific outcome is associated with five resources. There are four thousand resources in the RESOURCE table. There are two thousand misconceptions each associated with five resources. There are four thousand keywords each associated with five resources. The RESOURCE_FACT_TABLE, therefore, contains three hundred and seventy-five thousand records.

TABLE A.5: OPERATIONS FOR THE NORMALISED SCHEMA

NORMALISED SCHEMA OPERATIONS						
Query Component	**Table 1**		**Table 2**		**Resultant Table**	**Number of Operations**
	Name	Size	Name	Size		
First (Select)	LEARNER	150			1	150
Second (Join)	1st Result	1	LEARNER_COURSE	1200	8	1200
Third (Join)	2nd Result	8	COURSE	40	8	320
Fourth (Join)	3rd Result	8	COURSE_CURRICULUM_GOAL	600	120	4800
Fifth (Join)	4th Result	120	CURRICULUM_GOAL	300	120	36000
Sixth (Join)	5th Result	120	CURRICULUM_GOAL_ SPECIFIC_OUTCOME	3000	1200	360000
Seventh (Join)	6th Result	1200	SPECIFIC_OUTCOME	2000	1200	2400000
Eighth (Join)	7th Result	1200	SPECIFIC_OUTCOME_RESOURCE	10000	6000	1200000
Ninth (Join)	8th Result	6000	RESOURCE	4000	6000	24000000
			Total Number of Operations for the query			28002470

TABLE A.6: OPERATIONS FOR THE STAR SCHEMA

STAR SCHEMA OPERATIONS						
Query Component	**Table 1**		**Table 2**		**Resultant Table**	**Number of Operations**
	Name	Size	Name	Size		
First (Select)	LEARNER	150			1	150
Second (Join)	1st Result	1	LEARNER_COURSE	1200	8	1200
Third (Join)	2nd Result	8	COURSE	40	8	320
Fourth (Join)	3rd Result	8	RESOURCE_FACT_TABLE	375000	6000	3000000
			Total Number of Operations for the query			3001670

The results of Tables A.5 and A.6 imply that the star schema is just over nine times (9.3) more efficient than the normalised schema.

A.3.3 Performance Evaluation

To summarise, the first database, the star schema was 1.35 times better than the normalised schema and for the medium and large database; it was 3.92 and 9.3 times better, respectively. For a graphical comparison these results are illustrated in Figure A.3.

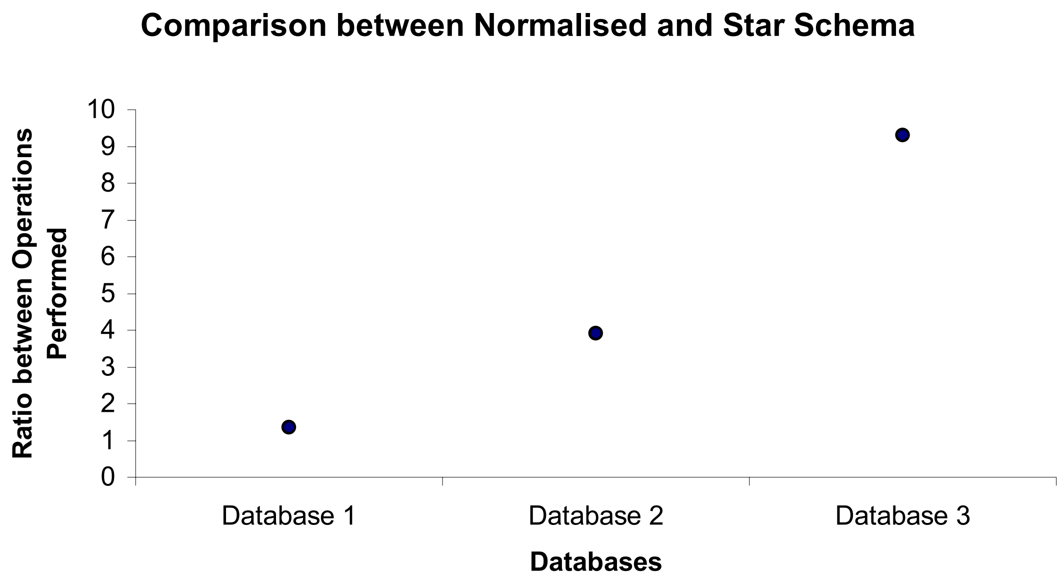

Figure A.3: Comparison Chart

As seen from the chart (Figure A.3) and the tables, the star schema holds an advantage over the normalised schema. Concurrent usage would increase the value of the star schema by decreasing the load on the database server in terms of processing power and memory usage.

The star schema is, therefore, justified by its ability to reduce the load on both processor and random access memory when executing a query. This ability is one of the main reasons businesses utilise the star schema structure in the storage and retrieval of their decision support information. These star schemas normally form the basis of data warehouses. An added advantage of the star schema is that their indexing techniques are generally faster than the indexing techniques utilised in a normalised (operational) schema by an order of up to one hundred (Oracle Corporation, 2002). In conjunction with the speedier indexing techniques, the star schema executes fewer operations in order to complete a query. This means that the already efficient star schema becomes even faster with the introduction of appropriate indexing techniques.

Furthermore, the star schema improves in performance as the database size increases. This, as previously stated, is one of the reasons star schemas are utilised in the design of data warehouses. The implications for the resource base is that the queries based on the star schema component will be executed with greater efficient than if it were executed within the normalised schema. The efficiency will increase as the size of the resource base escalates with the addition of learners, courses, resources, misconceptions and educators.

A.4 CONCLUSION

As previously mentioned, the star schema reduces the number of joins undertaken by the database. The cost of successfully executing a query has helped determine which of the two schemas are the most efficient in retrieving data from the resource base. It has thus been demonstrated that a star schema is less taxing on the computer processor than a normalised schema. Vendor whitepapers (and documentation) also recommend the use of data warehousing techniques for the retrieval of data from large databases consisting of a majority of static data (Oracle Corporation, 2002). The resource base will benefit from the increased speed and efficiency with which a star schema handles significant quantities of data.

Appendix B

Academic Papers

In adjunct to this dissertation, two papers have been prepared. The first paper was presented at the WWW Conference 2001: the 3rd Annual Conference on World Wide Web Applications. The conference took place at the Rand Afrikaans University in Johannesburg on 7–11 May 2001. This paper presented is entitled "The Individualizing of Educational Resources Organized on an Intranet". It has been published in the conference proceedings which is available on the Internet at `http://www.rau.ac.za/WWW2001`

The second paper, entitled "Individualising Access to Educational Resources", has been prepared and will be submitted to a suitable journal for consideration. A copy of this paper has been included in this appendix.

The third paper, entitled "Towards a Model for Organising and Accessing Educational Resources on an Intranet", was accepted as a Spotlight presentation at the seventeenth IFIP World Computer Conference. The conference took place in Montreal in Canada on 25–30 August 2002.

The Individualizing of Educational Resources Organized on an Intranet

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Modern Education Challenges

There are many challenges facing today's education system. These challenges include larger class numbers, the increasing demand for more diverse courses and the escalating diversity amongst learners. This situation can lead to a decrease in individual learner performance as well as a decline in learner motivation. A decline in motivation can become a factor in learner dropouts. A struggling learner is more likely to cancel a course than one who is not. Large class sizes compound the problems of the striving learner, since individual misconceptions, ambiguities and inconsistencies are not addressed in the traditional lecture situation (Slay, 2000; Marsden, 1996).

Another problem with large class sizes is that the needs of the individual are not considered. Each learner comes from a different community, has a disparate culture, comes with a unique background and uses one of a multitude of learning styles. The above-mentioned factors play a large role in the attitude and academic success of a learner. These factors, however, are not the only influences on learner success. Other factors include gender, mental maturity and learner determination (Passerini & Granger, 2000; Slay, 2000).

If a learner is to succeed academically, all the above-mentioned facets of the individual need to be considered. This is due to the nature of learning. Knowledge is constructed on the foundation of prior learning and experience. This building of knowledge is known as the theory of constructivism (Squires & Preece, 1999).

Building Knowledge

There are a number of different types of constructivism. All types of constructivism, however, emphasise that the learner has to be actively involved in the creation of his or her own knowledge. A particular type of constructivism (social constructivism) highlights the social aspect of learning. In other words, knowledge is created through social interaction (Smith-Gratto, 2000; Squires & Preece, 1999).

Thus, the development of knowledge should not be a passive event. Studies have shown that learning only takes place if the learner's interest is held. One of the ways to hold a learner's interest is to involve the learner in his or her own learning. The activities that are able to involve learners in learning include reading, writing, discussing and solving high-level or synthesis problems (problems that require thought and creativity) (McConnel, 1996). Unfortunately, the larger the class, the more complicated it becomes to prepare for, administer and manage an active learning environment (Slay, 2000).

One of the solutions that have been suggested is the use of computer technology as support for the traditional lecture or classroom situation. The use of the Internet and Web technologies has been particularly earmarked as a potentially useful solution to the large classes dilemma (Gillham, Buckner & Butt, 1999).

Advantages of Web Technologies

The reasons cited for isolating Web technologies as a prospective solution include the flexibility of the technology, the ability create different types of interaction and the plethora of educational resources currently available from both non-profit organisations and commercial concerns. It seems as though all the abovementioned reasons are interlinked.

The ability of the technology to create flexibility in learning can aid learners in managing their own learning. The learner can decide when to learn as well as what to learn and in which order to learn the material (Göschka & Reidling, 1998; Nah, Guru & Hain, 2000). To give the learner the power to decide when to learn also alleviates the strain on the available resources such as computer facilities and multimedia tools. Flexibility in computer technology also means that one multimedia or hypertext document or resource can suffice for many different learning styles. Multimedia technology can emulate a rich learning environment necessary for the stimulation and motivation of learners. Learners affected mostly by visual representation can benefit from a multimedia package, but simultaneously, learners who utilise a mostly auditory learning style, also benefit. The learner can choose which facet of the package to focus on, an option which is not available in media such as the printed media, e.g. books (Passerini & Granger, 2000; Göschka & Reidling, 1998).

A multitude of interactions can be realized using computer technology. The interactions include inter-learner and learner-educator interaction, which can be facilitated via tools such as e-mail and chat systems. The interaction that is most relevant to this study, however, is the learner-computer interaction. Multimedia and the emerging Internet technologies such as Dynamic Hypertext Mark-up Language (DHTML) and Java are allowing learners to interact with simulated environments, allowing greater learning to take place. Multimedia and web pages can support learning by their very nature and structure. Their structure offers learners a framework in which they can organise the knowledge being presented. This electronic organisation is more akin to the human cognitive organisation of knowledge than any other media currently available (Passerini & Granger, 2000; Nah, Guru & Hain, 2000; Smith-Gratto, 2000).

The educator needs an educational resource vast enough to meet the requirements of different cultures, learning styles and backgrounds. The Web is rich with resources that can be used in the educational environment (Passerini & Granger, 2000; Slay, 2000; Gillham, Buckner & Butt, 1999).

Problems with Internet Resources

Unfortunately, the Web is also a source that is not regulated. No single organisation or person owns the Internet. This means that every web page has to be scrutinized for validity and truthfulness before being used in any educational situation. Even a site that has been put up by an academic institution may not be suitable for certain education environment for two reasons. The first reason is that inexperienced learners often cannot read emotional undertones of written material, such as humour or sarcasm. The second reason is the integrity of the contents of a web page. An example cited by Smith-Gratto (2000) is one of a university that set up a site to illustrate the ease with which someone with basic scientific knowledge could fabricate the discovery of a new species. An unsuspecting and naïve learner from a different educational institution read these pages and truly believed that there was a new species of cow that lived in trees.

Thus, an educator either has to train learners to discern resources for themselves or an educator has to look for the resources on behalf of the learner (Smith-Gratto, 2000). Unfortunately for the educator, truthfulness and undertone are not the only characteristics than need to be scrutinized when choosing educational resources. There are an inordinate amount of pedagogical criteria that need to be met.

Some of the criteria for resources include: diversity, appropriateness, engagement, learner performance and reusability. The criterion of diversity considers the learning styles, gender, cultural backgrounds, and so forth, within the classroom. This suggests that the educator might have several different resources for each topic being taught to cater for the diversity within the classroom (Slay, 2000; Retalis & Skordalakis, 1998).

The criterion of appropriateness suggests that the educator should scrutinize the contents of a resource for aspects such as level of engagement. In other words, at what level of learner is the resource aimed (beginner, intermediate or expert). Other aspects of appropriateness are whether or not the content of the resource covers the topics of the curriculum and how well the topic(s) is covered (Retalis & Skordalakis, 1998).

The criterion of engagement looks at the manner in which resources present their content. Questions that an educator would ask under this banner would be: Does it capture the learner's attention? Is it interesting? Is it easy to follow? Is it easy to navigate? (Retalis & Skordalakis, 1998). Under the criterion of learner performance, an educator would ask slightly different questions. These would include: what will the learner learn? Will the learner's skills improve? What skills will improve? (Retalis & Skordalakis, 1998).

Reusability is one of the most important criteria. It asks what can the resource be used for and if the resource can be used under different circumstances. Reusability has several repercussions. A resource that can be used in several different courses is far more valuable than a resource that can only be used in one course. One of the reasons being is that it would take up less storage space. Another reason is that additional students would use the resource and it would probably be used more frequently (Retalis & Skordalakis, 1998).

The abovementioned criteria are just a few of the requirements put forward by educators to ensure the quality of educational resources. The need for so many standards implies that there are numerous resources on the Internet that are not suitable for educational environments. Thus finding a resource that is suitable for the level of learner and meets the pedagogical criteria could be compared to finding a diamond in a huge pile of dust (Squires & Preece, 1999; Astleitner & Sams, 1998; Small, Sutton, Miwa, Urfels & Eisenberg, 1998). It stands to reason that an educator could spend an enormous amount of time looking for appropriate educational resources. Once a resource has been found, it is thus advantageous to keep track of it.

The Need for a Resource Database

Keeping a record of educational resources maximises the value of the resource and minimises the efforts of the educator. Once a resource has been found, the educator is able to retrieve the resource when necessary. This saves the educator the time it takes to continually search for resources (Barker, 1999).

A database can be used as an electronic method of keeping record of the educational resources. The latest databases are able to store a number of different file types. The file types can range from entire programs to hyperlinks and Universal Resource Locators (URLs). Hyperlinks and URLs are particularly useful when organising educational resources. Firstly, they reduce the size of the database. Instead of storing entire web pages or programs, the database will just store the link to the relevant resource. Secondly, it effectively combats the issue of copyrights. Instead of undergoing the lengthy, and often expensive, copyright permission procedure, one can just store the hyperlink to the pages and point the learners to the resource. Storing a hyperlink may be construed as reasonable use (O'Hara & Peak, 2000). One problem that would need creative management is the problem of changing sites or sites that disappear or move.

Just storing the hyperlink may make it easier to retrieve a resource, however, the resources also need to be organised. Organising facilitates the finding of resources, it could be suggested that the resources (or at least the links to the resources) be stored in a database akin to a library. This implies that the data can be accessed via a number of routes. The routes could include title, author, subject, keywords or even by a misconception (Marshall, 1999; Hui, 1998).

By storing the information in a database, one can tailor the resources for an individual learner. Using dynamic web pages, which can access the database to get specific information, can do this. A typical use of a dynamic, database-driven web page would be a search function where the user enters a key word or phrase and the resulting, database-generated page is a list of related URLs. The dynamic web pages are also capable of delivering personalized web pages for each learner. A database thus offers the option of being able to provide each learner with his or her own unique set of educational resources. These resources would be selected to cater for the learner's individual weaknesses or personal misconceptions (Barker, 1999; Garrison & Fenton, 1999; Weber, 1996).

Envisaged Resource-Base

A database that stores resources not only has to store the information about the resources, but also needs to store information about learners and the course curricula.

Resources

Each resource could have a number of uses within a number of diverse courses. Since each course has a curriculum with associated objectives, one method of accessing the resources is via the curriculum or objectives route. Thus, each resource can have a number of links to several course objectives (or sub-objectives). For each objective, one could also have a number of misconceptions that could hinder learners from truly grasping the concepts being taught in class. These misconceptions could have resources associated with them so that educators and learners can find the resources via a misconception. A learner entering the learning web site should also be shown the resources which are appropriate to him or her. These resources should be chosen according to the syllabus model (for resources given to all learners attending the course) and comparing the syllabus model to the learner model (for individual feedback and guidance).

Learner Records

Along with the resources shared in the system, one would also need to store information about the learners using the system. This would allow the learners to be able to get the resources specific to their needs (Shaofeng & Kehong, 2000). The repercussions of individualising web pages leads to each learner needing a record within the database. This record needs to include, not only the learner's name and the courses for which he or she is registered but also the data that will aid the database in creating the personalised learning environment. The data that needs to be stored includes the learner's ability to solve problems, the learner's knowledge about the subject being taught and the misconceptions that the learner has inadvertently adopted along the way. All of these aspects will help deliver individualised learning (Weber, 1996; Roses, Nussbaum, Strasser & Csaszar, 1997).

These learner characteristics, however, have to be updated continuously, since as the learner becomes skilled in particular areas, the system has to adapt to these changes. In this way, the learner is continually being offered new challenges. This in turn, fortifies the learner's confidence, stretches the learner's abilities and hopefully motivates the learner to continue studying (Nah, Guru & Hain, 2000; Rosas *et al*, 1997).

Learners should also have the rights to make certain additions to the resource-base. Giving learners this right makes it easier for them to take ownership of their own learning. They should believe that they are in control. This means that although the resource-base or the educator can suggest certain resources, the learners should be able to search for and save their own resources as well (Squires & Preece, 1999).

The Curriculum Model

In order to deliver the necessary educational resources to the learner, the database also needs some sort of model with which to compare the learner's progress. This model could contain the curriculum and learning objectives for the courses being offered (Weber, 1996). Having a curriculum model available has a number of advantages. Firstly, it provides educators with a structure on which to build their lessons. To create a curriculum model, one must identify the course aims and objectives, which provide the structure for the course. The objectives can also be broken down into sub-objectives. A hierarchy can be established be the curriculum model in this manner. Each sub-objective can have a number of resources associated with it. This allows a learner to search for resources by the objectives of a course (Hui, 1998; Marshall, 1999). One resource can be used for many objectives – even across subject boundaries.

Secondly, a curriculum model can be used to give learners feedback on their learning. Feedback and guidance are very important facets of the educational environment. It gives the learner a feeling of direction and accomplishment when feedback is given in the correct manner (Marshall, 1999). By comparing a learner model to the curriculum model, an educator can determine where the strengths and weaknesses of the learner are situated. Once the problem areas are known, individualised feedback and guidance can be given. Feedback and guidance can include offering the learner alternative educational resources, which can be used to explain certain errors, correct misconceptions and offer suggested solutions to specific problems (Weber, 1996).

Accessing the Resources

Appropriate resources for learning and remedial purposes are supplied to learners by means of the curriculum and learner models. To facilitate the access to the learning materials, a suitable database model for storage and organisation of the resources should be found. Data warehousing, along with its close associate, data mining, hold some interesting prospects for the organisation, storage and retrieval of educational resources.

Data warehousing is a method of storing and organising an enormous amount of data for the purposes of analysis, pattern matching and trend finding. The characteristics of a data warehouse include its ability to store detailed as well as summarized data. Integrated data provides easy access to what would normally be stored in separate tables. Metadata is an important facet of data warehousing. Metadata puts data into context, i.e. it defines what the data means. A data warehouse should be more than capable of storing educational resources, along with their categorisations, descriptions and metadata. The data warehouse could also store the learner records and curriculum models, which will determine what resources the learners receive. Another important facet of the data warehouse is that it allows for straightforward data mining (Inmon, 1996).

Data mining is a method of extracting data from a data warehouse. An educator (or learner) could "discover" an educational resource by identifying relevant attributes. Even if a resource has not been categorized, the mining procedure should have the ability to scan the contents for anything significant. The educator could thus be given a selection of unusual resources from which to choose. Details of resources that were used for a course in previous years could be stored in the data warehouse as summarized data. Thus to access appropriate resources, data mining would use the summarized data, along with the data scan, to produce a list of potentially helpful resources. To aid an educator further, the educator could also do trend analyses (Inmon, 1996; Chou, Grossman, Gunopulos & Kamesam, 2000).

In business, one could, for example, use data mining to create customer profiles (especially in the marketing field in order to effectively target an audience). In education, an educator could use the same technique to develop learner profiles or to categorise learners in order to teach more effectively (Chou *et al*, 2000). The learner profiles could inform an educator as to what misconceptions are most prevalent in a particular class. An educator could also determine which misconceptions could lead to possible problems at a later stage by analysing historical learner data. An educator could also use the technique to create resource profiles to help determine which resources are more appropriate to different types (or categories) of learners. Analysing the access to the resources could also determine which resources are more effective for particular learners or misconceptions. This, in turn, would facilitate in individualising learning, which would make teaching a more effective and interesting craft.

Conclusion

Some of the challenges of modern education such as a lack of library books and increasingly large classes can be defrayed by the intervention of Internet technologies. The technology of the Internet allows educators to locate, create and distribute educational resources on a platform independent system.

Locating, creating and modifying resources take an enormous amount of time. Educators have to scrutinize each resource to ensure that it is appropriate for the learners and the course being taught. Appropriate resources, thus, must be organised and stored in such a way as to facilitate easy access, distribution and relocation.

A database model that can be utilized to store the education resources is a data warehouse. A data warehouse is not only used to store large amounts of data, but also to store summarized and detailed data along with metadata. Thus, a data warehouse can store the learner records and the curriculum models as well as the educational resources.

Data is extracted from a data warehouse by data mining techniques. However, data mining does more than extract data, it can also be used to analyse data and create information. In the resource-base, data mining should be able to help locate stored resources, match resources to learner needs and produce information that can help make teaching more effective.

The resource-base is, at the present, still a concept. Further research will entail the feasibility of the implementation of a resource-base using a data warehouse and data mining as the driving forces with the Internet/Web technology as the delivery mode.

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Individualising Access to Educational Resources

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Abstract

In South Africa, the latest educational paradigm, Outcomes-Based Education (OBE) shifts the focus from the educator to the learner. It is within this context that the need to give individual learners personalised attention arises. This paper focuses on a model developed to supply learners with educational resources based on personal misconceptions. This model utilises modelling concepts from data warehousing to facilitate the individual's access to educational resources.

Keywords: Educational resources; star schema; individualisation

Category: H.3.5; H.3.3; K.3.1

1. Education in Crisis

There are many challenges which face the modern educator and today's educational situation. These challenges include larger classes, the increasing demand for diverse courses and the escalating diversity amongst learners. These challenges are by no means isolated to the South African context; they are general trends in education as a whole. This implies that there is a generation of learners for whom learning is becoming an increasingly difficult trial. The trial involves overcoming personal misconceptions, ambiguities and inconsistencies which cannot be addressed within the traditional lecture situation [8; 13].

One solution to this challenge is to treat each learner as an individual. The theory of constructivism encourages this solution. The theory of constructivism, in very general terms, emphasises that knowledge is built on the foundation of prior learning and experience [11; 13; 14; 15]. Unfortunately, within the large class context, individualising teaching is not an easy task [13]. A number of proposals to ease this dilemma utilises Web and Internet technologies [4].

2. The Web as a Resource

The World Wide Web (WWW) is rich with resources which may be utilised within an educational setting. However, the WWW is a source that is not regulated. No single organisation or person owns the Internet. This means that every web page has to be scrutinised for validity and truthfulness before being used in any educational situation [17]. An educator has few alternatives: teach the learners to discern materials themselves, search for suitable resources on behalf of the learners or a combination of the two aforementioned strategies [14]. Discerning whether or not a resource is suitable for the classroom means putting it through a rigorous test of pedagogical criteria [12; 13]. Finding suitable materials, and sufficient in number to satisfy the needs of a diverse class of learners may be an exceptionally time-consuming task [1; 15]. Therefore, once a resource has been found, it becomes advantageous to keep track of it.

3. A Resource Database

Keeping a record of all the resources needed for a class maximises the value of the resource and minimises the efforts of the educator. This is due to the reduction in time an educator would spend in locating the appropriate resources [2].

A database seems to be the logical choice when deciding to electronically store and organise data. Database management systems are capable of storing not only files, but links to those files or Uniform Resource Locators (URL). The use of URL's may solve some of the issues involved with the use of educational resources. One of these issues is the copyright concern. Copyright permission procedures are often lengthy and expensive. Thus, instead of copying an entire site and requesting the permission to do so, one can store a URL which points to the site. The storage of the link is considered reasonable use [10]. The only foreseen problem with storing the URL is the matter of sites disappearing, moving or being changed [7].

Storing the URL combats only half of the problem. One also needs to organise the resources in such a way that it is easy to retrieve and search. By storing a various pieces of data, one may design a database that may easily be searched for author, keywords, subjects or courses and outcomes.

In turn, this implies that dynamic web pages may be utilised to facilitate personalised web pages for each learner. The web page could provide individual learners with the resources they need to overcome their personal misconceptions and allow them to search for resources based on keyword, course or course outcomes [2; 3; 16].

In many aspects, this resource database would need to differ from regular operational databases, since much of its data is relatively static. In other words, the data does not get updated on a daily or even weekly basis. Instead, the data is updated on an ad hoc way. These updates would be the editing of student details or resource details, such as URLs which hopefully do not change on a daily basis. Another way in which the resource database would differ from operational databases is that the majority of the operations done on the resource database would be queries in opposition to continual inserts and updates. The deletion of data from the resource database would not occur on a regular basis either. The only foreseeable deletions would be that of learners who have either dropped out or those learners who have completed their degrees or diplomas.

To summarise, there is a need for a database which facilitates the individualisation of learning by giving learners the educational resources they need to overcome their personal misconceptions and learning weaknesses. This database needs to be efficient in executing queries and have the capacity to handle a large number of queries. The design of this educational resource database (resource-base) needs careful consideration.

4. Resource-base Design

As previously mentioned, the resource-base has a specific function: to individualise learning through educational resources. The main users of this system, therefore, are the learners and the educators. Each of these users has specific needs which should be considered. Thus there are a few fundamental processes involving these users which are central to the resource-base.

Figure 1 illustrates these processes, which have been numbered for descriptive purposes.

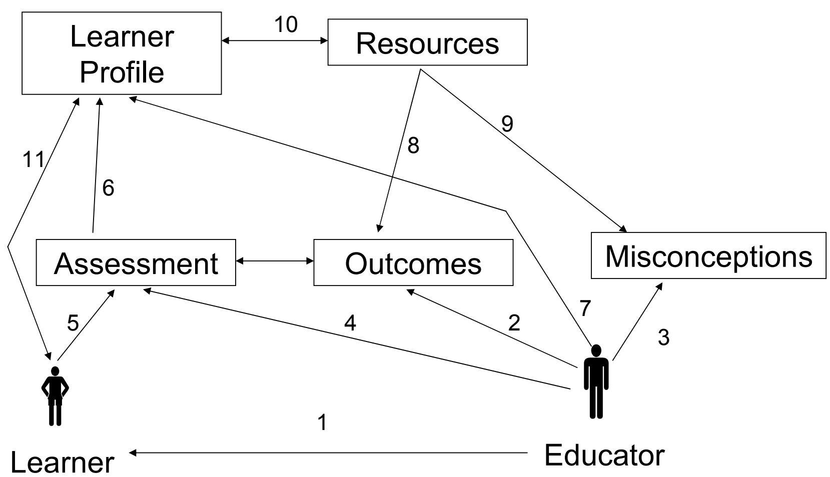

Figure 1: Basic Resource Database Processes

- Process 1: Educator teaches learner. This is the most fundamental of all the processes. This process may take place with or without the aid of computers or electronic media.

- Process 2: An educator creates, modifies and removes outcomes. Within the OBE context, each course must have outcomes (or objectives). These outcomes clearly state the purpose and the desired result (or behaviour displayed) from the learner.
- Process 3: An educator creates, modifies and removes misconceptions. These misconceptions outline the difficulties and conceptual problems which learners experience within a course. The resolution of misconceptions would aid a learner in better understanding the concepts being taught. Misconceptions often form a foundation on which poor academic progress or poor academic achievement rest. The educational theory of constructivism promotes the idea that prior knowledge forms the basis of new knowledge. In the same way that a house built on a poor foundation will not endure, knowledge or learning built on an insufficient base will not result in the desired outcomes being achieved.
- Process 4: An educator creates, modifies and utilises assessments. Although the assessment is beyond the scope of the resource database, it is still an integral part of the teaching/learning process. The results of the assessments indicate which misconceptions a learner entertains. Assessments, by rights, should be determined by the outcomes of the course. The outcomes should dictate what should be in tests, examinations, projects and other forms of assessment.

- Process 5: The learner is assessed. As mentioned in Process 4, this process does not form a part of the resource database. The results of the assessment, however, play an important part deciding which resources should be available to an individual learner.
- Process 6: The learner profile is updated. The results of the assessment are stored within the learner profile. This will determine the resources to which the learner will get access.
- Process 7: An educator is able to view and edit the learner's profile. An educator might be able to determine a learner's abilities and short-comings in informal assessments or class exercises which are not necessarily assessments. An educator, thus, would need to update or edit a learner's list of misconceptions.
- Process 8: The relevant resources are linked to the appropriate outcomes. This association makes finding resources more efficient for both educator and learner.
- Process 9: The relevant resources are linked to the appropriate misconceptions.
- Process 10: It is from the association between the resources and the misconceptions that the individual learner receives his or her resources based on his or her personal profile.
- Process 11: The learner may access his or her own learning profile to update personal details, individual learning styles and

learning preferences as well as personal interests. The learner may also view his or her own learning profile to gauge personal progress.

Two processes, which have not been mentioned, are those of searching and inserting resources. Both the educator and the learner should be able to search the resource database for educational resources for learning/teaching purposes. The educator should be able to add new resources. In doing so, the educator creates a "database of knowledge" from which both colleagues and learners may draw. Educators should be able to share resources in order to make searching for new resources more efficient. Sharing resources also makes creating new resources more cost-effective.

Given the requirements, the Entity-Relationship Diagram (ERD) may now be drawn (Figure 2). The standard decided upon for the fields and entities have been based on the international standard, the Instructional Management Systems (IMS) project hosted by Educom (also known as Educause). The IMS homepage may be found at http://www.imsproject.org and the Educause homepage may be found at http://www.educase.edu. This standard requires that each learner have a misconception profile, an assessment profile, a report and a learning preference profile. The two profiles of cardinal importance to the resource-base are the learning preference profile and the misconception profile. The learning preference profile stores the learner's preference for learning styles: visual, audio, kinetic. The learning preference also stores any learning disabilities the learner might have, e.g. dyslexia. The misconception profile provides a link to the learner's misconceptions. The misconceptions are, in turn, associated with resources. This enables each learner to receive a unique set of resources ordered by the courses for which the learner is enrolled

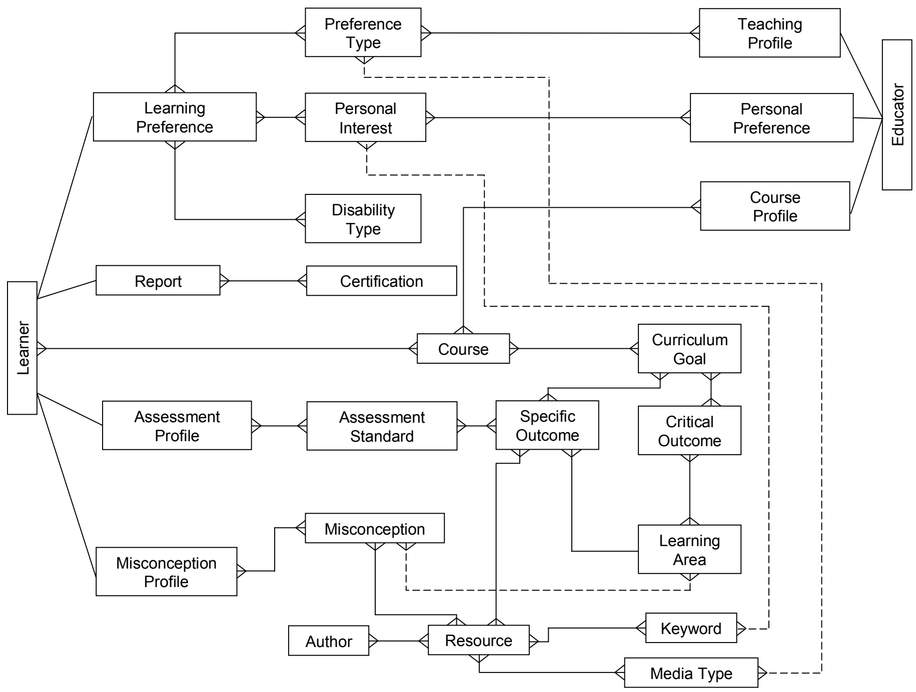

Figure 2: Resource-base ERD

The "what are my resources?" query should be done each time a learner accesses the resource-base. It implies that the resource-base design should facilitate quick query access.

4.1 Simplifying Queries

Quick and easy query access is not, unfortunately, the forte of the normalised database schema. The normalised schema is more suited to the storage of data in an optimal manner than the retrieval thereof. A data warehouse, on the other hand, is specifically designed to facilitate the quick and simply retrieval of data [6].

A data warehouse is in essence very different to a normalised schema. Where a normalised schema is optimised for reducing redundancy, a data warehouse is de-normalised. Although a data warehouse has more data redundancy than a normalised schema, this data redundancy is tightly controlled. Where a normalised schema's design is expressed by means of an ERD, a data warehouse's design is expressed as a star schema.

The star schema has two major components: the fact table and dimension tables. The fact table is the central table (or the table in the middle of the star). The dimension tables are the surrounding tables (or the tables that make up the "rays" of the star). The fact table is the table that contains the "answer" or "fact" to the query, in case of the resource-base, "what are my resources?" The dimension tables contain the descriptive contents, such as course details, outcomes, etc.

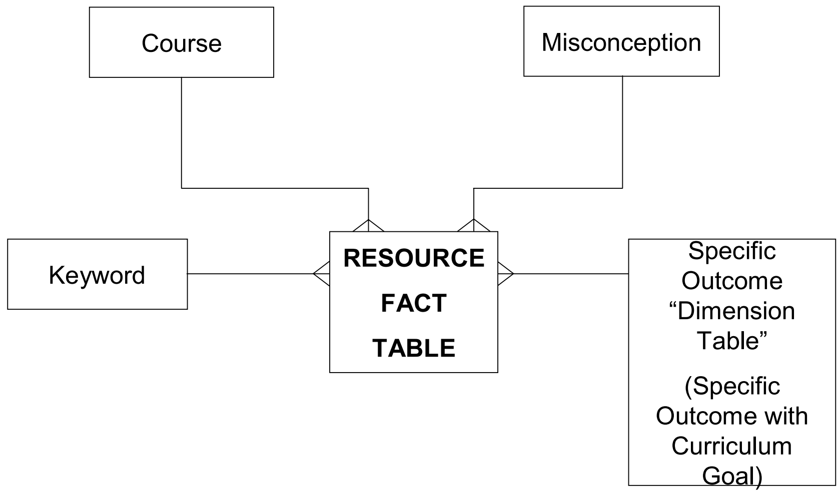

Figure 3: Star Schema

The question of “what are my resources?” is not the only query the learner may execute in the Resource-base. Discovering resources based on a search on keyword, course, misconception or outcome is another facility that should be available to both the learners and the educators. Since these queries revolve around the resources, it would be simple to add them to the star schema as dimensions. Figure 2 illustrates the star schema for the Resource-base. The table Specific Outcome “Dimension Table” is an amalgamation of the Specific Outcome table and the Curriculum Goal. Within the educational paradigm, OBE suggests that a course has curriculum goals, which are the broad aims of the course. These goals have “sub-goals” or specific outcomes. This hierarchy of outcomes is a part of the searching criteria, thus it is important that it be a part of the star schema. However, to introduce this hierarchy in its normalised format into the star schema is bad practice and therefore not advised [6]. Thus, the hierarchy has to be "collapsed" into one table containing redundant data.

Redundant data is not a problem within a star schema. In fact, the star schema gets its worth from controlled data redundancy.

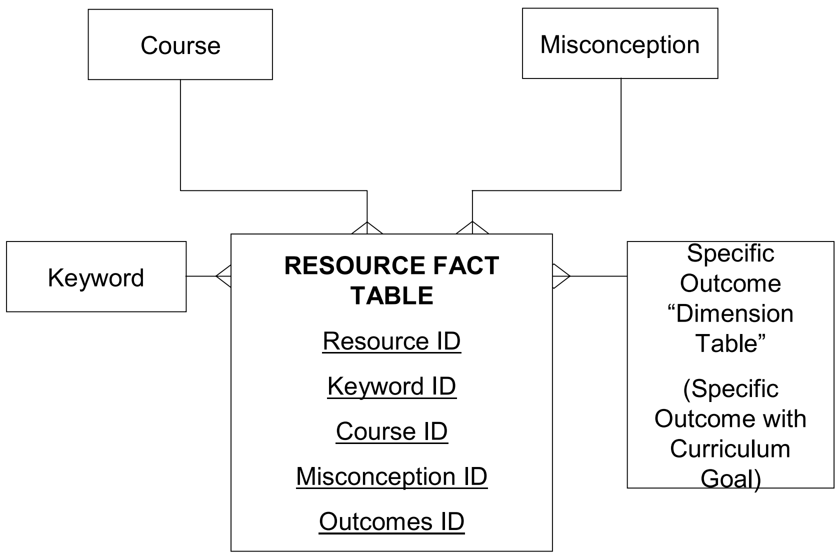

Figure 4: Star Schema Detail

In the Resource Fact Table, the key field is a compound key consisting of all the unique identifiers of the dimension tables (Figure 3). Although this causes quite a bit of redundancy, it makes searching more efficient. This is because, in a normalised schema, a query such as "what are my resources?" would require a number of joins. Within the star schema, however, these joins are reduced because the star schema has these "joins" inherent. Reducing the number of joins required to execute a query decreases the work that the processor has to do during the query. This, in turn, diminishes the time it takes to execute such a query. It also implies that more users are able to use the Resource-base without noticing a distinct decline in performance.

Thus the star schema should be utilised, but how should it be implemented?

4.2 Two Schemas, One Database

As previously discussed, the nature of the data stored within the Resource-base is relatively static. This relatively static nature of the data stored within the Resource-base lends itself almost effortlessly to the star schema. To create the entire database as a star schema, however, is not only an enormous task but also would exponentially increase the size of the database. It would also be a waste of computer resources, since the star schema's function is to simplify access to queries. The Resource-base, however, stores more than just the resources and although the above-mentioned queries do form a large part of the Resource-base, it does not form the entirety of the Resource-base's functions. Thus, it has been proposed that a portion of the Resource-base be converted to the star schema, while keeping the other components normalised. Thus the

Resource-base consists of both the normalised schema and the star schema within the same database.

This is possible because a star schema may be implemented within a relational database management system [6].

4.3 Database Management Issues

There are a few issues that need to be considered when implementing the Resource-base. The first is that a data warehouse is usually updated on a monthly or weekly basis and is normally a separate entity (on its own server) to the transactional database from which it receives its data. With the Resource-base, the data warehouse (star schema) resides alongside the normalised schema (or the transactional database). Thus, to update the Resource-base's data warehouse component, triggers and scripts would have to be run at the time of data input to provide real-time synchronisation.

The second issue is one of data integrity, especially since facets of data integrity include the data being up-to-date and accurate. The educational resources are not encapsulated within the Resource-base; rather the URL of the resource is kept within the database. This is a potential data integrity problem, since web pages and web sites have a habit of changing without prior notice or disappearing entirely. Although the debate of how the URLs may be kept up-to-date and accurate is beyond the scope of this paper, it is suggested that scripts may be utilised to check the availability of web sites and web pages, thereby facilitating semi-automatic maintenance.

Other issues beyond the scope of this paper include user rights (e.g. should a learner be able to add/edit resource details?), user privacy (e.g. should an educator be able to see all of a learner's misconceptions for every course?) and usability considerations.

5. Prototype

A prototype of the resource-base has been developed. The prototype focuses on the learners' perspective and includes the learners' web interface.

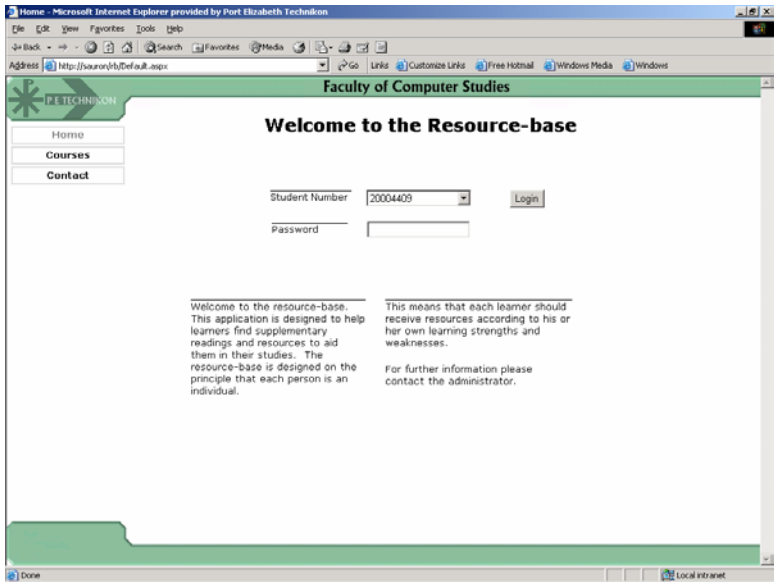

Figure 5: Resource-base Homepage

Figure 5 is a screenshot of the homepage of the Resource-base. When a learner logs in, the second page to be seen is a list of all courses for which the learner is registered. The learner may, from this list, see all the resources for each course or choose to see the outcomes for the courses.

A learner may also opt to see the resources according to all his or her personal misconceptions, regardless of course (Figure 7). A learner may also search for resources (Figure 8), based on keyword, misconception, course, outcome or keyword and course.

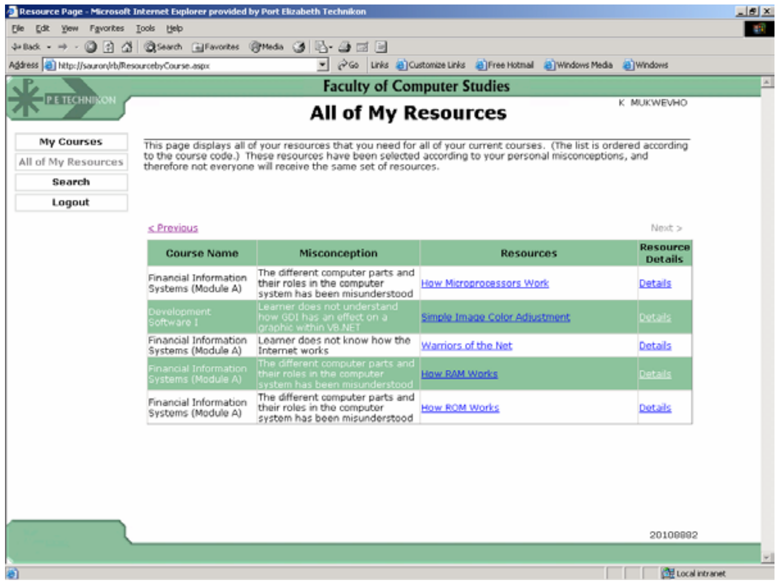

Figure 7: A Unique Set of Resources

A number of valuable lessons have been learned from the prototype development. The first of these lessons is that of data entry. The resource-base, because of the dual database schemas, has redundant data in numerous tables. This presents a challenge when entering data. Scripts and triggers will be an essential part of data entry and data updating in a live system. The second lesson is that of human nature. Setting up course materials and course outcomes takes time and careful consideration. Not all educators have the time, or the patience, to outline a course to the required level of detail. Inserting misconceptions is also time-consuming. A faster method of data entry is necessary. The third lesson is also that of human nature. Associating learners to their misconceptions manually is another task which requires time and patience. For lessons two and three, the ideal solution in a perfect world would be automation with the aid of artificial intelligence.

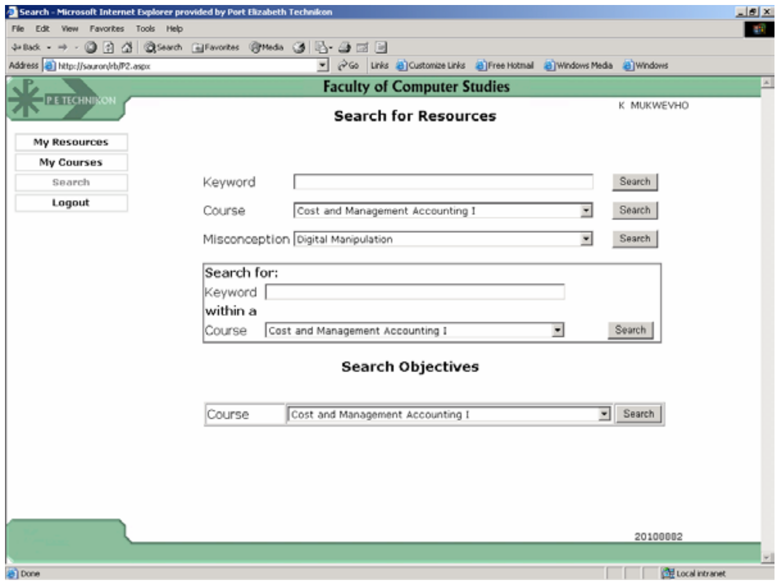

Figure 8: Search Screen

The learners' assessment results could be automatically transferred from their assessment to their personal profiles. An artificial intelligence module could assign, according to the assessment results, misconceptions. Misconceptions could be generated from the course outcomes. This would be the ideal solution.

An important question to ask is: "Would the learners use the Resource-base?" In the perfect world, the answer would be "yes". But in the imperfect world would this be the case? A survey is currently being developed in order to gauge the learners' interest in the utilisation of the resource-base. The results of this survey would be a field of further study and will hopefully be published in a later paper.

6. Conclusion

There are a plethora of challenges facing modern educators. Some of these challenges include a shift in paradigm in education from traditional teaching to an increasing modern view. This modern view includes outcomes-based education and the individualism of learners. All of these are within the framework of the theory of constructivism. The modern view also comes with technological advances such as the Internet.

It has been alluded to that perhaps the modern challenges could be solved with the aid of modern technology. One suggested solution is to utilise the Internet to supply both learners and educators with educational resources. These resources, however, need to be organised and stored effectively in order to justify the time, effort and money spent on their creation or the time and effort spent searching for them. In essence, a database of educational resources should aid learners and educators in locating resources that have already been "catalogued".

This resource-base should have a number of qualities: it should be easy to search, it should give individual learners the resources they need according to their own personal misconceptions and it should be quick. The resource-base, therefore, needs to be optimised for searching.

A normalised schema does not facilitate searching as well as a data warehouse or star schema. This implies that certain of the star schemas characteristics are highly desirable for the resource-base. However, there are a few of the characteristics of the star schema that are not as enticing. These undesirable traits include the manner in which the storage space needed for a data warehouse increases almost exponentially. It was thus decided that not all of the resource-base needs to be structured as a star schema. The resource-base was implemented as a hybrid of both the normalised schema and the star schema.

A prototype for the resource-base has been created and will be duly made available to the learners. The response of the learners towards the prototype is an avenue of further study. From the prototype, a number of issues have arisen. The automation of a number of the administrative aspects will have to be considered. Another consideration is an automated means by which to test for and report broken or missing URLs. The considerations about the rights of learners to add resources to the resource-base needs to be fully explored. These, however, will be left to further research.

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Towards a Model for Organising and Accessing Educational Resources on an Intranet

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Abstract: Giving students access to educational resources is important in the learning process. These resources must be well chosen and affective for the attainment of the objectives of the course. This paper describes how database and data warehousing techniques can be used to organise resources on an Intranet. This allows both educators and learners to have easy access to these resources, thus facilitating learning.

Key words: Educational Resources; Data Warehouse; Individualization.

1. MODERN EDUCATION CHALLENGES

There are many challenges facing today's education system. These challenges include larger class numbers, the increasing demand for more diverse courses and the escalating diversity amongst learners. This situation can lead to the learner perceiving seemingly insurmountable obstacles. Large class sizes compound the problems of the striving learner, since individual misconceptions, ambiguities and inconsistencies are not addressed in the traditional lecture situation (Slay, 2000; Marsden, 1996).

Another problem with large class sizes is that the needs of the individual are not considered. Each learner comes from a different community, has a disparate culture, comes with a unique background and uses one of a multitude of learning styles. The above-mentioned factors play a large role in the attitude and academic success of a learner. Other factors such as gender, mental maturity and learner determination can also determine learner success (Passerini & Granger, 2000; Slay, 2000).

If a learner is to succeed academically, all the above-mentioned facets of the individual should be considered. This is due to the nature of learning. Knowledge is constructed on the foundation of prior learning and experience. This building of knowledge is known as the theory of constructivism.

The theory of constructivism emphasises that the learner has to be actively involved in the creation of his or her own knowledge (Smith-Gratto, 2000; Squires & Preece, 1999). Unfortunately, the larger the class, the more complicated it becomes to prepare for, administer and manage an active learning environment (Slay, 2000).

One of the solutions that have been suggested is the use of computer technology as support for the traditional lecture or classroom situation. The use of the Internet and Web technologies has been particularly earmarked as a potentially useful solution to the large classes dilemma (Gillham, Buckner & Butt, 1999).

2. INTERNET RESOURCES

The Web is rich with resources that can be used in the educational environment. However, the educator needs an educational resource library (or resource-base) vast enough to meet the requirements of different cultures, learning styles and learner backgrounds (Passerini & Granger, 2000; Slay, 2000; Gillham, Buckner & Butt, 1999). Unfortunately, the Web is a source that is not regulated. No single organisation or person owns the Internet. This means that every web page has to be scrutinized for validity and truthfulness before being used in any educational situation. An educator has two alternatives: teach the learners to discern materials for themselves, or search for suitable resources on behalf of the learners (Smith-Gratto, 2000). Unfortunately, for the educator, truthfulness and undertone are not the only characteristics than need to be scrutinized when choosing educational resources. There are an inordinate amount of pedagogical criteria that need to be met (Slay, 2000; Retalis & Skordalakis, 1998).

The need for so many standards implies that there are numerous resources on the Internet that are not suitable for educational environments. Thus finding a resource that is suitable for the level of learner and meets the pedagogical criteria could be compared to finding a diamond in a huge pile of dust (Squires & Preece, 1999; Astleitner & Sams, 1998). It stands to reason that an educator could spend an enormous amount of time looking for appropriate educational resources. Once a resource has been found, it is thus advantageous to keep track of it.

3. THE NEED FOR A RESOURCE DATABASE

Keeping a record of educational resources maximises the value of the resource and minimises the efforts of the educator. Once a resource has been found, the educator is able to retrieve the resource when necessary. This saves the educator the time it takes to continually search for resources (Barker, 1999).

A database can be used as an electronic method of keeping record of the educational resources. The latest databases are able to store a number of different file types. The file types can range from entire programs to hyperlinks and Universal Resource Locators (URLs). Hyperlinks and URLs are particularly useful when organising educational resources. Firstly, they reduce the size of the database. Instead of storing entire web pages or programs, the database will just store the link to the relevant resource. Secondly, it effectively combats the issue of copyrights. Instead of undergoing the lengthy, and often expensive, copyright permission procedure, one can just store the hyperlink to the pages and point the learners to the resource. Storing a hyperlink may be construed as reasonable use (O'Hara & Peak, 2000). One problem that would need creative management is the problem of changing sites or sites that disappear or move.

Just storing the hyperlink may make it easier to retrieve a resource, however, the resources also need to be organised. Organising facilitates the finding of resources, it could be suggested that the resources (or at least the links to the resources) be stored in a database akin to a library. This implies that the data could be accessed via a number of routes. The routes might include title, author, subject, keywords or even by a misconception (Marshall, 1999; Hui, 1998).

By storing the information in a database, one can tailor the resources for an individual learner. Using dynamic web pages, which can access the database to get specific information, can facilitate this. A typical use of a dynamic, database-driven web page would be a search function where the user enters a key word or phrase and the resulting, database-generated page is a list of related URLs. The dynamic web pages are also capable of delivering personalized web pages for each learner. A database thus offers the option of being able to provide each learner with his or her own unique set of educational resources. These resources would be selected to cater for the learner's individual weaknesses or personal misconceptions (Barker, 1999; Garrison & Fenton, 1999; Weber, 1996).

4. RESOURCE-BASE DESIGN

In designing a resource-base, one has a number of important factors to consider. These factors include the usability of the resource-base, which is closely tied to the users' needs.

The users of the resource-base are the educators and the learners. The needs of the educator and learner differ in some areas and overlap in others. Educators should have facilities to input and edit courses and the course objectives (and sub-objectives). These courses and objectives need to be associated with the relevant resources. Another association that needs to be made is the one between the misconceptions a learner might develop and the resources that help to overcome these misconceptions. Educators should also be able to assign resources to learners based on the learners' individual strengths and weaknesses. It is debatable as to whether both educators and learners should have the authority to add resources to the resource-base, as this becomes a quality assurance issue (Smith-Gratto, 2000; Astleitner & Sams, 1998). However, both the learners and the educators should be able to search and select resources according to the routes previously mentioned.

The resource-base revolves around storing data about resources for fast and simple access. A regular relational database, however, is more suited to the storage of data than the retrieval thereof. A data warehouse, on the other hand, is more suited to the retrieval (and analysis) of data (Kimball, 1996). Hence, it was decided to utilise the tools that a data warehouse offers.

4.1 Data Warehouse Basics

A star schema is used to model a data warehouse. A star schema consists of two types of tables: the fact table and dimension tables. The fact table is the centre of a star schema. The fact table contains the data about which a data warehouse is most concerned, e.g. the resource details. Each star schema usually has only one fact table (a data warehouse may involve more than one star schema). The dimension tables are those tables that surround (and are attached to) the fact table. These tables describe the fact table and are the routes that are the most common methods of accessing the data stored in the fact table (Kimball, 1996), e.g. key words, course, course objectives, misconceptions, etc.

These are not the only routes that could be used to access or locate resources. Other routes include media type, author name and title. Since these routes the paths less travelled, it was decided that it would not be advantageous to include these as search methods in the star schema. However, it would be a pity to lose such attributes.

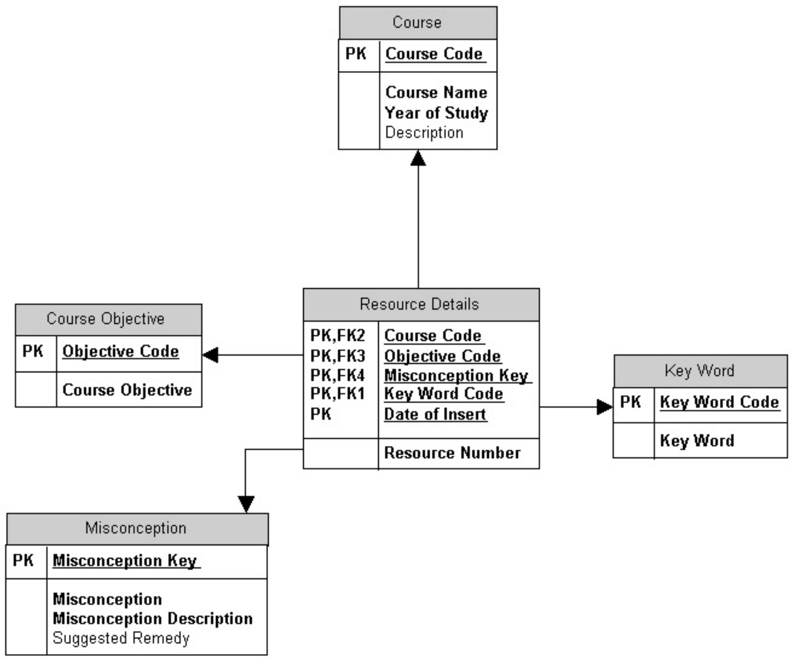

Figure 1. Resource-base Star Schema

4.2 Two Databases, One Resource-base

The decision to remove the author name, media type and title from the star schema were two-fold. The first is the sheer size of the star schema implementation. Fact tables are sparsely populated. This means that the size of the data warehouse grows at an exponential rate. One could try to normalize a star schema but this only result in a space saving of less than one percent and it slows the access speed down considerably (Kimball, 1996). The solution was to divide the resource-base into two components: a regular relational database and a "data warehouse" database (see figure 1).

The relational component contains the resource descriptions such as author and title. The "data warehouse" component contains the fact table and the dimension tables for fast access. The "data warehouse" component is not a true data warehouse, since none of the ordinary data warehouse or data mining operations will be done on it. Instead, it will be used purely for the tools it can offer in terms of search and retrieval.

The components are linked via the resource number, which serves as a primary key in the relational component and as a foreign key in the "data warehouse" fact table.

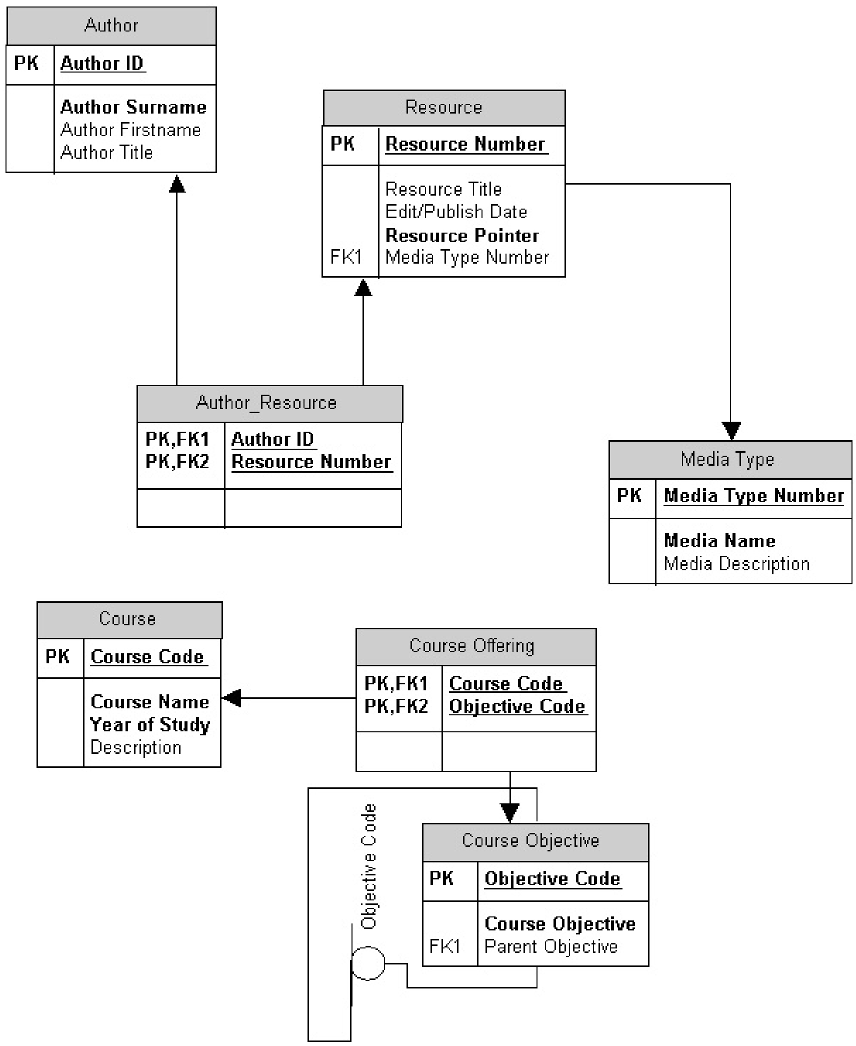

Figure 2. The Relational Component

The relational component consists of a number of normalised tables. The course grouping consists of the Course, the Course Objectives, the associative entity between them and the recursive relationship between the objectives. The Resource group consists of the Resource, Author, Media Type (e.g. video, html, and graphics) and the associative entity between author and resource. The resource record contains a resource pointer, which will eventually store some sort of pointer (e.g. URL) to the actual resource. The details of the pointer and the surrounding issues are beyond the scope of this paper and the issues encompassing this pointer are avenues for further research.

This model has yet to be translated into a prototype and tested for its ability to satisfy the resource-base requirements.

5. CONCLUSION

Some of the challenges of modern education such as a lack of library books and increasingly large classes can be defrayed by the intervention of Internet technologies. The technology of the Internet allows educators to locate, create and distribute educational resources on a platform independent system.

Locating, creating and modifying resources take an enormous amount of time. Educators have to scrutinize each resource to ensure that it is appropriate for the learners and the course being taught. Appropriate resources, thus, must be organised and stored in such a way as to facilitate easy access, distribution and relocation.

A design for the resource-base has been considered and a compromise between a relational database and data warehousing tools is being entertained. Further research includes the development of the prototype, testing and assessment.

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