GUIDED ENTITY RELATIONSHIP MODELLING WITHIN A SIMULATION OF A REAL WORLD CONTEXT

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Declaration

I declare that this thesis, which I submit for the degree of Doctor of Philosophy at Northumbria University, results entirely from my work has not previously been submitted for a degree at this or any other university.

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First of all I would like to thank my supervisors' team, Professor Paul Brna and Dr.Paul Vickers for their invaluable comments, support and encouragement during my study.

I am greatly indebted to the groups of volunteers who were involving in testing my prototype systems.

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ABSTRACT

This thesis examines the contribution of a guided discovery learning approach within a simulated real world context to learning. In order to consider the potential of this approach, a database design task is chosen (Storey & Goldstein, 1993) which requires the learner to capture the semantics of the domain application in a real world situation and then translate this into a data model for the database management system. This approach to learning has advantages since simulating a real world system in a classroom can be a very difficult and time-consuming activity.

The aims of the thesis is, therefore, to investigate the possibility of simulating real world situation for gathering database requirements and a teaching strategy that is suitable for this real world situation context. In order to reach the research goal, two main research questions need to be answered. Firstly, to what extent can a simulation of a real world situation improve the quality of learning in the database design area? Secondly, the extent to which a guided discovery teaching strategy can enhance the learning of database design within such a (simulated) real world context? A framework for simulating the real world situation and guided discovery strategies had been designed in order to implement four versions of a prototype systems called GERM for evaluation in order to answer the research questions.

The main results obtained from a small group of learners and lecturers indicates that the potential of guided discovery learning within a real world context can improve the quality of learning in database design - in particular entity relationship modelling. Amongst other advantages, it can help students to change their basic misconceptions. Furthermore, it also can improve students' skills in a real world situation. The promising results suggest further lines of research.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Information systems is provide the means of storing, generating and distributing information for the purpose of supporting the operations and management functions of an organisation, in particular planning, controlling, and making vital decisions. Therefore, a database system, which is a main part of the information system, must be correctly designed for providing the right information to executive staff for making crucial decisions accurately.

In turn, the successful implementation of a database depends on a correct design. If a database is designed incorrectly, users will have difficulty in retrieving certain types of information, and there is the added risk that searches will produce inaccurate information, which can adversely affect the profitability of a business. If the data kept and used in a database is going to affect the way a business performs its day-to-day operations and it also is going to influence the future direction of the business, the accurate design of database system must be a concern.

1.2 Why Database Design?

Database design is often complex task for designers (Storey & Goldstein, 1993) because the task needs to capture the semantics of the domain application in a real world situation and then translate them into a data model for the database management system. This section, therefore, introduces some real world problems in database design tasks.

1.2.1 A various kinds of Requirement Sources

The eliciting of database requirements by students from the application domains in the real world such as for a company can be a very difficult task because the requirements are not always readily available in a form that can be used by students in a classroom environment. The requirements may be also distributed across

many sources such as users' point of view, company's document forms/reports etc. Therefore, designers have to interview users and study the documentation of a company (Chen, 1983). In a real world situation, however, users often use informal language and also talk in terms of their roles within their organisation. Furthermore, they usually explain something in terms of examples, analogies and by illustrations. For example, instead of talking about aircraft they talk about jumbo jets, 747s or Concorde (Barker, 1990).

1.2.2 Ambiguity of Entity Type, Relationship Type, and Attribute Problem

Entity type (Hall and Gordon, 1998) is often confused with both relationship type and attribute because students lack understanding of the subject domain and are also unfamiliar with the application domain. Storey and Goldstein (1988, 1989) also pointed out that novice database designers have experienced problems in identifying entity types, distinguishing entities from attributes, and distinguishing entities and attributes from relationships.

1.2.3 Misconceptions

From the educator's perspective, it is very important to know about any of the learner's faulty models before developing a tutoring system. Misconceptions underlie many of the faulty models that we have to take into account in order to design tutoring system to support learners to realise their faulty model and to form a correct model (Brna, 1987., Fung et al, 1990).

From our teaching experience in data modelling, learners often have some misconceptions between entity type vs. entity instance and relationship type vs. relationship instance and attribute vs. value. They think entity instance, relationship instance, and attribute value are entity type, relationship type, and attribute. For example, they think jumbo jets, which is an entity instance of aircraft, is an entity type (Barker, 1990).This basic misconception can make a learner construct entity relationship diagram (ERM) completely wrong. Therefore, it is best to know a learner's misconception very well and store this knowledge in a learner model used by the tutoring system. The system can then provide a relevant teaching strategy.

1.3 Traditional Approach in Teaching Database Design

Traditionally, the theory of database design is introduced to students by means of a series of lectures that outline the relevant concepts, notations and methodologies, which are fundamental to the subject. This traditional approach may contain a number

of lecture slides, accompanying notes, practical exercises and their model solutions etc. Due to the limited time available for lectures, only a very few problems can be demonstrated. Group tutorials may accompany lectures, allowing students some opportunity for hands-on experience in constructing entity relationship models, but the tutor can only provide limited individual assistance to the students.

Although the traditional method of teaching Entity Relationship Modelling (ERM) in a classroom environment may be sufficient as an introduction to the concepts of database design, students cannot be expected to gain expertise in the domain solely by attending lectures. Even if some effort is made to offer students individual help through tutorials, since a single tutor must cater for the needs of the entire group of students, it is inevitable that they obtain only limited personal assistance. Furthermore, the difficulties of providing advice at the appropriate level for each student's abilities also become apparent in-group tutorials, with less able students struggling and more able students not being sufficiently challenged.

1.4 Guided Discovery Learning

Discovery learning (Bruner, 1961) is an approach to instruction through which students interact with their environment by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments. Psychological research (Anderson, 1993) argues that knowledge acquired from discovery learning is retained for longer than knowledge obtained from direct instruction.

However, it is not easy to make learners discover by themselves. The guided discovery approach, therefore, emerged in order to help learners to discover. This approach (Mosston & Ashworth, 1990) focuses on the production of new knowledge by giving sequences of information which cause a corresponding set of responses by learners. The combination of information by a teacher elicits a correct response that is discovered by learners. The cumulative effect of this converging process leads learners to discover the sought concept or principle. Furthermore, the process can induce a learner to develop more cognitive skills.

The guided discovery approach is not quite appropriate to implement in the class room environment because learners do not discover at the same speed. However, it is suitable for one-to-one situations, in particular for computerised instruction as in tutoring systems.

1.5 How to overcome the Problems?

Because database design is a complicated task, designers have to learn not only the basic concepts but also need practical application of the relevant techniques (McLeod, 1996; VanLehn, 1996) in an environment which is as close as possible to a real world situation. However, one of the main problems in the traditional approach is the large number of students to be taught. Therefore, individualized instructions, which are more effective than traditional classroom instruction (Bloom, 1984), are usually impractical. The content and timing of the knowledge transfer process have to be tailored to the needs and abilities of a group of students. Furthermore, teaching in a classroom cannot easily simulate a real world application domain for students to practise in.

Thus, a promising approach to overcome this problem is the development of computer-aided educational systems, which can simulate the real world situation together with guided discovery learning theory, as a complement of the traditional approach for students to learning and practising by themselves.

1.6 Aim of the Research

We are investigating the possibility of simulating real world situation of database requirement and teaching approach that is suitable for the real world situation to develop a tutoring system for students practicing Entity Relationship Modelling. In order to reach the research goal, two main research questions need to be answered:

1.6.1 To what extent can a simulation of real world situation improve the quality of learning in database design?

1.6.2 The extent to which guided discovery teaching strategy can enhance the learning in database design within the real world context?

1.7 Structure of the Thesis

The structure of the thesis is as follows:

Chapter 1: This chapter introduces some problems encountered in teaching database design and outlines the research questions.

Chapter 2: This chapter provides a review of tutoring systems developed for teaching database design and points out some problems that these tutoring systems have not addressed. This chapter also investigates the database requirements for representing a real world situation and introduces a framework for simulation of real world situations.

Chapter 3: This chapter introduces pedagogical strategies for teaching database design within a real world context.

Chapter 4: This chapter discusses learning environments suitable for teaching database design.

Chapter 5: This chapter describes the implementation of four prototype tutoring systems for teaching database design.

Chapter 6: This chapter shows the results of evaluation of the four prototype tutoring systems.

Chapter7: This chapter presents conclusions, ad outlines the contribution of the thesis and offers suggestions for further work.

CHAPTER 2

SIMULATION OF REAL WORLD SCENARIO FOR TUTORING SYSTEMS IN TEACHING ENTITY RELATIONSHIP MODELLING

Due to the complexity of database design task, extensive practice is the only way to improve the learner's skill. However, because of time limitations and the large number of students, the traditional classroom-teaching approach cannot provide this extensive practice. Tutoring systems (TS), therefore, can be very useful tools for giving more chances to students for practising database design tasks at their own pace.

This Chapter, therefore, introduces previous tutoring systems, especially those developed for entity relationship modelling. In general, there are two types of tutoring system: non-intelligent TS and intelligent TS. Intelligent tutoring systems (ITS) focus on the student's knowledge and then provide individualised instruction, while non-intelligent TS cannot give indivudual instruction to each student. A detailed of the two types of TS for entity relationship modelling is presented in the following sections.

2.1 Non-intelligent Tutoring System

From the mid 1980s until the early 1990s the term CAL (Computer Aided Learning) was often used to refer to the development of either a single computer program or a series of programs which replaced more traditional methods of instruction, in particular the lecture. This approach describes an educational environment in terms of a computer program to assist the learner in learning a particular subject. It assists the learner by integrating an approach of instructional methods. Thus, CAL is not only a single computer program but also an educational strategy devised to teach a particular subject.

Since 1995, CBT (Computer Based Training) has evolved considerably. The approach uses computers and multimedia technology for training. It can encompass any type of training that involves a learner interacting with a computer. An interactive learning experience between the learner and computer in which the computer provides

a number of situations, the learner must respond, and the computer then give feedback to the learner whereas CAL focuses on only teaching strategy.

However, both CAL and CBT are considered to be non-intelligent TS because neither focuses on the level of the learners' knowledge or builds a model of the learner, which is the important part of an ITS. Therefore, tutoring systems, which are derived from these approaches, usually consist of three models as shown in Figure 2.1.

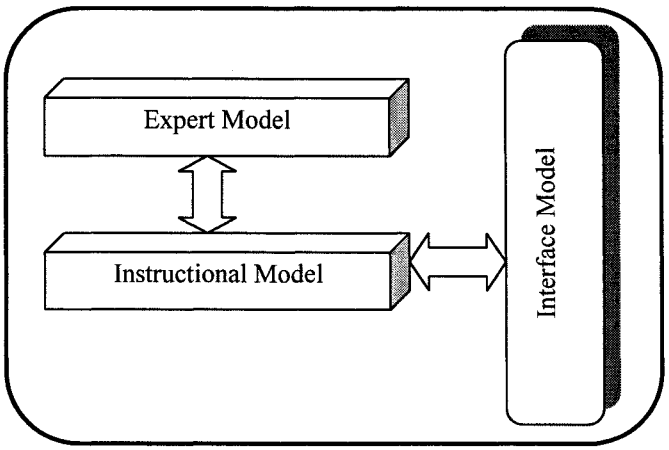


Figure 2.1: The components of a non-intelligent tutoring system

The Expert Model contains knowledge from human expert(s). The Interface Model receives input from the learner and provide feedback. The Instructional Model provides instruction by considering the learner's input and expert knowledge from expert model.

The database design task is quite complicated and lacks direct rules to employ, therefore, there are few tutoring systems developed to support the traditional classroom approach. The following section, however, introduces three non-intelligent tutoring systems for teaching data modelling using the entity relationship diagram.

2.1.1 DBTool: (Lim & Hunter, 1992) This system was developed as a learning tool for students learning database design. The interface of the system gives learners the chance to construct entity types, relationship types, and attributes on their own. It also provides knowledge about constructing entity relationship models in terms of a help index based on keyword topics that are related to constructing entity relationship model using the tool. Even though the online help system might be convenient for some students to find some basic concepts in constructing entity relationship models, it is not that different from textbooks. Moreover, the tool supports only simple

notations for constructing entity relationship models, which is not sufficient for some more complex database requirement scenarios.

2.1.2 Concept Tutor (Ahrens & Sankar, 1993) This tutoring system was developed as a tutorial with textual explanations of the topics, which does not require any learner interaction other than moving on to the next topic. Each topic provides a number of database case studies. Each case study provides a number of questions alongside solutions by applying if-then rules to explain the reasons for any solutions. However, the context and order of topics is the same for all learners.

2.1.3 Didactic Tutor (Ahrens & Sankar, 1993) This system attempts to involve learners in the process of decision rules reasoning by asking multiple-choice questions and giving immediate positive or negative feedback in order to make interaction between learners and the system. However, the system cannot give individualised instruction to each student. The context and order of the topics remains the same for all students.

2.2 Intelligent Tutoring Systems

The approach known as intelligent tutoring systems (ITS) has been pursued by researchers in education, psychology, and artificial intelligence. The goal of this approach is to provide the benefits of one-to-one instruction. It enables learners to practise their skills by carrying out tasks within highly interactive learning environments.

Normally, computer based systems such as CAL or CBT use traditional instructional methods by providing instruction to learners without concerning themselves with a model of the learner's knowledge. Thus, these instructions sometimes cannot assist learners individually.

By contrast an ITS assesses each learner's actions within these interactive environments and develops a model of their knowledge, skills, and expertise. Based on the learner model, it can tailor instructional strategies, in terms of both the content and style, and provides relevant explanations, hints, examples, demonstrations, and practice problems to individual learner.

In order to provide the relevant instruction to learners, an ITS system is composed of three types of knowledge, organised into four separate software modules (as shown in Figure 2.2.)

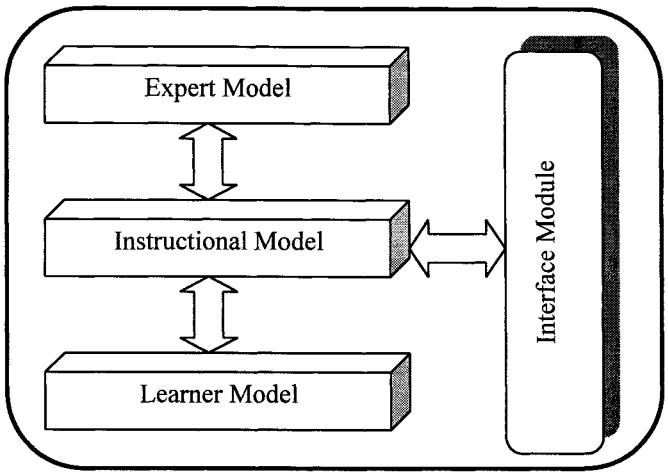


Figure 2.2: The components of an intelligent tutoring system

- **An expert model** is a computer representation of a domain expert's subject matter knowledge (declarative knowledge) and problem-solving ability (procedural knowledge). This knowledge enables the ITS to compare the learner's actions and selections with those of an expert in order to evaluate what he or she does and does not know.
- **A Learner model** is a level of learner's knowledge while he/she interacts with the tutoring system. The model evaluates each learner's performance from his/her behaviour during interacting with the tutoring system in order to determine his or her knowledge, perceptual abilities, and reasoning skills. The model will generate evidence and uses inference to provide a number of relevant instructions to individual learner.
- **An instructional model** contains knowledge for making decisions about instructional tactics. It relies on the diagnostic processes of the learner model for making decisions about what, when and how to present information to a leaner. For example, if a student has been evaluated as a beginner in a particular procedure, this model will show some step-by-step demonstrations of the procedure before asking the user to perform the procedure on his or her own. When a learner gains expertise, this model might decide to present increasingly complex scenarios. Furthermore, this model may also choose topics, simulations, and examples that are relevant to a level of learner's knowledge.
- **An interface model** is important as a communication medium and learning environment that can support learner in a task. It can also act as an external representation of the expert model and instructional model.

These kinds of tutoring systems can provide the student a wides selection of practice database case studies alongside individualised feedback for solving each case study. Moreover, it is very convenient for the students, who need to practise and learn at their own pace. The following section introduces ERM-VLE (Hall & Gordon, 1998a; Hall & Gordon, 1998b; Hall & Gordon, 1998c), COLER (Constantino-Gonzalez & Suthers, 2000; Constantino-Gonzalez, et al., 2001) and KERMIT (Suraweera & Mitrovic, 2001,2004), three intelligent tutoring systems developed for teaching data modelling using the Entity Relationship Diagram.

2.2.1 ERM-VLE: (Gordon&Hall,1998; Hall&Gordon,1998a;b;c)

The system was designed as a text-based virtual learning environment for practising entity relationship modelling. Learners can interact with the learning environment with a restricted set of textual commands relating to communication, movement and object manipulation. There are two important components of the system that described in more detail as follows.

- **The learning environment & Interface**

The learning environment was designed as a virtual world, which consists of a number of interconnected rooms such as the entity type creation room or attribute creation room etc. However, the interface of the system has been separated into three main areas:

- **Current ERM Area:** This area displays a current graphical representation of the Entity Relationship model constructed by the learner. The graphical representation is updated by the activities of the learner. However, the learner cannot directly interact with the graphical representation.
- **ERM World Area:** Learners can communicate with the system in this area by keying textual commands. This area displays the current room location and a record of interactions between the learner and the tutoring system.
- **Scenario Area:** This area represents the database requirement scenario by short phrases of formal language, which the learner has to deal with. The scenario can change automatically dependent on the learner's achievement.

- **Teaching Strategies**

The task of the learner is to construct an entity relationship model from a given scenario by navigating the virtual world and manipulating objects. The tutoring system uses the virtual world to teach learners about the right procedure for constructing an entity relationship model. Learners must complete their work in the entity creation room before moving to another room. Within ERM's World Area, learners can issue textual commands such as pick up, drop, name, evaluate, create and destroy to manipulate objects. The effect of the command is determined by the current location. For instance, the learner can construct an entity type while he or she works in the entity creation room. The evaluation command will provide feedback in constructing entity relationship model.

Because the entity relationship model solutions for each problem scenario are attached together in the virtual world, the system does not allow a learner to construct the entity relationship model, which is different from the solution model. It is quite restricted for the learner because he or she is forced to follow an identical solution path. As a result, the learner does not receive any explanations for their mistakes. Moreover, the text- based tutoring system might be not suitable for teaching the subject like data modelling in which learner has to draw diagrams. However, when the system was evaluated with a group of participants (Hall & Gordon, 1998a), novices felt that they had increased their understanding of entity relationship modelling. On the other hand, the experienced designers felt that the structure of the virtual world had restricted them.

2.2.2 COLER: (Constantino-Gonzalez & Suthers, 1999; 2000; 2001)

This system is designed as a World Wide Web (WWW)-based computer-mediated collaborative learning environment for teaching Entity Relationship modelling. The goal of the system is to enhance students' skill in constructing entity relationship models and to support them in developing collaborative and critical thinking skills. At the beginning stage, the system will give a chance for students to construct an individual entity-relationship model from the given database requirement scenario and then work in small groups via a networked environment to encourage collaboration. An agent is designed for coaching the students in a collaborative learning environment and improving the students' skills.

- **Learning Environment & Interface**

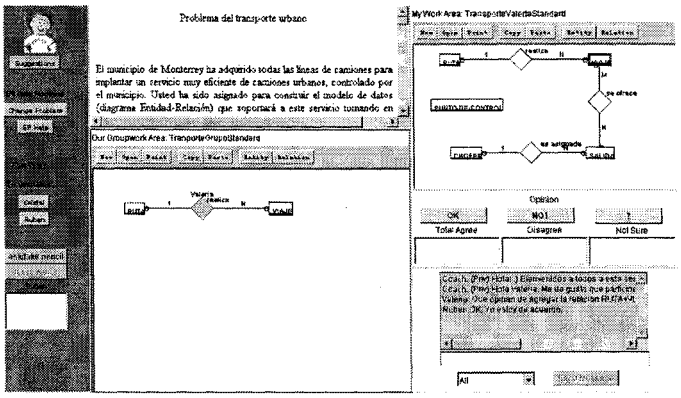


Figure 2.3: COLER' s Interface

(http://lilt.ics.hawaii.edu/lilt/software/coler/)

The interface of the system consists of a problem description window, a private workspace, a shared workspace and a chat window. The problem description window displays the database requirements scenario. After considering the scenario, students have to construct individual solutions in the private workspace and then join a group to develop a group solution in the shared workspace. Only a single member can edit the shared workspace at any time. Once any modifications are completed, another member of the group is given the opportunity to modify the shared workspace. The chat window is used by the students to communicate with each other. Each student's client contains a private coach which monitors the private workspace of its students. The coach also monitors the shared workspace and records the students' opinions in the workspace and chat discussions. The interface also contains an opinion panel which shows the opinions of the group on the current issue. Each member has to vote on each opinion with either agree, disagree or not sure.

- **Teaching Strategies**

The system applies two pedagogical theories that explain how social interaction mediates learning: Socio-Cognitive Conflict Theory and Cognitive Dissonance. The first emphasizes domain learning and the latter social communication. According to the Socio-Cognitive Conflict Theory, students learn from disagreements when they identify and resolve conflicts in their viewpoints, present alternatives, and request and give explanations.

Cognitive Dissonance Theory states that the existence of disagreement among members of a group produces cognitive dissonance in the individual, who experiences pressure to reduce this dissonance, leading the student to a process of social communication and revision of his/her position. The value of the disagreement does not depend as much on the correctness of the opposing position as on the attention, thought processes and learning activities it induces. Thus, it is important to help students recognise and address their differences. As a result, the system is designed for students to initially solve the problem individually and then join a group to develop a group solution. The designers argue that this helps to ensure that the students participate in discussions and that they have the necessary raw material for negotiating differences with other members of the group. The system also contains a help feature that can be used to obtain information about entity relationship modelling.

2.2.3 KERMIT: (Suraweera & Mitrovic, 2001, 2004)

This system was designed for University students learning conceptual database modelling. It teaches the basic entity relationship model. It presents the requirements for a database and the student is required to design a corresponding entity relationship diagram. The system is not designed as a substitute for conventional teaching, but as a complement to classroom teaching. Thus, the system assumes that students are already familiar with the fundamentals of database theory.

The main objective of the system is to individualise instructions for each student. It records the student's knowledge of the domain in the form of a student model. Instructions are generated dynamically on the basis of these student models. Furthermore, selecting topics and problems are also performed on the basis of the student model. This ensures that the instructions are individualised to each student. The teaching system is designed for students to work individually at their own pace. A student initially logs on to the system after identifying himself/herself. An introduction of the user interface is provided for first time users. The student is given the requirements of a case study and he/she is required to design a database that fulfils these requirements. The student is required to use entity relationship modelling constructs to model their solution.

The entity relationship model can be constructed using the workspace that is integrated in the system's interface. Once the student feels that he/she has completed the diagram or feels the need for guidance from the system, they can submit their solution to be evaluated by the system. The system then offers instructions depending on its evaluation of the student's solution. Once they have completed a problem by constructing a correct solution, the system will select a new problem that best suits the student.

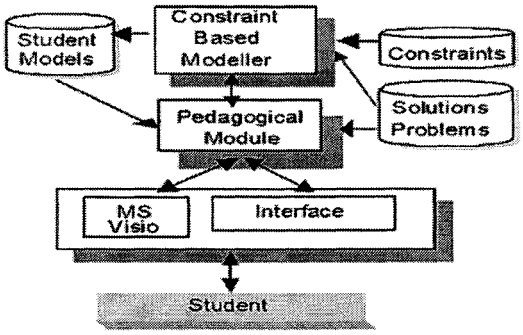


Figure 2.4: KERMIT's Architecture

The system's architecture, illustrated in the Figure 2.4 consists of *a user interface*, *a student modeller* and *a pedagogical module*. It also contains a *knowledge base* and *a database* that consists of problems and their ideal solutions.

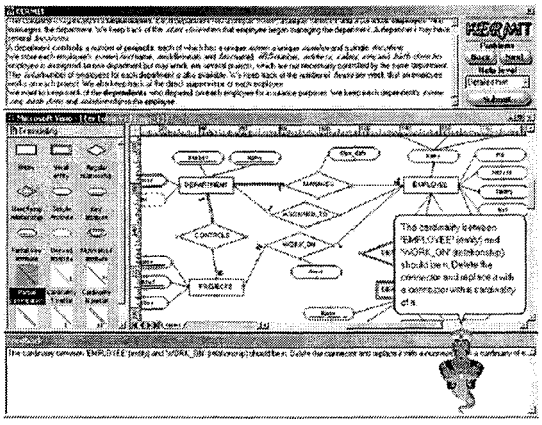


Figure 2.5: KERMIT's Interface

[http://nz.cosc.canterbury.ac.nz/~tanja/kermit.html#overview]

- **The system's interface**

The interface of the system, illustrated in Figure 2.5, consists of three windows. *The top window* is used to display the problem text so the student can always remind himself/herself easily of the requirements of the database. It also has

a drop down list for the students to choose their desired level of feedback. *The middle window* is the workspace for students to model their solution. The workspace consists of a toolbar that consists of all the constructs used in entity relationship modelling. The student is required to construct their entity relationship diagram by using this toolbar. *The lowermost window* displays feedback messages from the system. The teaching system also incorporates an animated agent, which performs animated behaviours and communicates the feedback messages verbally.

- **Student modeller**

This modeller is based on *constraint based modelling* (CBM), a student modelling approach that tries to reduce the complexity of the student model task by focusing on the student's errors. It evaluates the student's answers by checking them for syntax errors or semantic errors and comparing them to correct answers. Domain knowledge in CBM is represented as syntactic constraints and semantic constraints, where a constraint defines a set of equivalent problem states. An equivalence class generates the same instructional action; thus the states in an equivalence class are pedagogically equivalent. This is based on the assumption that there can be no correct solution to a problem that traverses a problem state, which violates the fundamental concepts of the domain. Violation of a constraint signals the error, which comes from incomplete and incorrect knowledge.

- **Pedagogical Module**

The system generates instructional actions to a student by providing feedback messages, which are grouped into six levels in an increasing amount of detail: correct, error flag, hint, detailed hint, all errors and solution. The first level of feedback – correct, – simply indicates whether the submitted solution is correct or incorrect. The error flag indicates the type of construct (e.g. entity, relationship, etc.) that contains the error. Hint and detailed hint offer a feedback message generated from the first violated constraint. A list of feedback messages on all violated constraints is displayed at the all errors level. The entity relationship schema of the complete solution is displayed at the final level: solution level.

Furthermore, the system examines the long-term student model to select a new problem by focusing on the greatest number of student's errors, which violated

constraints in order to ensure that students get the most practice on the constructs with which they experience difficulties.

2.3 Simulation and Tutoring Systems

In general, both non-intelligent tutoring systems and intelligent tutoring systems can be used as practice tools for students who want to learn at their own pace. Although the development of non-intelligent tutoring systems is not complicated in comparison with intelligent tutors, they are limited in their effectiveness. This is because they cannot focus on an individualise student's needs. Therefore, the same set of instructions would be provided to all the students using the system. Intelligent tutoring systems, however, provide individualised instructions to each student.

In the traditional teaching approach, very few practical problems can be demonstrated in a classroom environment because of various limitations whereas database design can only truly be learned by extensive practice (McLeod, 1996). Thus, tutoring systems can be useful tools for complementing classroom-based teaching.

However, the previous tutoring systems for teaching data modelling (both non-ITS and ITS) represent the database requirement problem scenario in formal language which is different from real world situations. In the real world, database designers have to confront the users' requirements and also have to deal with a range of company documents (Chen, 1983). Our study, therefore, seeks to investigate and develop a simulation of a real world situation which is different from previous systems as shown in Table 2.1.

NAME	TYPES		COMPONENTS				
	NON ITS	ITS	Interface Scenario		Model		
			Tradition	Simulation	Teaching	Learner	Expert
DBTool	√		√	×	√	×	√
Concept Tutor	√		√	×	√	×	√
Didactic Tutor	√		√	×	√	×	√
ERM-VLE		√	√	×	√	√	√
COLER		√	√	×	√	√	√
KERMIT		√	√	×	√	√	√
Our Systems	√	√	√	√	√	√	√

Table 2.1: The comparison between our system and previous systems

From the lessons learnt from above study of the literature on tutoring systems we conclude that we can address the research questions (stated in chapter 1) by developing four prototype systems called Guided Entity Relationship Modelling (GERM) as shown in Table 2.2.

Version	Requirement Scenario	Pedagogical Strategies
GERM 1	Traditional Scenario	Simple feedback(Yes/No)
GERM 2	Traditional Scenario	Guided Discovery Strategy
GERM 3	Simulation Scenario	Simple feedback(Yes/No)
GERM 4	Simulation Scenario	Guided Discovery Strategy

Table 2.2: Four versions of GERMs

The characteristics of tutoring systems identified in Table 2.2 map onto the four GERM systems as shown in Table 2.3.

NAME	TYPE		COMPONENTS				
	NON ITS	ITS	Interface Scenario		Model		
			Tradition	Simulation	Teaching	Learner	Expert
GERM 1	√		√	×	√	×	√
GERM 2		√	√	×	√	√	√
GERM 3	√		×	√	√	×	√
GERM 4		√	×	√	√	√	√

Table 2.3: The detail components of four versions of GERMs

The goal of this study, therefore, is to investigate the nature of real world database requirements and to design a simulation framework of a real world situation for students to practise with. Moreover, we also investigate and design a teaching strategy that is suitable for teaching using a real world situation.

According to the literature review, all of the tutoring systems for teaching database design represent the database requirement scenario in term of formal language, which is different from the real world. The following section introduces a framework for simulating database requirements in a real world situation by beginning with reviewing the basic concepts of simulation in education and the use of simulation in tutoring systems. The framework is then designed and introduced in this chapter.

2.4 Simulation in Education

According to Whitehead (1929) and Rogers (1969) one of the weaknesses of traditional education is that it often provides information without concern for its practical application to the real world. Both Whitehead and Rogers suggest that knowledge gained from conventional teaching methods is not useful until learners have to deal with a real world situation. Educators, therefore, try to take the advantage of technology (especially computer technology) to develop simulations of real world situations for helping students learn about real world problem situations.

2.4.1 Definition of Computer Simulation

We can defined the word "computer simulation"in a variety of definitions. It depends on the subject domain and the educational goal. Some researchers define a simulation as a program that contains a model of a real system. The learner changes values of input variables and observes the resulting changes in values of output variables (Reigeluth & Schwartz, 1989). However, in this study, we prefer Doyles's (2002) definition.

"*Simulation refers to the artificial representation of a complex real world process with fidelity to achieve a particular goal, such as in training or performance testing.*"

2.4.2 The Types of Simulation in Education

Basically, a simulation is dependent upon a model of a real world system which can be categorised into three groups (Van Joolingen & De Jong, 1991a).

- *Physical systems:* These are systems that already exist in the natural world e.g. biological systems. Because of their complexity, we can only study the system through observation. A computer simulation, therefore, is needed to represent the models of natural world systems for educational purposes.
- *Artificial systems:* These are systems that are developed by people. A simulation might be found in aviation in the form of flight simulations, or the simulation of some artificially created situation such as a post office or other business company for the training of professional people in occupations in which human errors would be costly and dangerous.

- *Hypothetical systems:* These systems do not exist in the real world, for example, the simulation of a world without friction (Smith, 1986), or some simulation models of the economy.

The simulation of a real world business with which we are concerned in some ways is not as rich as the above kinds of simulation since we are not concerned with an executable physical simulation. We are more concerned with simulation of a variety of information sources within a business organisation. Our work is closer to an artificial system in that we are not representing a real business but one that is like a real business.

However, the types of simulation sometimes can be classified in the way in which a learner may interact with it as follows (Alessi & Trollip, 1985):

- *Physical simulations:* Learners will learn some skills from a simulation of physical objects.
- *Procedural simulations:* Learners will learn skills from operating devices or systems.
- *Situational simulations:* Learners will learn skills from playing certain roles.
- *Process simulations:* Learners will acquire skills from observation of the development of the simulation state over time.

This view of interacting with simulations makes the problem of understanding the simulation implicit. Our work, however, requires learners to interact with the simulation in order to understand it, and to make explicit what is often implicit. Hence we would prefer a new category to extend Alessi and Trolip's list (Alessi & Trollip 1985) which emphasises exploring the underlying model, here an informational model.

Some researchers suggest that the main characteristic of a simulation is whether it concerns a *conceptual* or an *operational* model (Van Berkum & De Jong, 1991).

- *Conceptual models:* The models will consist of principles, concepts, and facts, which are related to the real world systems being simulated. These models can be found in areas such as physics or economics.
- *Operational models:* The models are composed of sequences of cognitive or non-cognitive procedures which can be applied to the real systems.

Examples of this kind of model include troubleshooting of avionics, (Lesgold et al., 1992), troubleshooting of complex devices, (Towne et al., 1990), or radar control (Munro et al ,1985).

The underlying models certainly have both conceptual and operational elements. To this extent, Van Berkum and De Jong's framework fits our work well.

2.4.3 The Fidelity of the Simulation in Education

The level of similarity between the simulation and the real world is referred to as fidelity. There are several different kinds of fidelity that try to simulate different kinds of situation (Polson and Richardson, 1988). There are a number of reasons for attempting to achhieve a high degree of fidelity. First, if differences between the simulation and real situation are minimised, the transfer of knowledge acquired in the simulation situation to the real world situation should be increased (Alessi, 1988). Secondly, the learner's motivation might be increased when dealing with high fidelity simulations (De Hoog, De Jong, & De Vries, 1991). Finally, the understanding, of learners might be enhanced by practising with a high fidelity simulation, in particular in the form of animations which support visualisation procedures (Rieber, 1996a). However, it may be necessary to include specific features that are required for learning objectives such as stopping, slow down, or speed up from a real process (Lewis, Stern, & Linn, 1993). Furthermore, it might be reasonable to remove some features from the real systems in order to simplify the learning situation in the initial stages for the novice learners (Cunningham, 1984).

Researchers in the area of simulation in education categorised the fidelity of environment simulation into four types (Polson, 1988): *Physical fidelity* (feels the same), *Display fidelity* (looks the same), *Mechanistic fidelity* (behaves in the same way), *Conceptual fidelity* (is thought of as the same).

2.4.4 The Use of Simulation in Tutoring Systems

Many of the educational simulations are based on physical systems. We provide a few examples, and point out what we can learn from these for our purposes.

Brow et al (1982) developed a simulation of a device (a regulated power supply) with a general purpose electronic simulator called SPICE (Simulation Program with Integrated Circuit Emphasis). Faults can be inserted in this simulation, and the student then diagnoses them. In addition, the system contains a natural

language interface, which permits students to pose questions. For us, the most interesting aspect is the attempt by the system to analyse student input. However, we have chosen to avoid the natural language problem by simulation of a real world situation which consists of a large number of relevant and non-relevant information for students to learn.

Hollan et al (1984) developed a simulation of a steam propulsion plant consisting of a graphical interface to a mathematical model of the plant. The interface allows learners to select from a library of views of the propulsion system and to interact with a selected view to change the state of the underlying simulation model. Several levels of detail of the propulsion plant can be depicted in different views. The level of detail can vary from gauges and dials to schematic diagrams. One instructional advantage of this system is the ability to show global views of systems that are physically dispersed in a real power plant. The main lesson for our study is the need to provide alternative views of a company's activity in the real world situation for students to learn how to design databases.Towne et al (1990) developed a simulation-based software tool that can produce system behaviours from a deep model of the system. It was designed for use in training troubleshooting skills and for conducting research in intelligent tutoring, contains a generalised model of an expert diagnostician and domain independent editing tools to construct graphic simulations of equipment systems. However, the system does not provide much in the way of guided discovery learning.

Reimann (1991) designed REFRACT, a computerised interactive simulation program for optical refraction. It provides a discovery learning environment within the phenomenon of refraction (Snell's law, lens makers' equation) which the learner can explore in a self guided, hypothesis driven more manner. The students's task is to find out about the laws that govern the domain by conducting experiments and analysing their results. In each simulated experiment, students have to predict the outcome before they receive feedback. REFRACT is based on graphical simulation and allows for direct manipulation of the objects involved into the simulation. Furthermore, students have available tools to inspect and record graphical simulation as well as tools for analysing experimental outcomes quantitatively. REFRACT does not guide students during their exploration but it does, at least, give feedback once the student has finished a task.

Lesgold, et al (1992) developed a computer-based learning by design environment that uses artificial intelligence technology to teach Air Force technicians to efficiently perform the hardest troubleshooting tasks that arise in their jobs, diagnosing faults in a system with thousands of parts. The environment combines a simulation of the system with which they work every day and a coach that provides advice when they reach impasses while attempting these difficult tasks. However, the coach does not support training in a way that is related to guided discovery learning.

Whitelock, et al (1993) developed a simulation of elastic collisions to elicit 16–17 year-old physics students' understanding of collisions. In general, the students appear to use two different models of reasoning namely a *linear causal* and a *resistance/reciprocal causal* model. These models however break down when the students are confronted with a computer simulation if conservation of energy is not understood. The computer simulation allows pupils time to run experiments which they think will confirm their faulty models but which facilitate a shared understanding of energy conservation. This study takes a different approach by simulating faulty models. The approach of allowing the exploration of faulty models is more straightforward with physical systems. However, in database design tasks we cannot define the rules as exactly.

Arthur (1999) designed a simulation of the discourse patterns and pedagogical strategies of a typical human tutor in order to assist college students in learning the fundamentals of hardware, operating systems, and the Internet in an introductory computer literacy course.

Ong & Mannan (2004) developed virtual reality simulations and animations in the teaching automated machine tools, which deals primarily with the numerical control (NC) of the motions of automated machine tools. These virtual reality simulations and animations provide the capability of training students in NC programming and operations without the need to work on actual NC machines in the laboratory. The simulations are suitably placed in the package to engage the students and enhance their concentration, while at the same time generate interactions. Motivation is seen as coming in part from working with a physically faithful model of reality while we are working with a more conceptually faithful model of a business and this may also help to motivate students.

2.5 The simulation of real world situation in Database Design

One way to improve skills in problem understanding for students is simulation (Paul and Hlupic, 1994). Database design is a subject in which students have to learn from real world problems. However, a traditional classroom-based teaching approach usually represents the database requirement problem in terms of formal language rather than as a simulation of the real world problem.

2.5.1 Database Requirements in the real world situation

Database requirements from real world application domains (such as a company) are not always readily available in a form that can be used by students in a classroom environment. The requirements may be also distributed across many sources such as users' views, company's document forms/reports etc. Therefore, we have to investigate a database application domain in the real world situation before developing a database requirement scenario within a real world context.

2.5.1.1 Review of an Organisation Structure

Traditionally, a commercial organization's structure is divided into separate functions. In general, it has been categorized into five main departments (Laurie, 1999): *Personnel department*, *Production department*, *Marketing department, Financial department* and *Research and development (R&D) department* as shown in Figure 2.6.

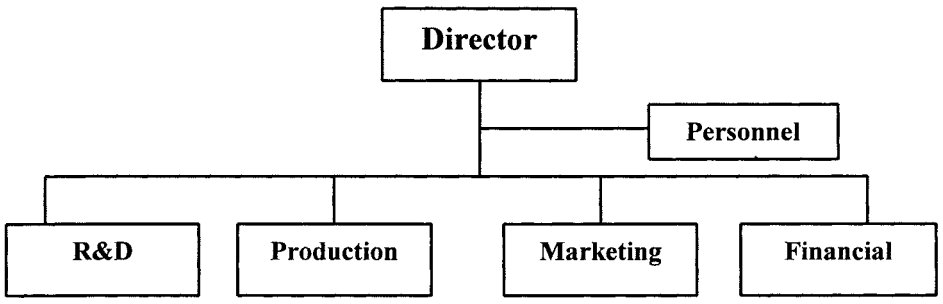


Figure 2.6: Organisation Structure

2.5.1.2 Review of Organisation Level

Generally, the main objective in designing a database system is to provide crucial information to an organization at three different levels: *Operational level*, *Managerial level* and *Executive level* (Leonard & Joseph., 1999). The different levels have different database requirements needs. Therefore, database designers have to

understand and deal with these three levels of an organization as a database requirement domain application in the real world situation.

- *Operational level*: At the operational level of an organization, the routine day-to-day business processes and interactions with customers occur. An information system is designed to automate repetitive activities, such as sales transaction processing. The transaction is composed of basic documents such as customer files, customer order forms, product files, invoices forms etc. The processing of this level is recording, summarizing, sorting, updating and merging etc. The output of the system is count and summary reports of activity such as an inventory report etc.
- *Managerial level*: At this level, functional managers focus on monitoring and controlling operational-level activities and providing information to higher levels of the organization. Therefore, the input of this level is the reports from the operational level. The processing of this level is an aggregation of data. An information system at this level could provide a manager with monthly report information such as sales forecasting, inventory planning and financial forecasting etc.
- *Executive level*: At this level, senior staff, such as the president, vice president and director, focus on longer-term strategic issues facing the organization. The decisions at this level are very complex problems. For example, a director may decide to develop a new product. Therefore, information systems at this level obtain inputs from the managerial level or other database and then aggregate summaries of trends and projections of the future or strategic planning for assisting with this crucial decision.

2.5.1.3 Review of Users' levels and behaviour in an organization

Generally, a successful database design must satisfy users' needs. Basically, we can group users with an organization into three main categories: *functional level*, *line manager level* and *executive level* (Arthur, 1997). Different user levels have different requirement needs.

- *Functional level*: These users essentially carry out the operational activities. So they know about the processes of their work very well. The database requirement at this level is generally the information used on a day-to-day basis such as customer files, product files and order forms etc.

- *Line manager level*: These users are responsible for the day-to-day productivity of their departments in order to provide the information to the executive level. Thus, the database requirements at this level basically are monthly reports such as sales forecasting, inventory planning and short-term plans etc.
- *Executive level*: At this level, the users focus on the direction of an organization. Therefore, the database requirements should be the information which can support their decision making about the direction of the company such as financial report, long-term plan, budget report etc.

In addition, most users tend to use informal language and also talk in terms of their roles within the organisation. Furthermore, they usually explain something in terms of examples, analogies and by illustrations. Instead of talking about aircraft they talk about jumbo jets, 747s or Concorde (Barker, 1990).

2.5.1.4 Review of Documentation System in an Organisation

Traditionally, a database designer obtains database requirements by conducting interviews with end users to discover their requirements. However, this traditional approach can be costly and time consuming. Therefore, the review of existing system documentation within an organization can help designers to discover the proper requirements. We can categorize documents within an organization into three groups (John, et al, 1979) as follows:

- *Describing how the organization is organized*: Policy statements, Method and procedure manuals, Organization charts, Job descriptions, Performance standards, Delegations of authority etc.
- *Describing what the organization plans to do*: Statement of goals and objective, Budgets, Schedules, Forecast, Plan (long and short range) etc.
- *Describing what the organization does*: Financial statements, Performance reports, Staff studies, Transactional files (customer order, invoices and expense records), Master reference files (customer's file, employee's file, product's file), Legal papers (copy rights, patents, trade marks) etc.

2.6 Summary

The database design task (Storey & Goldstein, 1993) requires the designer to capture the semantics of the domain application in a real world situation and then translate them into a data model for the database management system. We investigate a real world situation and design the framework for simulating the situation for students to learn database design, in particular, for entity relationship modelling within a real world context. The comparison between the traditional scenario and the simulation of real world scenario has been described in Table 2.4.

Scenario Components	Traditional Scenario	Simulation Scenario
Overall Problem Representation	Describing all of the requirements by using formal language	A number of sources e.g. users' requirement, forms or reports
Organisation structure	✗	✓
Users' layer	✗	✓
Users' Requirement	✗	✓
Documents' system	✗	✓

Table 2.4: The comparison between traditional scenario and simulation scenario

CHAPTER 3

DESIGN OF PEDAGOGICAL STRATEGIES FOR GUIDED DISCOVERY LEARNING

From the point of view of researchers in intelligent tutoring systems (ITSs), a pedagogical strategy is a crucial component. Therefore, there are attempts to seek the best approach for developing tutoring strategies. This chapter examines literature on teaching strategies, which relate particularly to guided discovery learning in ITSs. The theoretical foundations of guided discovery learning and various guided discovery tutoring systems are discussed in more detail. Finally, the chapter introduces the teaching strategy that has been selected as suitable for teaching entity relationship modelling within a real world context.

3.1 Teaching Strategies in ITS

In general, the approach for deriving teaching strategy in tutoring systems can be categorised into three groups (du Boulay & Luckin, 2001). First, strategies derived from expert human teacher tactics. Second, generating them from observation of learners. Lastly, developing them from a learning theory. All of these approaches will be introduced in the following sections.

3.1.1 Investigation of Expert Teachers

An effective intelligent tutoring system based on this approach is Socratic Tutoring (Collins et al., 1975). Socratic Tutoring employs tactics from expert teachers to diagnose problems that the learners have and then teach them according to the learning goal. Another intelligent tutoring system in which had been developed by Lepper et al. (1993) also investigates the tactics which teachers employ to motivate learning. However, expert teachers often use many kinds of tactics to teach pupils – it depends on the situation. It is very hard to summarise a teacher's tactics in term of rules since they take a great deal of the context into account.

3.1.2 Developing Strategies from Student's Behaviour

In general, there are a variety of educational literatures on how students with different characteristics respond to different teaching methods. The ranges of these characteristics include sex, ability, learning style, background knowledge, age and so on. Furthermore, researchers in the area of artificial intelligence in education also have looked at how students of differing ability and background respond to particular systems. Arroyo et al. (2000) is a recent example of this style of work. They categorised students by sex and by level of cognitive development. They wanted to establish how variations in the style of hints in the context of an arithmetic program interacted with sex and with cognitive development. Hints varied on two dimensions: degree of interactivity and the nature of the symbolism used. They looked at the reduction in the number of mistakes on a problem following a hint as one of the dependent variables. They found a number of interaction effects (e.g. that "high cognitive ability students do better with highly symbolic hints while low cognitive ability students do worse with highly symbolic hints"). These and related results should enable the program to make "macroadaptive" (Shute, 1995) changes to its teaching strategy to suit particular sub-groups of students. Despite the wealth of work, it is difficult to derive general guidelines about the differential effect of students' characteristics of sufficient precision and reliability to support the design of machine teachers. However, this methodology offers an interesting avenue for research but in terms of making predictions about how real students will react, it depends crucially on the fidelity of the underlying simulations.

3.1.3 Applying a Learning Theory

This approach starts from a learning theory and derives appropriate teaching tactics and strategies for intelligent tutoring systems from that theory. Learning theories are still being used to inform system design: for example, Constructivism (Akhras and Self, 2000) and Reciprocal Teaching (Chan and Chou, 1997).

3.1.3.1 The Basics of Behaviourism

The theory of behaviourism concentrates on the study of overt behaviours that can be observed and measured (Good & Brophy, 1990). It views the mind as a "black box" in the sense that response to stimuli can be observed quantitatively, totally ignoring the possibility of thought processes occurring in the mind. Some key players

in the development of the behaviourist theory were Pavlov, Watson, Thorndike and Skinner. Our work does not intend to make use of behaviourism since we are interested in the thought processes of the learner.

3.1.3.2 The Basics of Cognitivism

Cognitive theorists view learning as involving the acquisition or reorganization of the cognitive structures through which humans process and store information (Good and Brophy, 1990). Amongst other things, our research uses the removal of misunderstandings (or misconceptions) as a measure of effective learning. Guided discovery learning is essentially a cognitivist theory with some elements of social learning.

3.1.3.3 The Basics of Constructivism

"Constructivists believe that learners construct their own reality or at least interpret it based upon their perceptions of experiences, so an individual's knowledge is a function of one's prior experiences, mental structures, and beliefs that are used to interpret objects and events" (Jonassen, 1994). He also proposed that there are eight characteristics that differentiate constructivist-learning environments:

- Constructivist learning environments provide multiple representations of reality. The two primary representations in this thesis are the representation of the business and its functioning and the entity relationship models. There is an intermediate representation that is a kind of supporting for learning through the selection of entities, relations and attributes prior to forming the ER diagrams.

- Multiple representations avoid oversimplification and represent the complexity of the real world. Our work also represents a simulation of the complexity of real world organisation for students to practise instead of using a traditional approach, which is describing organisation in term of formal language.

- Constructivist learning environments emphasize knowledge construction instead of knowledge reproduction.

- Constructivist learning environments emphasize authentic tasks in a meaningful context rather than abstract instruction out of context. We seek to meet this need for authentic tasks through the use of a real world simulation of a business

- Constructivist learning environments provide real-world settings or case-based learning instead of predetermined sequences of instruction. Guided discovery learning is consistent with this view. It is a requirement that the learner can move around the environment in different ways even though it is structured to encourage a sequence of activities

- Constructivist learning environments encourage thoughtful reflection on experience. The process of checking that the model is consistent with the real world simulation requires such thoughtful reflection. Some of the activities may also encourage the learner to reflect on the processes involved.

- Constructivist learning environments facilitates the constructions of context- and content-dependent knowledge.

- Constructivist learning environments support through social negotiation rather than competition between the learners, constructivist learning environments foster collaborative knowledge constructions. Our work does not provide a collaborative learning environment, and this is a feature that could be explored in further research.

3.2 Discovery Learning Theory

Psychological research (Anderson, 1993) argues that knowledge acquired from discovery learning is been retained for longer than knowledge gained from direct instruction. Discovery learning, influenced by Jerome Bruner (1961),uses Cognitive psychology as a foundation. Discovery learning is "an approach to instruction through which students interact with their environment by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments" (Ormerod,

1995). The belief is that students are more likely to remember concepts they discover on their own.

Discovery learning is most noticeable in problem solving situations. The learner calls on past experience and prior knowledge to discover new information or skills. It is a personal, internal, constructivist-style learning environment. "Emphasis on discovery in learning has precisely the effect on the learner of leading him to be a constructionist, to organize what he is encountering in a manner not only designed to discover regularity and relatedness, but also to avoid the kind of information drift that fails to keep account of the uses to which information might have to be put" (Bruner, 1961).

Teachers have found that discovery learning is most successful when students have prerequisite knowledge and undergo some structured experiences (Roblyer, Edwards, and Havriluk, 1997). The approach has been divided into three categories (Mosston, 1972): Guided Discovery, Problem Solving, and the Individual Learner-Designed Program.

However, it is very difficult for learners to discover the knowledge by themselves. Guidance, therefore, is an important strategy for assisting learners to discover knowledge. In addition, modern technology can now provide a virtual environment for students to explore. Simulations are also another area where computer technology can support discovery learning.

3.3 Review of Guided Discovery Tutoring

The area of artificial intelligence and education (AIED) has existed since the early 1970s. A number of researchers have produced a variety of intelligent tutoring systems (ITSs). Self's (1974) paper assumed as its starting point a three component architecture for ITSs - the domain knowledge, the student model, and the tutoring strategy components which are now part of the definition of ITSs.

However, the guided discovery framework (Elsom-Cook, 1990) tries to combine work on intelligent tutoring systems (ITSs) with educational environments. An educational environment (Elsom-Cook, 1990) is a computer-based system that can be manipulated by a student. The environment is designed in such a way that the students can learn about a domain by exploring the environment.

In guided discovery tutoring, Elsom-Cook (1990) introduced "an educational environment as a shared 'world', which is what the student is learning about. All actions upon that world, and all events which occur in that world, must be equally accessible to tutor and student. They must establish a common language for referring to the world, and the tutor must be able to see it in the same way with the student. The interface is the only way in which the learners can operate in the represented world. For the purposes of learning, the interface should be the represented world, which is composed of the domain to be learned. If the interface is designed appropriately, the represented world becomes, cognitively, directly present".

In order to support the idea of guided discovery, "a tutoring system must have a range of available teaching strategies. The dialogue model usually is the medium of interaction. Within a computer-based environment, the dialogue model consists of an overall structure to the guidance provided to the learner and a set of mechanisms or algorithms for generating and sustaining dialogue" (Elsom-Cook, 1990).

Ahmad (1987) studied the effects of solution-oriented and strategy-oriented feedback when using interactive computer-assisted instruction by giving four instructional guided discovery programs with identical instructions about the features of the problems and the relationships between the features. Two of the programs gave instructions for spatial strategies to solve the problems, while the other two gave instructions for solution feedback to solve the problems. The results showed that when learners were instructed on the spatial strategies, strategy feedback was more effective than solution feedback. The ways in which guided discovery learning is implemented encourages the learner to think about processes, which are related to tactics/strategies.

Ippel (1992) presents a framework for understanding conditions of discovery learning in computer-based microworlds. The framework focuses on characteristics of task environments that seem to be necessary for discovery environments. A prototype of the 10-square microworld implemented for a Macintosh SE/30 computer system was used in the experiment, which consisted of a sequence of five microworlds with different sets of constraints and a sixth microworld without constraints. Analyses of the study data indicate that continuing experience with the task turned the process of solving addition problems into a routine action, and that the 10-square microworld was effective in narrowing down the number of student choices. Our work also makes a comparison between a traditional learning environment and guided discovery learning environment for entity relationship modelling.

Boyle & Margetts (1992) developed a computer aided learning environment for teaching Pascal. The CORE approach is a design method for constructing learning environments based on principles derived from studies of language and cognitive development. The method has been applied so far to the design of learning environments for acquiring programming skills. The system was used with groups of students for an extended period of time. The students' assessment of the CORE Pascal learning system as an effective and enjoyable learning environment was very positive. Our work also tries to design a simulation of real world organisation in order to motivate and challenge students instead of using the traditional approach in which organisations are described in term of formal language.

Leutner (1993) studied effects of adaptive and non-adaptive instructional support by developing of an experiment of computer simulation game. The result showed that adaptive advice is more effective than non-adaptive. This means the information provided during interaction with the simulation is more effective than

information provided before the simulation. This result is useful for developing our tutoring system.

Mitrovic (1998) developed a guided discovery-learning environment tutoring system for teaching Structured Query Language (SQL) in the database subject area. The system provides guidance strategies by generating five levels of feedback: positive/negative, error flag, hint, partial solution and complete solution. At the positive/negative feedback level, the message informs the learner whether their solution is correct or not. An error flag message tells the learner about the clause in which the error occurred. A hint-type message provides more information about the type of error. Partial solution feedback displays the correct content of the clause in question. The complete solution shows the correct solution of the current problem. However, the system does not make explicit what are the rules used for guidance or the different strategies used.

Braught and Reed (2001) developed a tutoring system to teach beginning students the basics of computer organisation. The system presents one component of a computer at a time, starting with a simple interactive data path and building incrementally to a full-featured stored program machine. Both of these features make it possible to engage beginning students and effectively convey an understanding of how computers work. The system can also motivate the study of other computing topics such as data representation, assembly language programming, and RISC vs. CISC architectures. Our work also tries to develop a simulation of real world organisation in order to motivate students to learn instead of using the traditional approach which uses formal language in describing organisation.

Brandao (2002) investigated the possibility of designing and constructing a computer-based learning environment presenting the pedagogy and curriculum of

Schoenberg's harmonic teaching method (Schoenberg,1990), which is a method of teaching harmony in music. The results of the study showed that rules and pedagogical principles from Schoenberg's harmonic teaching method could be formalised and are amenable to modelling on a computer. However, the thesis does not make explicit what are the rules used for guidance or the different strategies used.

3.4 Guided Discovery Approach in our System

From the literature, we find a number of previous guided discovery tutoring systems designed around a learning environment that simulates complex real world systems, though no concern was given to facilitating exploration of that real world. However, Elsom-Cook's framework (1990) proposes guided discovery learning in which the learning environment allows exploration because this challenges and engages students in the process of discovery. Therefore, our system was designed to support an exploratory learning environment by applying Batra and Davis (1989) model which divides the process of learning data modelling into three levels: Enterprise level, Identifying level and Representation level. Furthermore, previous guided discovery tutoring systems usually use only solution feedback, which takes place after learners finish their solution, whereas our system tries to combine both solution feedback and strategy feedback, which takes place at every step of the learner's input in order to provide relevant guided messages. A comparison of our system and the previous systems is given in Table 3.1.

Guided Discovery Systems	Learning Environment		Guided strategies	
	Real world Simulation	Exploration Environment	Solution Feedback	Strategy Feedback
Previous Systems	✓	✗	✓	✗
Our System	✓	✓	✓	✓

Table 3.1 The comparison between our system and previous systems

In addition, whereas Elsom-Cook's framework, does not specify detailed strategies, we have designed our system to provide feedback based on various analyses of the situation including: managing the real world, mapping from natural language to data models, understanding the nature of the mistakes/errors/misconceptions that students have. The details of our framework are described in the next chapter.

3.5 Summary

From the review of literature concerning teaching strategies used in ITSs, guided discovery learning theory is chosen as the basis for developing a teaching strategy for entity relationship modelling within a real world context. The guided discovery learning used in this research is an extension of Elsom-Cook's (1990) framework. The framework proposes guided discovery learning as an exploratory learning environment alongside together with strategy feedback. The various guided discovery strategies, therefore, are designed and introduced as a new teaching approach for use within tutoring systems that are developed for teaching entity relationship modelling.

CHAPTER 4

DESIGN OF TUTORING SYSTEMS FOR TEACHING ENTITY RELATIONSHIP MODELLING

From a literature review of the field we identified the following intelligent tutoring systems for teaching Data Modelling : ERM-VLE (Hall & Gordon, 1998a; Hall & Gordon, 1998b; Hall & Gordon, 1998c), COLER (Constantino-Gonzalez & Suthers, 2000; Constantino-Gonzalez, et al., 2001) and KERMIT (Suraweera & Mitrovic, 2001,2004). These ITS represent database requirements in term of a traditional scenario using formal language for describing problems. However, we argue that this traditional scenario is not well suited to representing the situation which occurs in the real world.

Therefore, we introduce a framework for representing database requirements in terms of a simulation of a real world situation (simulation scenario) in which designers have to confront the users' requirements and also have to deal with a variety of documents of a company (Chen, 1983). Furthermore, we also argue that guided discovery learning is an appropriate approach for teaching entity relationship modelling within a simulation scenario since the scenario is suitable for the design of an exploratory environment, which is the important part of guided discovery learning.

In order to evaluate the effectiveness of a traditional scenario, a simulation scenario, and guided discovery learning (GDL) , the approach taken is to build four systems that differ as little as possible except in terms of the type of guidance and the type of scenario. For this, we cannot use existing systems and, therefore, decided to build four tutoring systems called GERM 1, GERM 2, GERM 3, and GERM 4 that incorporate traditional scenario, simulation scenario, and GDL approach within non-intelligent tutoring and intelligent tutoring systems. This allows meaningful comparison between the different tutoring approaches to be drawn. The differences

among the four systems are shown in Figure 4.1 The details of these four systems are described in the following section.

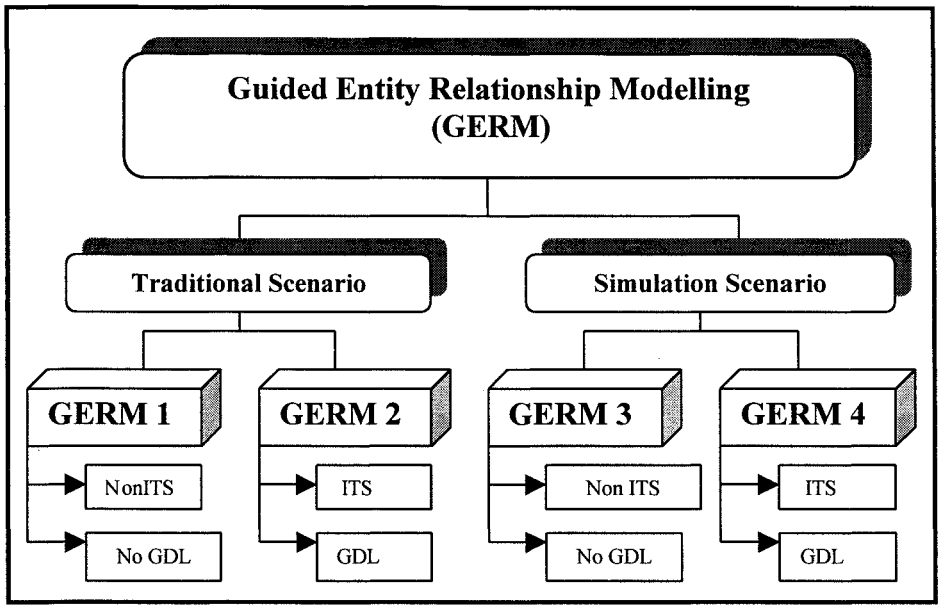


Figure 4.1: The characteristics of the four versions of GERM

4.1 The Design of GERM 1

There are two types of tutoring systems identified in the literature, which were developed for teaching entity relationship modelling, that is, non-intelligent-tutoring systems and intelligent tutoring systems. These tutoring systems usually use the traditional scenario by describing database requirements in terms of formal language. However, we cannot easily use the existing systems from the surveyed literature to evaluate their effectiveness. GERM 1, therefore, was designed for representing non-intelligent-tutoring systems that use the traditional scenario for displaying database requirements and also providing minimal help.

4.1.1 The Architecture of GERM 1

In order to represent non-intelligent-tutoring systems, GERM 1's components were composed of three models: expert model, instructional module, and interface module as shown in Figure 4.2.

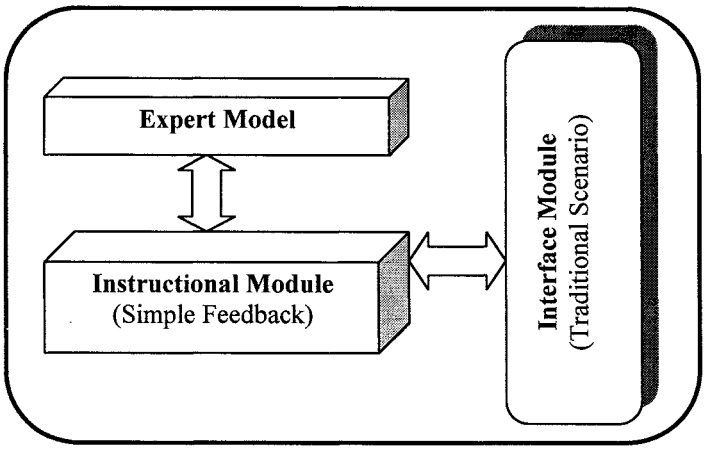


Figure 4.2: The Components of GERM 1

The figure describes main components of GERM1 by focusing on the traditional scenario within the interface module and simple feedback within the intructional module. It also contains arrows that representing the direction of an interation between model and module.

4.1.1.1 Expert Model: According to the characteristic of non-intelligent-tutoring systems, there are two types of solution knowledge database are stored in this model for checking against learner's answers. The first one is the database of the solution about entity types, relationship types, and attributes. The second one is the database of the solution about the correct notations, which are correnpondance to the solution of enity types, relationship types, and attributes.

4.1.1.2 Instructional Module: Because non-intelligent tutoring systems do not focus on the learner in terms of possessing a learner model, the instructional module has been implemented in a simple way. It will receive input data from the learner via the interface model and will compare this with the solution held in the expert model. If the input is the same as the solution, it will provide a simple "Yes" message to indicate the learner is correct. If the input is not the same as the solution, it will provide a "No" message.

4.1.1.3 Interface Module: From the literature we find that the interface screen of tutoring systems for teaching entity relationship modelling typically consists of three panes: the traditional scenario pane, the drawing tool pane, and the drawing space pane sequentially fitting into one screen. The detail of each pane is described as follows:

- **Traditional scenario:** This pane contains a traditional scenario that displays database requirements in formal language. The scenario describes all database requirements of the organisation.
- **Drawing Tool:** This pane contains a number of notations for drawing entity relationship diagram (e.g. the square symbol for representing entity type, connectors, etc.)
- **Drawing Space:** This pane displays only diagrams that learner can draw correctly. If the learner draws it incorrectly, this pane will display nothing.

4.2 The Design of GERM 2

The literature shows that there are two types of tutoring system which have been developed for teaching entity relationship modelling from surveyed literatures: non-intelligent-tutoring systems and intelligent tutoring systems. We have already pointed out that we cannot easily use the existing systems from the surveyed literature to evaluate their effectiveness. Thus, we designed GERM 2 as an intelligent tutoring systems which is different from GERM 1 in that it includes a learner model. However, GERM 2 still uses the traditional scenario for displaying database requirements, which is the same as GERM 1.

4.2.1 The Architecture of GERM 2

In order to represent intelligent tutoring systems, GERM 2 contains four models: expert model, instructional module learner model, and interface module as shown in Figure 4.3.

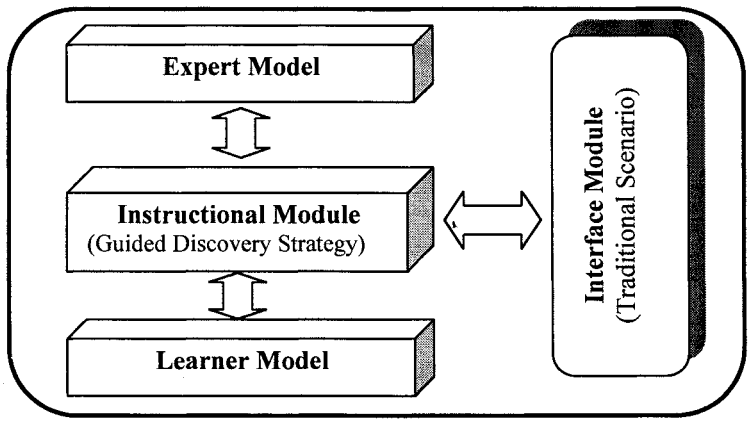


Figure 4.3: The Components of GERM 2

The figure describes main components of GERM2 by focusing on the traditional scenario within the interface module and Guided Discovery Strategy within the intructional module. It also contains arrows that representing the direction of an interation between model and module

4.2.1.1 Expert Model: To enable GERM 2 (which represents the intelligent tutoring systems class) to provide relevant guided messages, a variety of knowledge types are stored in the expert model model. The database for each knowledge type is described as follows:

- **Basic Definition Knowledge:** This database contains the basic definitions for some important objects such as entity type, relationship type, attribute, and primary key etc.
- **Basic Rules Knowledge:** This database contains basic rules for constructing entity types, relationship types, and attribute (e.g. each entity must be uniquely identifiable etc.)
- **Example Knowledge:** This database contains some common examples of entity types, relationship types and attributes within the organisation. For instance, in a university a student is an entity type.
- **Chen's Rules Knowledge** (Chen, 1983): Generally, designing databases entails the translation of data semantics of an application in the real world into a data representation that matches the underlying data model of the database management system (Chen, 1977). The requirements of a database application are usually represented in English. Chen, therefore, proposed some rules for translating English sentences into Entity Relationship Diagrams. For instance, *a common noun* corresponds to an entity type, *a transitive verb* corresponds to a relationship type, and *an adjective* corresponds to attribute etc.

4.2.1.2 Learner Model: This model contains knowledge of the level of knowledge and understanding the learner has about identifying entity types, relationship types, and attributes Descriptions of these levels are given in Tables 4.1 to 4.3 below.

Entity Knowledge Level (EKL)	Learner' knowledge
EKL 0	Learners believe any words can be an Entity Type.
EKL 1	Learners believe any nouns can be an Entity Type.
EKL 2	Learners know what is an Entity Type for the particular company.

Table 4.1: The level of learner's knowledge in identifying entity type

Relationship Knowledge Level (RKL)	Learner' knowledge
RKL 0	Learners believe any words can be a relationship type.
RKL 1	Learners believe any verbs can be a relationship type.
RKL 2	Learners know what is a relationship type for the particular company.

Table 4.2: The level of learner's knowledge in identifying relationship type

Attribute Knowledge Level (AKL)	Learner' knowledge
AKL 0	Learners believe any words can be an attribute.
AKL 1	Learners believe any noun,adjective, adverb can be an attribute.
AKL 2	Learners know what is an attribute for the particular company.

Table 4.3: The level of learner's knowledge in identifying attribute

4.2.1.3 Instructional Model

Before providing a guidance message, the instructional model model has to receive the learner's answer from the interface module and compare it with the level knowledge in the leaner model to ascertain the learner's knowledge level so that an appropriate guidance strategy can be selected. Although, GERM 2 cannot provide an exploration environment, we have developed the guidance strategies as shown in Table 4.4 – 4.6 as follows.

Entity Knowledge Level (EKL) Current Level → Target Level	Guidance Strategy
EKL 0 → EKL 1	Giving some messages that make leaner focuses on nouns.
EKL 1 → EKL 2	Giving a definition of an entity type and examples of an entity type.

Table 4.4: Guidance strategy in identifying entity type

Relationship Knowledge Level (RKL) Current Level → Target Level	Guidance Strategy
RKL 0 → RKL 1	Giving some messages that make leaner focuses on verbs.
RKL 1 → RKL 2	Providing a definition of a relationship type and examples of a relationship type.

Table 4.5: Guidance strategy in identifying relationship type

Attribute Knowledge Level (AKL) Current Level → Target Level	Guidance Strategy
AKL 0 → AKL 1	Giving some messages that make leaner focuses on adjectives.
AKL 1 → AKL 2	Providing a definition of an attribute and examples of an attribute.

Table 4.6: Guidance strategy in identifying attribute

4.2.1.4 Interface Module: In order to compare the effectiveness between non-ITS and ITS with the traditional scenario, the interface of GERM 2 is the same as GERM1 i.e. the traditional scenario pane, the drawing tool pane, and the drawing space pane sequentially fitting into one screen. The detail of each pane has already described in section 4.1.1.3.

4.3 The Design of GERM 3

The literature has shown that intelligent and non-intelligent tutoring systems for teaching entity relationship modelling usually use the traditional scenario for representing database requirements. However, we argue that the traditional scenario cannot represent some real world situations. Thus, GERM 3 was designed as a non-intelligent-tutoring system that uses a the simulation scenario (Chapter 2) for displaying database requirements and providing only simple feedback for support learners. This allows comparison with GERM1 and GERM2 which use traditional scenarios.

4.3.1 The Architecture of GERM 3

GERM 3 comprises three models: expert model, instructional module, and interface module as shown in Figure 4.4.

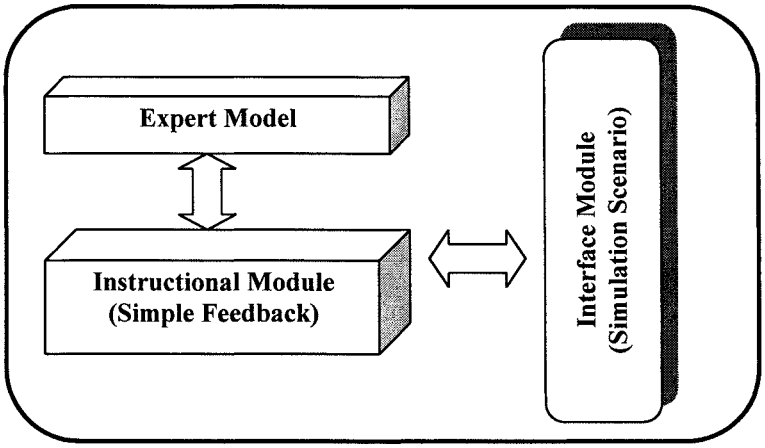


Figure 4.4: The Components of GERM 3
The figure describes main components of GERM3 by focusing on the simulation scenario within the interface module and simple feedback within the intructional module. It also contains arrows that representing the direction of an interation between model and module.

4.3.1.1 Expert Model: GERM3 is a non-intelligent-tutoring system so the expert model consists of two types of solution database for checking the learner's input. The first one is the database of some correct words from the simulation scenario that correspond to an entity type, a relationship type, and an attribute. The second one is the solution for the correct entity relationship diagram.

4.3.1.2 Instructional Module: This module receives the learner's solutions from the interface model and compares them against the solution from expert model. If the input is the same as the solution, it will provide a simple "Yes, you are right " message. If the input is not the same as the solution, it will provide a simple message "No, you are wrong".

4.1.3.3 Interface Model: The database requirements in a real world situation (such as a company) are not always readily available in a form that can be used by students in a classroom environment. The requirements may be also distributed across many sources such as users, documents etc. This model, therefore, attempts to simulate a real world organisation. Moreover, the learning environment is designed in such a way that the students can learn about the domain through an exploration environment

(Elsom-Cook, 1990) by applying the Model of Conceptual Design (Batra. and Davis, 1989). This model divides the stages of learning into three layers: Enterprise layer, Identifying layer and Representation layer.

- **Enterprise level:** At this level, students will read, contemplate, comment, elicit user requirements, seek clarification, or establish connections. The objective of this enterprise phase is to develop a reasonable understanding of the application domain. The learning goal for the student's exploration within this level, therefore, is guiding students to discover information that will be useful for designing the database.
- **Identifying level:** At this level, learners would concentrate on some specific aspect of the user requirements and try to understand the application problem in more details. Learners might construct their knowledge structure for solving the problem. As a result, learners have to employ their knowledge of semantic rules for transforming information in the real world application domain into a data model in terms of Entity, Relationship and Attribute. Thus, the learning goal for the sexploration at this level is to guide the learner to discover how to identify entity type, relationship and attribute.
- **Representation level:** At this level, learners will focus on gathering complete information and the justification to construct a conceptual data representation or diagram. Thus, the learning goal at this level is for the learner to discover how to draw an entity relationship diagram.

However, although there are three levels helping to structure the exploration of the learning environment, GERM3's environment allows the student to move between the three levels at will, with guidance being provided by the system.

4.4 The Design of GERM 4

GERM1 (non-intelligent) and GERM2 (intelligent) used a traditional scenario and GERM3 provided a simulation scenario within a non-intelligent-tutoring system environment, Therefore, GERM4 was designed as an intelligent tutoring system with a simulation scenario providing guidance messages for supporting learners.

4.4.1 The Architecture of GERM 4

In order to represent intelligent tutoring systems, GERM 4's components were composed of four models: expert model, instructional module, learner model, and interface module as shown in Figure 4.5. The figure also contains arrows that representing the direction of an interation between model and module.

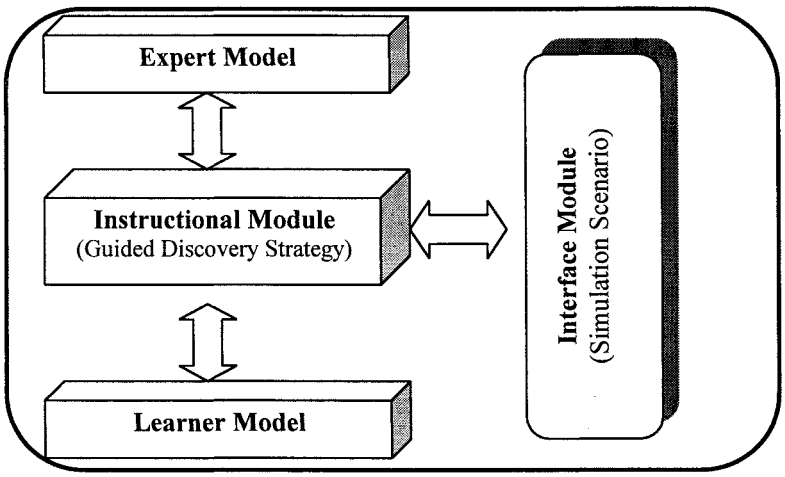


Figure 4.5: The Components of GERM 4
The figure describes main components of GERM4 by focusing on the simulation scenario within the interface module and guided discovery strategy within the intructional module. It also contains arrowsthat representing the direction of an interation between model and module

4.4.1.1 Expert Model: In order that GERM 4 (an intelligent tutoring system with a simulation scenario) can provide relevant guided messages within the simulation of a real world situation, a variety of knowledge types are stored in the expert model. Apart from the knowledge of forms/report, most of components of this model are similar to the expert model of GERM2. The database of knowledge of this model is described as follows:

- **Basic Definition Knowledge:** This database contains the basic definition of some important objects such as entity type, relationship type, attribute, and primary key etc.
- **Basic Rules Knowledge:** This database contains some basic rules about entity type, relationship type, or attribute. For instance, each entity must be uniquely identifiable etc.
- **Example Knowledge:** This database contains some common examples of entity type, relationship type or attribute within organisation. For instance, student is an entity type for university.
- **Chen's Rules Knowledge** (Chen, 1983): Generally, database design task entails the translation of data semantics of an application in the real world into a data representation that matches the underlying data model of the database management system (Chen, 1977). The requirements of database application are usually represented in English. Chen, therefore, proposed some rules for translating English sentence into Entity Relationship Diagram. For instance, *a common noun* corresponds to an entity type, *a transitive verb* corresponds to a relationship type, and *an adjective* corresponds to attribute etc.
- **Form/Report Rules Knowledge** (Choobineh, et al., 1988): The most common use of forms/reports is as an input to the process of constructing an entity relationship model (Chen, 1976). Generally, a form/report consists of a title, form fields, and blank spaces or slots for accepting and displaying data values of form fields. When a blank form is filled with data values, it is a form instance. This database contains some rules for translating elements of forms/reports into an entity relationship diagram. For instance, *the title of form/report* might be an entity type, and *any field* within forms/reports might be an attribute etc.

4.4.1.2 Learner Model: The learner model contains knowledge of the level of knowledge and understanding the learner has abouy identifying entity types, relationship types, and attributes. Because the simulation scenario can represent entity instances, relationship instances and attribute values, the model had to extend the three knowledge levels from GERM2 into four levels as shown in Figure 4.7 – 4.9.

Entity Knowledge Level (EKL)	Learner' knowledge
EKL 0	Learners believe any words can be an Entity Type.
EKL 1	Learners believe any nouns can be an Entity Type.
EKL 2	Learners believe an Entity Instance is an Entity Type.
EKL 3	Learners know what is an Entity Type for the particular company.

Table 4.7: The level of learner's knowledge in identifying entity type

Relationship Knowledge Level (RKL)	Learner' knowledge
RKL 0	Learners believe any words can be a relationship type.
RKL 1	Learners believe any verbs can be a relationship type.
RKL 2	Learners believe a relationship instance is a relationship type.
RKL 3	Learners know what is a relationship type for the particular company.

Table 4.8: The level of learner's knowledge in identifying relationship type

Attribute Knowledge Level (AKL)	Learner' knowledge
AKL 0	Learners believe any words can be an attribute.
AKL 1	Learners believe any noun,adjective, adverb can be an attribute.
AKL 2	Learners believe a value of attribute is an attribute.
AKL 3	Learners know what is an attribute for the particular company.

Table 4.9: The level of learner's knowledge in identifying attribute

4.4.1.3 Instructional Module: Because GERM 4 uses a simulation scenario which can represent entity instances, relationship instances, and attribute values, the instructional model has to extend the GERM2 instructional strategy in order to guide a learner who has misconception between entity instance vs. entity type etc.The detail of the strategies is given in Table 4.10 – 4.12 below.

Entity Knowledge Level (EKL) Current Level → Target Level	Guidance Strategy
EKL 0 → EKL 1	Giving some messages that make learner focuses on nouns.
EKL 1 → EKL 2	Giving a definition of an entity type and examples of an entity type.
EKL 2 → EKL 3	Providing learners some messages that make them know what different between an entity type and an entity instance.

Table 4.10: Guidance strategy in identifying entity type

Relationship Knowledge Level (RKL) Current Level → Target Level	Guidance Strategy
RKL 0 → RKL 1	Giving some messages that make learner focuses on verbs.
RKL 1 → RKL 2	Providing a definition of a relationship type and examples of a relationship type.
RKL 2 → RKL 3	Providing learners some messages that make them know what different between a relationship type and a relationship instance.

Table 4.11: Guidance strategy in identifying relationship type

Attribute Knowledge Level (AKL) Current Level → Target Level	Guidance Strategy
AKL 0 → AKL 1	Giving some messages that make learner focuses on adjectives.
AKL 1 → AKL 2	Providing a definition of an attribute and examples of an attribute.
AKL 2 → AKL 3	Providing learners some messages that make them know what different between an attribute and a value of attribute.

Table 4.12: Guidance strategy in identifying attribute

4.4.1.4 Interface Model: In order to make some comparison between non-ITS and ITS within a simulation scenario environment, the interface model of GERM4 had to be the same as the interface model of GERM3, which comprises of three layers: enterprise, identifying, and representation.

4.5 Summary

We developed four tutoring systems called GERM 1, GERM 2, GERM 3, and GERM 4 in order to use them to evaluate the effectiveness of traditional scenario, simulation scenario, and guided discovery learning (GDL) approach and answer our research questions. The details of four versions of GERM are described in Table 4.13 as follows.

Version	Requirement Scenario	Pedagogical Strategies
GERM 1	Traditional Scenario	Simple feedback (Yes/No)
GERM 2	Traditional Scenario	Guided Discovery Strategy
GERM 3	Simulation Scenario	Simple feedback (Yes/No)
GERM 4	Simulation Scenario	Guided Discovery Strategy

Table 4.13 The summary of four versions of GERMs

CHAPTER 5
IMPLEMENTING OF TUTORING SYSTEMS FOR TEACHING ENTITY RELATIONSHIP MODELLING

In order to evaluate the effectiveness of the simulation scenario and guided discovery strategies, four versions of Guided Entity Relationship Modelling (GERM) Tutoring Systems were developed by using Microsoft Visual Basic and Microsoft Agent. The two scenarios (traditional and simulation) are the basis of these four versions - each being supplemented with either guided discovery or a much simpler help system. The previous chapter explained the rationale and architecture of all four systems; because the four GERM systems themselves are an important part of the contribution of this work this chapter discusses their implementation in more detail.

5.1 GERM 1

In Chapter 4, we described the design architecture of GERM 1 which consisted of three models, i.e., the interface model, expert model, and pedagogical model. This section explains the implementation details.

5.1.1 Interface of GERM 1

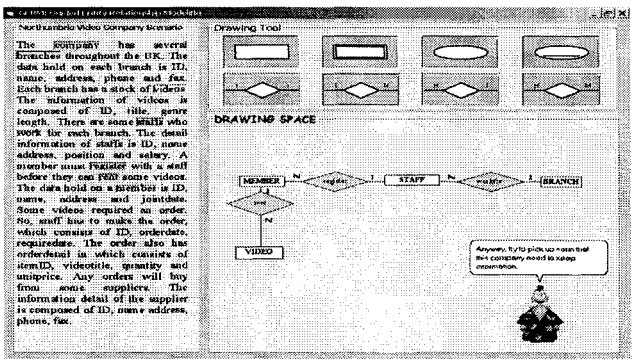


Figure 5.1: The interface of GERM 1

Existing database tutoring systems (such as ERM-VLE, COLER, and KERMIT) which use a traditional scenario generally have their interfaces organised as four main areas: scenario area, tool area, drawing space, and instruction area. This practice has been adopted for the GERM 1 system, as shown in Figure 5.1.

5.1.1.1 Scenario Area

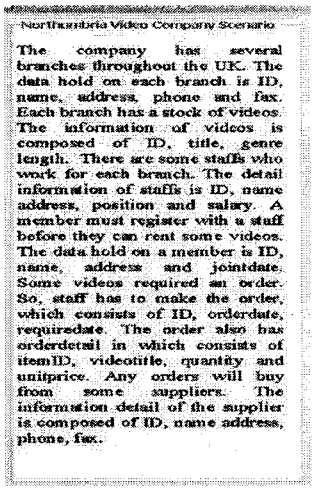


Figure 5.2 Scenario Area

The scenario area displays the database requirement scenario in the same way as is used in a traditional approach. The requirements of the organisation have already been gathered and described formal language. In order to avoid the difficulty of domain application, we selected a Video Company as a case study because it is quite common and learners can imagine the company scenario quite easily.

5.1.1.2 Drawing Tool Area

Within the drawing tool area (see Figure 5.3) we provided eight basic notations: strong entity type, weak entity type, attribute, primary key, one-to-one, one-to-many, many-to-one, and many-to-many. Even though there are more than eight notations in entity relationship diagram, we selected only the basic notations, which are sufficient for constructing an entity relationship diagram for the video company scenario.

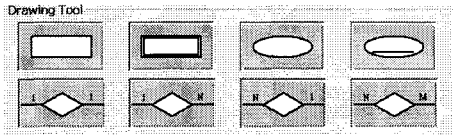


Figure 5.3 Drawing Tool

5.1.1.3 Drawing Space Area

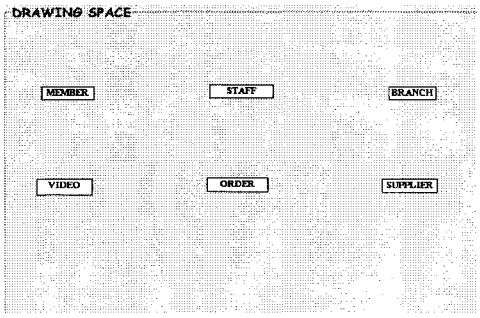


Figure 5.4 Drawing Space Area

The drawing space area displays the entity relationship diagram being constructed by the learner. For instance, figure 5.4 shows a drawing space in which the learner can construct –corrected six entity types (Member, Staff, Branch, Video, Order, and Supplier).

5.1.1.4 Instruction Area

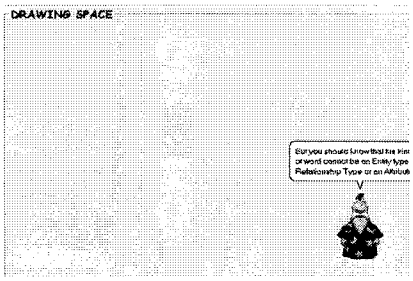


Figure 5.5 Instruction Area

User feedback is provided within the drawing space area. We selected the Microsoft Agent character Merlin, to be a tutor giving pedagogical feedback. The Merlin tutor (Figure 5.5) can give instructions both textually and as synthesized speech. Merlin is not restricted to being displayed in the drawing space area and the learner can move him to any area of the screen. Moreover, learners also can stop the help from Merlin at any time.

5.1.2 Learner's interaction

First of all Merlin introduces the learner to the GERM1 program and how it works. There are three stages to the interaction. The learner begins by using the scenario area, then the drawing tool area, and last the drawing space area.

- **Scenario Area**

  In the scenario area, learners have to read through the scenario and pick up any words they think are important for the organisation to store in the database system (that is, they are identifying entity types, a relationship types, and attributes). To mark a word for selection the user simply clicks on it. For instance, *branches* has been marked in Figure 5.1 because the learner selected it as an important object. At this stage, if learner selects a correct word Merlin will give positive feedback. However, Merlin will provide negative feedback if he or she clicks on an incorrect word.

- **Drawing Tool Area**

  After selecting a word (e.g. *branches*), the learner has to choose a relevant notation in the drawing tool area. At this stage, if the learner selects the right notation,

Merlin will give positive feedback. Again, negative feedback will be given if the wrong notation is selected.

- **Drawing Space Area**

After choosing a correct notation from the previous area, learner has to click on the drawing space area to draw the diagram. For example, after selecting the right notation for *branch* and clicking at the drawing tool area, a diagram containing an entity type of *branch* entity type is drawn (see Figure 5.4).

5.1.3 Pedagogical Strategies for GERM 1

GERM 1 does not employ a guidance strategy in teaching learners. It just provides very simple feedback e.g. "Yes" which means you were right and "No" which means you were wrong.

5.2 GERM 2

Just like GERM 1, the GERM 2 system represents the database requirements using a traditional scenario. The interface and the interaction of GERM 2, therefore, are the same as GERM 1. However, unlike GERM1 (which is a non-intelligent tutoring system), GERM2 is an intelligent tutoring system. Thus, GERM2's teaching strategy is quite different from that of GERM1.

5.2.1 Pedagogical Strategies of GERM 2

GERM 2 employs a guidance strategy (Elsom-Cook, 1990) for teaching learners. The strategy tries to guide students to discover knowledge about data modelling with entity relationship diagrams. There are three guidance actions in this tutoring system: action in identifying entity types, action in identifying relationship types, and action in identifying attributes, which are described as follows.

5.2.1.1 Guidance Action in identifying Entity Type

Learner's Actions/ (Knowledge Level)	GERM 2'SAction 1 Using strategy 1 (E)	GERM 2'SAction 2 Using strategy 2 (E)
Selecting any word types e.g. article, preposition etc but not noun and followed by clicking at the entity type notation **(EKL 0)**	Providing messages that make learners realise that these kinds of words cannot be Entity type.	Providing guidance messages that make learners focus on noun.
Selecting noun but it is not an entity type and following by clicking at the entity type notation **(EKL 1)**	Providing the messages that make learners aware that not every noun can be an entity.	- Providing the definition - Providing examples. - Providing some rules.

Table 5.1 guidance action in identifying entity type

5.2.1.2 Guidance Action in identifying Relationship Type

Learner's Actions/ (Knowledge Level)	GERM 2'sAction 1 Using strategy 1 (R)	GERM 2'sAction 2 Using strategy 2 (R)
Selecting any word types e.g. preposition, article etc but not verb and followed by clicking at the relationship notation **(RKL 0)**	Providing the messages that make learners realise that these kinds of words cannot be relationship type.	Providing the guidance messages that make learners are focusing on verb.
Selecting verb but it is not a relationship type and followed by clicking at the relationship notation **(RKL 1)**	Providing the messages that make learners aware that not every verb can be a relationship type.	- Providing the definition - Providing examples. - Providing some rules

Table 5.2 guidance action in identifying relationship type

5.2.1.3 Guidance Action in identifying Attributes

Learner's Action/ (Knowledge Level)	GERM 2s' Action 1 Using strategy 1(A)	GERM 2s' Action 2 Using strategy 2 (A)
Selecting any word types but not noun, not adjective, and not adverb. And following by clicking at attribute notation (**AKL 0**)	Providing the messages that make learners realise that these kinds of words cannot be attribute.	Providing the messages that make learners are focusing on noun, adjective, or adverb.
Selecting noun but it is not an attribute. And following by clicking at attribute notation (**AKL 1**)	Providing the messages that make learners aware that not every noun can be an attribute.	- Providing the definition - Providing examples. - Providing some rules
Selecting adjective but it is not an attribute. And following by clicking at attribute notation (**AKL 1**)	Providing the messages that make learners aware that not every adjective can be an attribute.	- Providing the definition - Providing examples. - Providing some rules
Selecting adverb but it is not an attribute. And following by clicking at attribute notation (**AKL 1**)	Providing the messages that make learners aware that not every adverb can be an attribute.	- Providing the definition - Providing examples. - Providing some rules

Table 5.3 guidance action in identifying attribute type

5.3 GERM 3

Like GERM 1, the GERM 3 system is a non-intelligent tutoring system. However, rather than using a traditional formal approach, GERM 3 represents the database requirements in using a real world simulation (simulation scenario).

5.3.1 The Interface of GERM 3

In order to design an exploratory learning environment (Elsom-Cook, 1990) for simulating a real world scenario, we applied a Model of Conceptual Database Design (Batra & Davis, 1989) by separating the interface of the system into three layers: enterprise, identifying, and representation. The details of each layer are described below.

5.3.1.1 Interface of Enterprise Layer

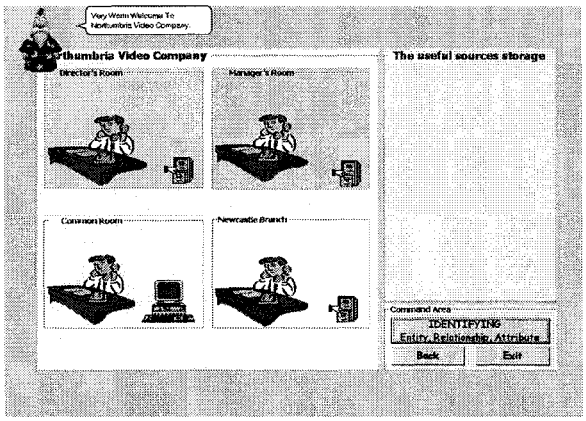


Figure 5.6 Interface of Enterprise Layer

At the enterprise layer, a simulation of a real world video company is used to present the database requirements. The enterprise layer, therefore, provides both relevant and non-relevant informationn to help students to learn how to select the right sources for designing the database. In order to support the learning objective, we separated this layer into four main areas: *Requirement Sources*, *Collecting Storage*, *Command*, and *Instruction*, which will be described in more detail below.

5.3.1.1.1 Requirement Sources Area

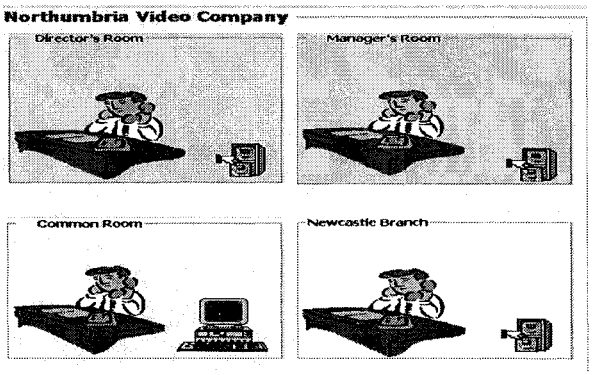
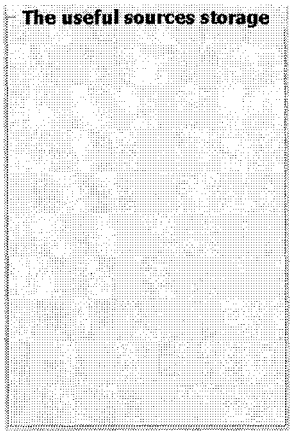


Figure 5.7 Requirement Sources Area

In the requirement sources area, we apply the framework of database requirements in a real world situation to design the simulation of a real world scenario. We provide database requirements from two types of sources: users and documents.

- **Simulation of Users' Requirements:** We simulated three levels of users' requirements: Director, Manager, and two operations staff by presenting pictures of them as shown in Figure 5.7. When the learner clicks on picture to select a source, the source tells its requirements using informal language, much like what happens in the real world. Therefore, learners can consider the users' requirements by listening to all the information before making a decision about what requirements to collect.
- **Simulation of Document System:** We provided three levels of a document system alongside each level of users by using a filing cabinet to represent the storage of documents (see Figure 5.7). When the learner clicks on a chosen cabinet many documents are displated. They can then open each document from the list to see whether or not it is relevant to the database system before making a decision to collect it.

5.3.1.1.2 Collecting Storage Area



After deciding which requirements to select from the sources, the learner can collect them in the collecting storage area (see Figure 5.8). They can then transfer these sources to the next step: identifying layer, which lets them consider each source in more detail in order to identify the entity types, relationship types, and attribute.

Figure 5.8 The collecting sources storage Area

5.3.1.1.3 Command Button Area

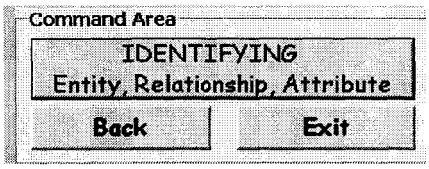


Figure 5.9 Command Button Area

To enable effective navigation three command buttons are provided: Identifying, Back, and Exit, which are described in more detail as follows.

- **Identifying Button:** After gathering requirement sources, learners can move to the identifying step by clicking the *identifying* button. All of their chosen sources will

move to the next screen ready to open for identifying the entity types, relationship types, and attributes.

- **Back Button:** The *back* button allows the learner to switch to another case study. When clicking this button, the system displays a list of available simulation case studies from which the student can choose. (However, in its current implementation the system only has one case study built into it).
- **Exit Button:** The *exit* button is pressed when the learner wants to leave the system.

5.3.1.1.4 Instruction Area

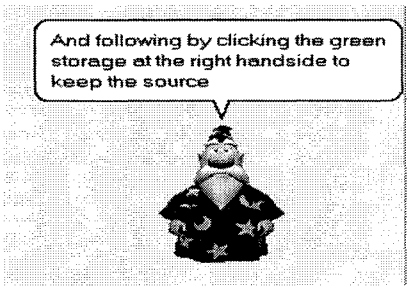


Figure 5.10 Instruction Area

Actually, there is no dedicated instruction area. Instead, feedback is provided by the Merlin character (Figure 5.10) in collecting storage are (Figure 5.8). Merlin (one of the characters in Microsoft Agent) acts as a tutor who gives feedback to the learner. Merlin can provides feedback both textually and as spoken language. The learners can move Merlin to any area of the screen or turn him off at any time.

5.3.1.2 Identifying Layer Interface

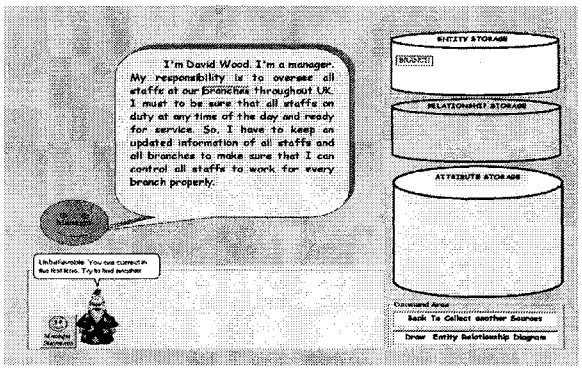


Figure 5.11 Interface of identifying layer

In the identifying layer, learners can click to open the statements of directors and managers or any forms/reports etc. Merlin will help the learners to discover the right entity types, relationship types and attributes by giving guidance messages. However, learners can move back to the enterprise layer for collecting more useful sources if needed. The components of this layer are described below.

5.3.1.2.1 Transfer Requirement Sources Area

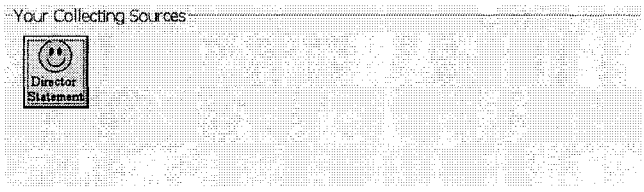


Figure 5.12 Transfer Requirement Sources

The requirement sources that learners collect from the enterprise layer are transferred to the transfer-requirement-sources area for the learner to pick up entity types, relationship types, and attributes.

5.3.1.2.2 Scenario Area: The scenario area was developed to display the requirement scenario for students to learn how to identify entity types, relationship types, and attributes. For instance, Figure 5.13 shows what is displayed when the learner opens a director statement; Figure 5.14 shows what is displayed when a staff registration formis chosen.

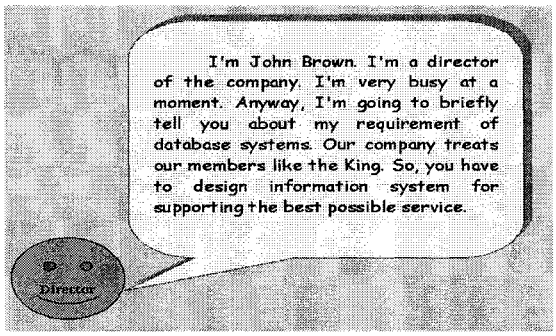


Figure 5.13 Scenario of user requirement

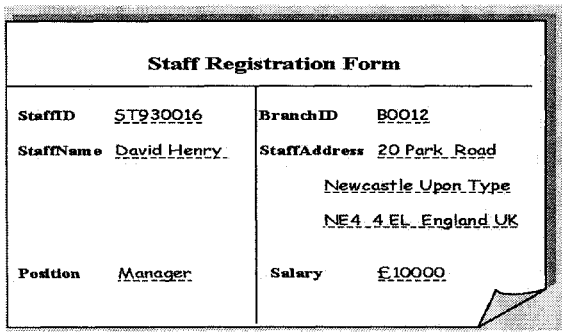


Figure 5.14 Scenario of report and form

5.3.1.2.3 Storage Area

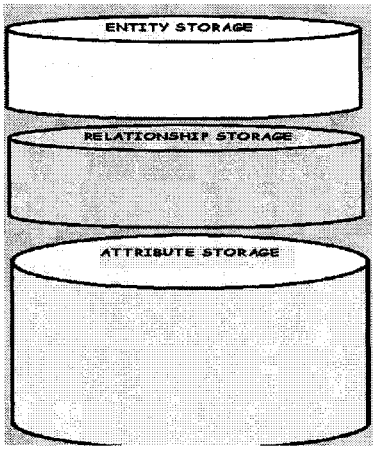


Figure 5.15 Storage Area

The storage area consists of entity type storage, relationship type storage, and attribute storage. Each storage serves for student to collect the right objects (entity type, relationship type, and attribute).

5.3.1.2.4 Instruction Area

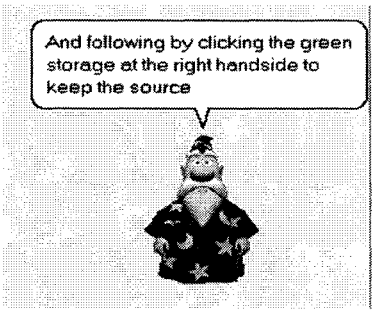


Figure 5.16 Instruction

As before, instruction and guidance is provided by the moveable Merlin character. Feedback at this layer is focused on guiding the learner towards learning how to identify entity types, relationship types and attributes correctly.

5.3.1.2.5 Command Button Area

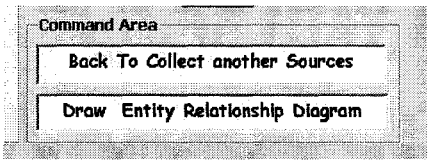


Figure 5.16 Command Button

There are two command buttons in this layer. The top button in Figure 5.16 takes the learner back to the enterprise layer to collect more requirements sources. The bottom button lets the learner move to the next layer for constructing an entity relationship diagram.

5.3.1.3 Interface of Representation Layer

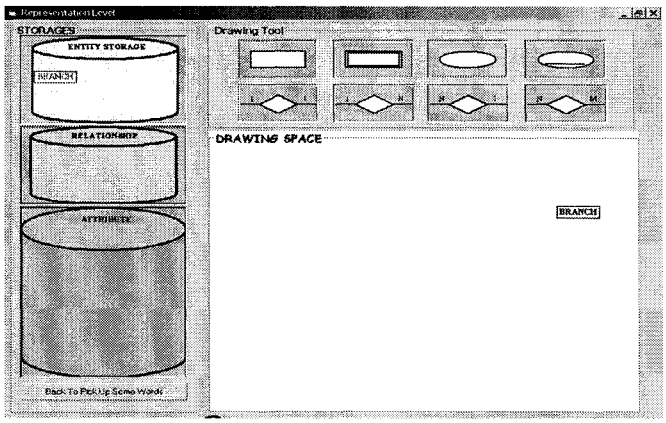


Figure 5.17 Interface of Representation Layer

At this layer, the entity types, relationship types, and attributes from the identifying layer will be transferred to a storage area related to the storage area from the previous layer. Learners can then construct an Entity Relationship Diagram (ERD) within this layer. This layer has been separated into four areas as follows.

5.3.1.3.1 Collecting Object Area

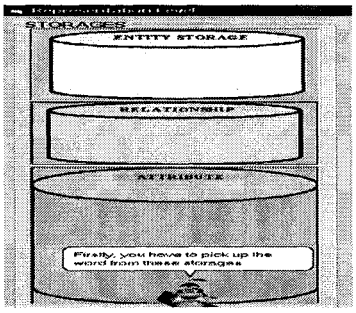


Figure 5.18 Collecting Object

This area contains the objects that the learner has brought over from the identifying layer. The learner can then click on any object to construct an entity relationship diagram.

5.3.1.3.2 Drawing Tool Area

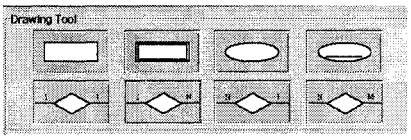


Figure 5.19 Drawing Tool

The drawing tools of this layer of GERM 3 are the same as GERM 1 and 2, which provide eight notations for learner to construct entity relationship diagram.

5.3.1.3.3 Drawing Space Area

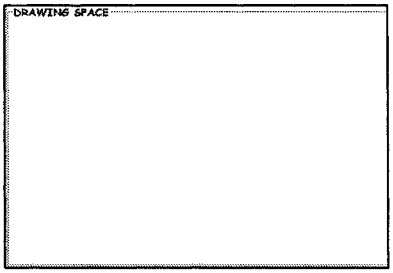


Figure 5.20 Drawing Space

The drawing space area displays the entity relationship diagram being constructed by the learner.

5.3.1.3.4 Instruction Area

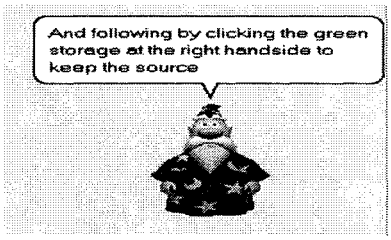


Figure 5.21 Instruction Area

The instruction area of this layer is generally the same as the previous layer. The instructions, however, are focused on guiding the learner towards being able to draw an entity relationship diagram.

5.3.2 Learner's Interaction of GERM 3

5.3.2.1 Learner's Interaction within Enterprise Layer

The interface of the enterprise layer provides a variety of requirement sources such as users' statements and documents for learners to consider and collect into the storage area sources. When they think they have collected enough sources to identify the entity types, relationship types, and attributes, the learner can then click on the identifying buttons to move to the identifying layer, which is described in the next section.

5.3.2.2 Learner's Interaction within Identifying Layer

At the identifying layer, the requirement sources that learners collected from the enterprise layer will transfer into the collecting sources area. Learners can click to open the sources. They can then select any words by clicking. The selected word will be marked. After that they have to choose the relevant storage by clicking. If it is a correct object, it will display on the storage. If it is wrong Merlin will give simple negative feedback. For instance, when learners pick up *branch* and choose the entity storage area, this is the correct answer. Thus, the *branch* entity type is displayed in the entity storage area as shown in Figure 5.11.

5.3.2.3 Learner's Interaction within Representation Layer

The representation layer serves to assist the learner in constructing an entity relationship diagram. Thus, learner has to pick up the object within the storage area and select the relevant notation within the drawing tool area. They can then draw the entity relationship diagram by clicking in the drawing space area. Merlin can help them construct the entity relationship diagram by providing information about the different notations that can be used.

5.3.3 Pedagogical Strategies of GERM 3

GERM 3 gives only simple feedback in all three layers, that is, "Yes" which means you are right and "No" which means you are wrong, for helping students to learn how to construct data modelling using entity relationship diagram.

5.4 GERM 4

Like GERM 3, the GERM 4system represents database the requirements through a real world simulation (simulation scenario). Therefore, the interface and the interaction of the system are the same as GERM 3. However, GERM 4 is an intelligent tutoring system and so its focus is on the learner model and teaching model. The implementation of the pedagogical strategies of this system is described in more detail below.

5.4.1 Pedagogical Strategies:

GERM 4 employs guidance strategies (Elsom-Cook, 1990) for helping students to learn about data modelling through drawing entity relationship diagrams. It uses the same guidance strategies as GERM 2 but the guidance actions are different from GERM 2 because a simulation scenario as opposed to a traditional approach is used. The guidance actions are focused on the identifying layer; for the enterprise and representation layers the system provides only simple feedback. There are three guidance actions in this tutoring system: action in identifying entity type, action in identifying relationship type, and action in identifying attribute, which are described as follows.

5.4.1.1Guidance Action in identifying Entity Type

Learner's Actions/ Knowledge Level	GERM 4'SAction 1	GERM 4'SAction 2
	Using strategy 1 (E)	Using strategy 2 (E)
Selecting any word types e.g. preposition, article etc but not noun and clicking at an entity storage (**EKL 0**)	Providing the messages that make learners realise that these kinds of words can not be Entity type.	Providing the guidance messages that make learners focus on noun.
Selecting noun but it is not an entity type and clicking at the entity type storage (**EKL 1**)	Providing the messages that make learners aware that not every noun can be an entity.	- Providing the definition - Providing examples. - Providing some rules. - Guidance to the title of Forms/Report.
Selecting an instance of entity and following by clicking at the entity type storage (**EKL 2**)	Providing the messages that make learners know that the instance is one member of an entity type.	Providing the messages that make learners realise that the entity type should be a set of instances.

Table 5.4 guidance action in identifying entity type

5.4.1.2 Guidance Action in identifying Relationship Type

Learner's Actions/ Knowledge Level	GERM 4'sAction 1 Using strategy 1 (R)	GERM 4'sAction 2 Using strategy 2 (R)
Selecting any word types e.g. preposition, article etc but not verb and following by clicking at the relationship type storage (**RKL 0**)	Providing the messages that make learners realise that these kinds of words cannot be relationship type.	Providing the guidance messages that make learners are focusing on verb.
Selecting verb but it is not a relationship type and following by clicking at the relationship type storage (**RKL 1**)	Providing the messages that make learners aware that not every verb can be a relationship type.	- Providing the definition - Providing examples. - Providing some rules Guidance to some verbs at Forms/Report.
Selecting an instance of relationship type and following by clicking at the relationship type storage (**RKL 2**)	Providing the messages that make learners know that the instance is one member of a relationship type.	Providing the messages that make learners realise that the relationship type should be a set of instances.

Table 5.5 guidance action in identifying relationship type

5.4.1.3 Guidance Action in identifying Attributes

Learner's Action/ Knowledge Level	GERM 4'sAction 1 Using strategy 1 (A)	GERM 4'sAction 2 Using strategy 2 (A)
Selecting any type words but not noun, not adjective, and not adverb. And following by clicking at attribute storage (**AKL 0**)	Providing the messages that make learners realise that these kinds of words cannot be attribute.	Providing the messages that make learners are focusing on noun, adjective, or adverb.
Selecting noun but it is not an attribute. And following by clicking at attribute storage (**AKL 1**)	Providing the messages that make learners aware that not every noun can be an attribute.	- Providing the definition - Providing examples. - Providing some rules - Guidance to have a look at the field of reports/forms.
Selecting adjective but it is not an attribute. And following by clicking at attribute storage (**AKL 1**)	Providing the messages that make learners aware that not every adjective can be an attribute.	- Providing the definition - Providing examples. - Providing some rules - Guidance to have a look at the field of reports/forms.
Selecting adverb but it is not an attribute. And following by clicking at attribute storage (**AKL 1**)	Providing the messages that make learners aware that not every adverb can be an attribute.	- Providing the definition - Providing examples. - Providing some rules - Guidance to have a look at the field of reports/forms.
Selecting a value of the attribute. And following by clicking at attribute storage (**AKL 2**)	Providing the messages that make learners know that it should be one value of the attribute.	Providing the messages that make learner realise that attribute should be a set of all value.

Table 5.6 guidance action in identifying attribute type

5.5 Summary

In order to evaluate the effectiveness of a simulated of real world scenario and guided discovery strategies, four versions of Guided Entity Relationship Modelling (GERM) had been developed as follows.

- **GERM_1:** This tutoring system represents the database requirements using a traditional scenario (as used in the classroom). Previous tutoring systems for data modelling also take this approach. The program just provides very simple feedback e.g. "Yes" which means you were right and "No" which means you were wrong.

- **GERM_2:** This tutoring system, like GERM 1, also represents the database requirements in formal language. In addition the program employs a guidance strategy (Elsom-Cook, 1990) for teaching learners. The strategy tries to guide students to discover knowledge about data modelling and entity relationship diagrams.

- **GERM_3:** Rather than using the traditional approach of earlier tutoring systems (and GERM 1 & GERM 2), the GERM 3 program uses a simulation of a real world scenario to represent the database requirements. As Chen (1983) identified, this means the database designer is confronted by requirements as stated directly by the users and by a variety of different types of company documents. Like GERM1, this system does not employ a guided discovery strategy and uses only simple feedback, e.g. "Yes" and "No".

- **GERM_4:** Like GERM 3 this program represents the database requirements as a simulation of a real world situation. In addition (like GERM 2), this program also employs a guidance feedback strategy (Elsom-Cook, 1990.

As a result, we can use the four versions of the GERM tutoring system to evaluate the effectiveness of each tutoring system approach (i.e. traditional scenario vs simulation, and guided discovery learning vs. non-intelligent tutoring) to answer the two main research questions mentioned in Chapter 1. As the GERM 1 system takes the same approach as the earlier database tutoring systems identified in the literature (see Chapter 2), it is, in some way, representative of this baseline class of tutoring systems. Because it uses the same interaction approach and case studies as

the other three GERM systems, we are able, therefore, to compare the guided-discovery simulation scenario approach to this baseline class.

CHAPTER 6

EVALUATION OF GERM TUTORING SYSTEMS

6.1 Introduction

In general, the aim of this research is to improve the quality of learning in the area of database design, in particular data modelling using entity relationship diagrams. We argue that the traditional classroom-based teaching approach cannot simulate real world problem situations because of time limitations and the increasingly large number of students involved. Thus, the study focused on developing a framework for simulating real world situations and designing a novel teaching approach which is suitable for such real world scenarios. We also argue that guided discovery learning is an appropriate teaching strategy for real world problem situations. To test these ideas we implemented four prototypes of the Guided Entity Relationship Modelling (GERM) Tutoring System for use in an evaluative study.

The aim of the evaluation of this research is to measure, using the four versions of the GERM Tutoring System, the educational effectiveness of guided discovery learning strategies for simulated real world situations for teaching data modelling using entity relationship diagrams. Therefore, the main research question that concerns us is how well can the GERM Tutoring System improve the quality of learning in data modelling with entity relationship diagrams?

6.2 General Research Questions

In general, learners' knowledge has been categorized into two types: declarative knowledge and procedural knowledge (Anderson, 1995; Papert, 980; Schunk, 1996; Salmoni, Schmidt and Walter, 1984). So, in order to evaluate the educational effectiveness of the GERM Tutoring System and to answer the main research question, these two types of knowledge need to be measured. Consequently, we can specify the following two overarching research questions:

1. To what extent does the GERM Tutoring System (particularly the version which uses a guided discovery approach with a real world simulation scenario) improve students' declarative knowledge in data modelling using entity relationship diagrams?

2. To what extent does the GERM Tutoring System (particularly the version which uses a guided discovery approach with a real world simulation scenario) improves students' procedural knowledge of data modeling using entity relationship diagrams?

6.3 Specific Research Questions

The subject domain of our study (data modelling using entity relationship diagrams), allows us to identify six specific declarative and procedural knowledge categories as follows:

- **Declarative Knowledge:**
    1. Definition knowledge,
    2. Misconception knowledge, and
    3. Notation knowledge.

- **Procedural Knowledge:**
    4. Knowledge of the procedures for identifying three main objects (i.e. entity types, relationship types and attribute types),
    5. nowledge of how to construct entity relationship diagrams within a traditional scenario problem, and
    6. knowledge of how to construct entity relationship diagrams within a simulation of a real world problem scenario.

As a result, in order to answer the two general research questions from the previous section, we can derive six specific research questions for measuring declarative knowledge and procedural knowledge as follows:

1. How does the GERM Tutoring System improve student knowledge in defining entity types, relationship types and attributes?
2. How does the GERM Tutoring System improve student knowledge in terms of reducing their misconceptions about basic concepts?

3. How does the GERM Tutoring System improves student knowledge of the notations used in drawing entity relationship diagrams?
4. How does the GERM Tutoring System improves student knowledge in articulating the procedures for identifying entity types, relationship types and attributes?
5. How does the GERM Tutoring System improves student knowledge in identifying entity types, relationship types and attributes in a traditional scenario problem?
6. How does the GERM Tutoring System improves student knowledge in identifying entity types, relationship types and attributes within a simulation of a real world problem scenario?

6.4 Methodology

From the literature, we can identify two main approaches used to evaluate the effectiveness of tutoring systems in general and learning environments in particular. The first approach is to compare an invented system with a traditional classroom teaching approach. This technique uses pre-tests and post-tests to measure learners' knowledge so that the relative effectiveness of the invented system and the traditional approach (classroom) can be evaluated. Examples of tutoring systems evaluated in this manner are given below.

- Anderson & Corbett (1992) developed the LIPITS intelligent tutoring system for teaching LISP programming. Comparing the learning outcomes from LISPITS and a classroom attendance approach showed that both the experimental group and the classroom group scored equally well on a post-test. However, in terms learning efficiency, the LISPITS learner group took 11.4 hours whereas classroom group took 15 hours.

- Shute & Glaser (1990) created the Smithtown intelligent tutoring system for teaching economics. The results of the evaluation showed that students who used Smithtown could finish faster than classroom group (5 hours vs. 11 hours).

- Lesgold et al (1992) developed the SHERLOCK intelligent training system for training airforce technicians. In this study the ITS learner group solved significantly more problems in the post-test than the classroom learner group. Moreover, the ITS group took 20 hours compared to 25 hours for the conventional training group.

- Meyer et al (1999) created a simulation-based tutor called ISIS for teaching science enquiry skills (generating hypotheses, designing and conducting experiments, drawing conclusion, accepting/rejecting hypotheses). The group that used ISIS generally scored better than the classroom group.
- Suraweera & Mitrovic's (2004) KERMIT intelligent tutoring system was developed for teaching data modelling using entity relationship diagrams by representing database requirements in terms of a traditional scenario (formal language). A study showed that the learners who used KERMIT performed better than the classroom group.

Whilst the comparative study approach allowed the above systems to be evaluated, it is hard to draw general conclusions because of the number of differences between the invented tutoring system itself and classroom. For example, the tutoring systems could support students individually whereas the lecture-style classroom teaching could not.

The second evaluation method identified in the literature is to compare different features of a single learning system (thereby avoiding the problems of comparing a tutoring system with the classroom approach). This approach also uses the pre-test/post-test instruments to measure learners' knowledge. Examples of the tutoring systems that have been evaluated using this approach are discussed below:

- Arroyo et al (1999,2000) developed an intelligent tutoring system called Animal Watch for teaching arithmetic in the context of biology. The system was constructed to allow the effectiveness of symbolic and concrete hint symbolism to be compared and the effectiveness of hint interactivity in learning by doing and learning by being told scenarios to be tested. Actual results from this work are sparse, but it was found that girls do better with interactive hints and learners with high cognitive levels do better with symbolic & interactive hints.

- Luckin et al (2001) investigated the role of narrative in the comprehension of educational interactive media programs by developing a suite of systems called Galapagos which consists of three versions of programs with the same content but different structure, i.e., linear, resource based learning, and guided discovery learning.

Results showed that learners were much more likely to refer back to other sections as they constructed their answers within the resource based learning and guided discovery learning versions, and thus tended to use quotes from the material in their notes, which linear users did not do.

- Ainsworth et al (2002) developed a tutoring system called CENTS to examine the effects of different multiple representational systems in learning primary mathematics by creating three formats of representation, i.e. pictures, maths, and mixed. Results indicated that learners in the pictures-only condition do better on the post-test than the other groups. In addition, learners in the mixed condition did not co-ordinate the picture and mathematical representations.

This evaluation approach, can be very time consuming but allows the researcher to control for a number of learning factors such as one-to-one learning style, the number of modules within tutoring systems, and so forth.

With their KERMIT system Suraweera & Mitrovic (2004) have shown the advantages of using a tutoring system over a classroom environment for a traditional scenario. The aim of our study is to compare the effectiveness of a traditional scenario against a simulation scenario, and a guided discovery approach (intelligent tutoring system) against simple feedback (non-intelligent tutoring system). Therefore, our study will focus on comparing different versions of tutoring systems.

As a result, the second evaluation approach identified above is better suited to our study. Thus four versions of the GERM tutoring system were developed, each version having combinations of teaching and feedback strategies. The pre-test/post-test has been used for the measurement of the learners' knowledge. The questionnaire and interview technique was also used in order to collect qualitative data from lecturers. Thus, we are able to reliably cross check our data between the two data sources: students and lecturers. The details of data collection procedures used are described in the following section.

6.4.1 Instrument

- **The Prototype GERM Tutoring Systems:** To allow cross-system comparisons, four different versions of the GERM Tutoring System were developed with different combinations of the two teaching strategies

(traditional approach and real world simulation approach) and the two feedback strategies (guided discovery learning and simple feedback). A summary of the GERM system combinations is given below in Table 6.1.

Version	Requirement Scenario	Pedagogical Strategies
GERM 1	Traditional Scenario	Simple feedback(Yes/No)
GERM 2	Traditional Scenario	Guided Discovery Strategy
GERM 3	Simulation Scenario	Simple feedback(Yes/No)
GERM 4	Simulation Scenario	Guided Discovery Strategy

Table 6.1: The different versions of the GERM Tutoring System

- **Pre/Post Test Papers:** Pre and post tests were used in order to measure the participants' declarative and procedural knowledge before and after using the GERM systems. The pre/post test paper was divided into two main parts: a declarative knowledge section and and a procedural knowledge section.

A) **Declarative Knowledge Part:** This part of the paper test has been divided into three sections regarding the subject domain and research questions as follows:

➢ **Definition Test:** The definition of some important keywords in the subject domain e.g. Strong Entity Type, Weak Entity Type, Relationship Type, one-to-one Relationship, one-to-many Relationship, many-to-many Relationship, Attribute and Primary key are tested by giving a number of correct/incorrect statements about keywords. Thus, students have to make a decision and write down a ✓ symbol in front of the correct statements or write down a × symbol in front of the incorrect messages. For example, "An entity type is an object that organisations need to keep information."

➢ **Misconception Test:** Learner misconceptions about keywords in the subject domain, i.e., Entity Type vs. Entity Instance, Relationship Type vs. Relationship Instance and Attribute vs. Value will be tested by giving a number of correct/incorrect statements about the keywords.

Again, students have to make a decision and mark a ✓symbol in front of the correct messages and a × symbol in front of the incorrect messages.

- **Notation Test:** Knowledge of notations for representing important keywords (Strong Entity Type, Weak Entity Type, Relationship Type, one-to-one Relationship, one-to-many Relationship, many-to-many Relationship, Attribute and Primary key) are tested by giving a space for students to draw the appropriate notation for a given keyword.

B) **Procedural knowledge part:** In this part, the paper test has been divided into three sections regarding subject domain and research questions as follows:

- **Entity, Relationship and Attribute Identifying Procedure:** This part provides space for students to describe the procedure for identifying entity types, relationship types and attributes.

- **Traditional Scenario Case Study:** This part gives a traditional scenario case study for students to analyse and draw a corresponding entity relationship diagram.

- **Simulation of real world Scenario Case Study:** This part presents a case study a real world simulation scenario for students to analyse and draw a corresponding entity relationship diagram.

- **Lecturers' Questionnaire:**

The aim of the lecturers' questionnaire is to allow cross checking with the learners' pre/post test results. A group lecturers who teaching data modelling with entity relationship diagrams participated in this part of the study.

6.4.2 Selection of Participants

An electronic mail was sent inviting all the students on undergraduate computing courses in the School of Computing, Engineering, and Information Sciences at Northumbria University to volunteer to take part in evaluating the GERM prototype systems. Twelve students volunteered to be participants and they were categorised as follows:

- **Group A:** This group consists of four volunteers who have background knowledge in data modelling with entity relationship diagrams.

- **Group B:** This group consists of four volunteers who have background knowledge in data modelling with object modelling diagrams.

- **Group C:** This group consists of four volunteers who have no background knowledge in data modelling

6.4.3 Procedure

The evaluation was run individually and separately for each participant. An observer was responsible for the preparation of the physical environment for collecting information from each participant. The observer had to ensure that each participant understood all steps of the evaluation procedure clearly. Only one participant from each of the groups A, B, and C worked with each of the four GERM versions. The details of each step in the evaluation are given below.

- **Initial set up:** In this first step, the observer gave important information to participants such as an outline of the evaluation procedure, its duration, and its aims in order to make sure that participants were clear about every aspect of the procedure. Furthermore, the observer gave a chance for participants to ask any questions until they were happy.

- **Collecting Background Information:** The observer handed out background information sheets to the participants on which to record personal information such as surname, sex, course of study etc and also to

outline their background knowledge/experience of data modelling using entity relationship diagrams. The observer also interviewed participants if they did not give the relevant background information.

- **Informed Consent Form:** The observer handed out informed consent form to read and sign to ensure the participants were willing to be volunteers.

- **Pre-Test Process:** Before starting the pre-test, the observer had to be sure that the participants understood all the instructions in the paper test. To do this, some practice questions were asked to check the participants' understanding and also to give them a chance to ask any questions until they were happy before starting the process.

- **Training:** We developed a simple program with the same features as the GERM Tutoring System for participants to practise with before starting work with the real GERM Tutoring systems to ensure that they did not have any usability problems during the formal evaluation process.

- **Starting up Dynamical Cam program:** The Dynamical Cam program catches every single mouse event (together with a time stamp),.thus, the observer can monitor the action of participants and their activity durations after the experiment.

- **Learning GERM Tutoring System:** In this step, the observer gave the participants one hour to use their allocated version of the GERM Tutoring System. The observer also took notes about participants' behaviour during this period.

- **Post-Test Process:** Immediately after finishing the learning session with the GERM Tutoring System, the observer handed out the Post-Test Paper which was identical to the pre-test paper in order to measure knowledge improvement of participants.

6.5 Data Analysis

The correct answers from pre/post test examination results will be calculated into percentage of correct answers. The margin of percentages between the pre- and post-test results, therefore, is a measure of the effectiveness of the learning experience for each topic in paper test.

6.6 Evaluation Result

6.6.1 GERM_1: Guided Entity Relationship Modelling with a traditional scenario and simple feedback

GERM_1 represents the database problem in term of formal language, which is usually used in the classroom and the previous intelligent tutoring systems in teaching Data Modelling Subject such as ERM-VLE (Hall & Gordon, 1998a; Hall & Gordon, 1998b; Hall & Gordon, 1998c), COLER (Constantino-Gonzalez & Suthers, 2000; Constantino-Gonzalez, et al., 2001) and KERMIT (Suraweera & Mitrovic, 2001,2004), also use a formal language for representing the database problem. The program does not employ a guidance strategy in teaching learners. It just provides very simple feedback e.g. "Yes" which means you were right and "No" which means you were wrong.

6.6.1.1 Participant_1: The student who has background knowledge in data modelling through being formulas with Object Oriented Modelling. He has no background knowledge in using Entity Relationship Diagram.

- **Pre-test Result:** The result revealed that student has some background knowledge in the definition such as Entity Type, Relationship Type and Attribute etc. However, he still has some misconception between entity type vs. entity instance and relationship type vs. relationship instance and attribute vs. value. Moreover, the result suggests that he has no background knowledge about notation or symbol in entity relationship diagram. Furthermore, he also cannot describe the procedure for identifying an entity type, a relationship type and an attribute. Nor can he identify an entity type, a relationship type and

attribute from either the traditional case study or simulation of real world case study. The detail of the pre-test result has been shown in Table 6.2.

The knowledge types			GERM 1 & Participant 1		
			Correct	Total	%
Declarative Knowledge	Definition	Strong Entity Type	2	4	50%
		Weak Entity Type	2	4	50%
		Relationship Type	4	4	100%
		One-to-One Relationship	4	4	100%
		One-to-Many Relationship	3	4	75%
		Many-to-Many Relationship	3	4	75%
		Attribute	3	4	75%
		Primary Key	4	4	100%
	Misconception	Entity Type vs. instance	1	4	25%
		Attribute vs. Value	1	4	25%
		Relationship vs. instance	0	4	0%
	Symbol	Entity Type	0	2	0%
		Relationship Type	0	4	0%
		Attribute	0	2	0%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Simulation Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Identifying Procedure	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	4	0%

Table 6.2: Pre-test result of participant 1 before practising GERM 1

- **Participant 1's Action in Learning GERM 1 (Appendix A)**

By contrast with pre-test result, student can identify entity type, relationship type and attribute correctly during his practising of GERM 1. It is mainly because GERM 1 provides a traditional scenario that is quite simple. Therefore, it is likely suggestion that he can apply his background knowledge from Object Oriented Modelling to choose the correct answer.

- **Post-test Result**

After practising GERM 1, he took the post-test examination (Table 6.3). Although he can identify entity type, relationship type and attribute correctly when using GERM_1, he cannot change his misconception. He also cannot identify entity type, relationship type and attribute correctly within the simulation of real world situation. However, he improves his knowledge of notation or symbol and can identify entity type, and attribute within traditional scenario. The comparison of pre-test result and post-test result is shown in Table 6.4.

Knowledge Types			GERM 1 & Participant 1		
			Correct	Total	%
Declarative Knowledge	Definition	Strong Entity Type	3	4	75%
		Weak Entity Type	2	4	50%
		Relationship Type	4	4	100%
		One-to-One Relationship	4	4	100%
		One-to-Many Relationship	3	4	75%
		Many-to-Many Relationship	3	4	75%
		Attribute	3	4	75%
		Primary Key	4	4	100%
	Misconception	Entity Type vs. instance	1	4	25%
		Attribute vs. Value	1	4	25%
		Relationship vs. instance	0	4	0%
	Symbol	Entity Type	2	2	100%
		Relationship Type	4	4	100%
		Attribute	2	2	100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	3	4	75%
		Relationship Type Identifying	1	4	25%
		Attribute Identifying	15	20	75%
	Simulation Scenario	Entity Type Identifying	1	4	25%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	5	20	25%
	Identifying Procedure	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	4	0%

Table 6.3: Post-test result of participant 1 after practising GERM 1

Knowledge Types			GERM 1 & Participant 1		
			Pre-test	Post-test	Margin
Declarative Knowledge	Definition	Strong Entity Type	50%	75%	+25%
		Weak Entity Type	50%	50%	0%
		Relationship Type	100%	100%	N/A
		One-to-One Relationship	100%	100%	N/A
		One-to-Many Relationship	75%	75%	0%
		Many-to-Many Relationship	75%	75%	0%
		Attribute	75%	75%	0%
		Primary Key	100%	100%	N/A
	Misconception	Entity Type vs. instance	25%	25%	0%
		Attribute vs. Value	25%	25%	0%
		Relationship vs. instance	0%	0%	0%
	Notation	Entity Type	0%	100%	+100%
		Relationship Type	0%	100%	+100%
		Attribute	0%	100%	+100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0%	75%	+75%
		Relationship Type Identifying	0%	25%	+25%
		Attribute Identifying	0%	75%	+75%
	Simulation Scenario	Entity Type Identifying	0%	25%	+25%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	25%	+25%
	Identifying Procedure	Entity Type Identifying	0%	0%	0%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	0%	0%

Table 6.4: The pre/post test comparison of participant 1 & GERM 1

- **Summary: GERM_1 & Participant_1**

According to the result of using GERM 1 of participant 1, we can conclude that GERM 1 can improve learner's knowledge in notation of Entity Relationship Diagram and identifying entity type and attribute within a case study of traditional scenario. In term the definition knowledge part, the pre-test examination result reveals that has already have very good background knowledge. The post-test examination, therefore, cannot measure the improvement of the definition knowledge. But the evidence from questionnaire shows that he can improve his knowledge in the

definition of entity type, relationship type, and attribute. However, he cannot improve his knowledge in identifying entity type, relationship type, and attribute within a case study of simulation of real world situation. Moreover, he cannot describe the procedure of identifying entity type, relationship type and attribute.

- **Discussion the Result: GERM_1 & Participant_1**

The participant has background knowledge in data modelling through being formulas with Object Oriented Modelling. When he is practising GERM_1 that provides a tradition scenario, which is very simple, and the combination of very simple feedback (Yes/No), he might apply his previous background knowledge in Object Oriented Modelling and learn more about Entity Relationship Modelling. As a result, the post-test examination result reveals that he has some significant improvement of his knowledge in notation in Entity Relationship Diagram. He also can increase his knowledge in identifying entity type, relationship type and attribute within a case study of traditional scenario. However, he cannot improve his knowledge in the part of misconception, a case study of simulation of the real world situation scenario and the articulation of identifying procedure of entity type, relationship type, and attribute. It is simply because GERM_1 provides a tradition scenario, which is far from the real world situation and a combination of simple feedback. As a result, GERM_1 is not the effective Tutoring System enough to make him learn more about the situation in the real world and the procedure of identifying Entity type, Relationship type, attribute. The case study from GERM_1 also cannot represent some situation that can make student changes his misconception.

6.6.1.2 Participant_2: He is the first year of an undergraduate student in Management Information System Course at the school of informatics. He has no background knowledge in Data Modelling Subject using Entity Relationship Diagram but he has some background in management information systems.

- **Pre-test Result**

Although the pre-test result reveals that student can make some correct answers in the definition, such as Entity Type, Relationship Type and Attribute etc, it is not significant enough for conclusion that he has some background knowledge in definition. He might choose the right answer by fluke. However, he still has some misconception between entity type vs. entity instance and relationship type vs.

relationship instance and attribute vs. value. Moreover, he has no background about notation or symbol in entity relationship diagram. Furthermore, he also cannot describe the procedure of identifying entity type, relationship type and attribute and identifies entity type, relationship type and attribute from both traditional case study and simulation of real world case study. The detail of the pre-test result is shown in Table 6.5.

Knowledge Types			GERM 1 & Participant 2		
			Correct	Total	(%)
Declarative Knowledge	Definition	Strong Entity Type	1	4	25%
		Weak Entity Type	1	4	25%
		Relationship Type	1	4	25%
		One-to-One Relationship	2	4	50%
		One-to-Many Relationship	1	4	25%
		Many-to-Many Relationship	1	4	25%
		Attribute	2	4	50%
		Primary Key	2	4	50%
	Misconception	Entity Type vs. instance	0	4	0%
		Attribute vs. Value	1	4	25%
		Relationship vs. instance	1	4	25%
	Symbol	Entity Type	0	2	0%
		Relationship Type	0	4	0%
		Attribute	0	2	0%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Simulation Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Identifying Procedure	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	4	0%

Table 6.5: Pre-test result of participant 2 before practising GERM 1

- **Participant 2's Action in practising GERM 1 (Appendix B)**

Although the pre-test result reveals that the participant has no background in data modelling, in practising GERM 1 he can identify entity type, relationship type and attribute correctly almost all of diagram solution. It is simply because GERM 1 provides a traditional scenario that is quite easy to guess after receiving simple feedback "Yes, you were right" and "No, you were wrong". Therefore, it cannot

conclude that student can improve his knowledge in data modelling. As a result, we have to check his knowledge by taking a post-test examination.

- **Post-test Result**

After using GERM 1, he took the post-test examination. Although the post-test examination result (Table 6.6) reveals that he can make more correct answers in the part of definition, notation and traditional scenario, it is not significant enough for summation that he can improve his knowledge in such knowledge. The comparison of pre-test examination result and post-test examination result is shown in Table 6.7

Knowledge Types			GERM 1 & Participant 2		
			Correct	Total	%
Declarative Knowledge	Definition	Strong Entity Type	2	4	50%
		Weak Entity Type	1	4	25%
		Relationship Type	2	4	50%
		One-to-One Relationship	1	4	25%
		One-to-Many Relationship	2	4	50%
		Many-to-Many Relationship	1	4	25%
		Attribute	2	4	50%
		Primary Key	1	4	25%
	Misconception	Entity Type vs. instance	0	4	0%
		Attribute vs. Value	1	4	25%
		Relationship vs. instance	0	4	0%
	Symbol	Entity Type	0	2	0%
		Relationship Type	1	4	25%
		Attribute	0	2	0%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	1	4	25%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	5	20	25%
	Simulation Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	4	20	20%
	Identifying Procedure	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	4	0%

Table 6.6: Post-test result of participant 2 after practising GERM 1

Knowledge Types			GERM 1 & Participant 2		
			Pre-test	Post-test	Margin
Declarative Knowledge	Definition	Strong Entity Type	25%	50%	+25%
		Weak Entity Type	25%	25%	0%
		Relationship Type	25%	50%	+25%
		One-to-One Relationship	50%	25%	-25%
		One-to-Many Relationship	25%	50%	+25%
		Many-to-Many Relationship	25%	25%	0%
		Attribute	50%	50%	0%
		Primary Key	50%	25%	-25%
	Misconception	Entity Type vs. instance	0%	0%	0%
		Attribute vs. Value	25%	25%	0%
		Relationship vs. instance	25%	0%	-25%
	Notation	Entity Type	0%	0%	0%
		Relationship Type	0%	25%	+25%
		Attribute	0%	0%	0%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0%	25%	+25%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	25%	+25%
	Simulation Scenario	Entity Type Identifying	0%	0%	0%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	20%	+20%
	Identifying Procedure	Entity Type Identifying	0%	0%	0%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	0%	0%

Table 6.7: The pre/post test comparison of participant 2

- **Summary the Result: GERM_1 & Participant_2**

According to the result of using GERM 1 of participant 2, we can conclude that he cannot improve his knowledge in identifying entity type, relationship type and attribute within a simulation of real world situation. Moreover, he cannot describe the procedure of identifying entity type, relationship type and attribute. Furthermore, he still has the same misconception. However, he slightly increase some correct answers in the part of definition, notation and case study of traditional scenario but it is not significant enough to conclusion that he can improve his knowledge in such parts.

- **Discussion the Result: GERM_1 & Participant_2**

The participant has no background knowledge in data modelling using Entity Relationship Diagram. When he is practising GERM_1 that provides a tradition scenario, which is far from real world situation e.g. very simple and easy to guess, and the combination of very simple feedback (Yes/No), he might choose the correct answers but it does not make him learn anything more. As a result, the post-test examination result reveals that he has no a significant improvement of any knowledge in data modelling using Entity Relationship Diagram.

6.6.1.3 Participant_3: He is the forth year of an undergraduate student in computing course at the school of informatics. He has background knowledge in Data Modelling Subject using Entity Relationship Diagram from attending database module 3 years ago. But, from the interview, reveals that he had got a poor result in the examination.

- **Pre-test Result**

Although participant used to attend an entity relationship modelling course , the pre-test result shows that student can make just some correct answers in the definition, such as Entity Type, Relationship Type, and Attribute etc. It does not confirm that he still has some background knowledge in the definition some keywords in an entity relationship modelling.

Furthermore, the pre-test result also reveals that student has some misconception between entity type vs. entity instance and relationship type vs. relationship instance and attribute vs. value. Moreover, he does not know about notation or symbol in entity relationship diagram.

In addition, he also cannot describe the procedure of identifying entity type, relationship type and attribute and identifies entity type, relationship type and attribute from both traditional case study and simulation of real world case study. The pre-test result detail is shown in Table 6.8.

Knowledge Types			GERM 1 & Participant 3		
			Correct	Total	(%)
Declarative Knowledge	Definition	Strong Entity Type	2	4	50%
		Weak Entity Type	2	4	50%
		Relationship Type	2	4	50%
		One-to-One Relationship	2	4	50%
		One-to-Many Relationship	0	4	0%
		Many-to-Many Relationship	0	4	0%
		Attribute	2	4	50%
		Primary Key	2	4	50%
	Misconception	Entity Type vs. instance	1	4	25%
		Attribute vs. Value	0	4	0%
		Relationship vs. instance	1	4	25%
	Notation	Entity Type	0	2	0%
		Relationship Type	0	4	0%
		Attribute	0	2	0%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Simulation Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Identifying Procedure	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	4	0%

Table 6.8: Pre-test result of participant 3 before practising GERM 1

- **Participant 3's Action in using GERM 1: (Appendix C)**

Although the pre-test result reveals that the participant has a very little basic knowledge in data modelling, in practising GERM 1 he can identify entity type, relationship type and attribute completely a correct diagram solution. Student just did some mistakes in cardinality of a relationship. It is simply because GERM 1 provides a traditional scenario case study plus a simple feedback, which might can remind student about his previous knowledge in entity relationship modelling used to learn 3 years ago. However, we cannot confirm that student can improve his knowledge in data modelling.

- **Post-test Result**: After using GERM 1, participant took the post-test examination (Table 6.9). Although student can construct entity relationship diagram correctly with the solution when using GERM_1, the post-test result reveals that still

cannot change his misconception. He also cannot explain the procedure of entity relationship modelling and cannot construct entity relationship diagram with the case study simulation of real world situation.

However, he can improves his knowledge of the definition of some keywords and notation or symbol. Moreover, he also can construct entity relationship within the case study of traditional scenario. The comparison of pre-test result and post-test result is shown in Table 6.10

Knowledge Types			GERM 1 & Participant 3		
			Correct	Total	%
Declarative Knowledge	Definition	Strong Entity Type	4	4	100%
		Weak Entity Type	4	4	100%
		Relationship Type	4	4	100%
		One-to-One Relationship	4	4	100%
		One-to-Many Relationship	4	4	100%
		Many-to-Many Relationship	3	4	75%
		Attribute	4	4	100%
		Primary Key	4	4	100%
	Misconception	Entity Type vs. instance	1	4	25%
		Attribute vs. Value	0	4	0%
		Relationship vs. instance	1	4	25%
	Symbol	Entity Type	2	2	100%
		Relationship Type	4	4	100%
		Attribute	2	2	100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	4	4	100%
		Relationship Type Identifying	3	4	75%
		Attribute Identifying	16	20	80%
	Simulation Scenario	Entity Type Identifying	1	4	25%
		Relationship Type Identifying	1	4	25%
		Attribute Identifying	8	20	40%
	Identifying Procedure	Entity Type Identifying	1	4	25%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	1	4	25%

Table 6.9: Post-test result of participant 3 after practising GERM 1

Knowledge Types			GERM 1 & Participant 3		
			Pre-test	Post-test	Margin
Declarative Knowledge	Definition	Strong Entity Type	50%	100%	+50%
		Weak Entity Type	50%	100%	+50%
		Relationship Type	50%	100%	+50%
		One-to-One Relationship	50%	100%	+50%
		One-to-Many Relationship	0%	100%	+100%
		Many-to-Many Relationship	0%	75%	+75%
		Attribute	50%	100%	+50%
		Primary Key	50%	100%	+50%
	Misconception	Entity Type vs. instance	25%	25%	0%
		Attribute vs. Value	0%	0%	0%
		Relationship vs. instance	25%	25%	0%
	Notation	Entity Type	0%	100%	+100%
		Relationship Type	0%	100%	+100%
		Attribute	0%	100%	+100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0%	100%	+100%
		Relationship Type Identifying	0%	75%	+75%
		Attribute Identifying	0%	80%	+80%
	Simulation Scenario	Entity Type Identifying	0%	25%	+25%
		Relationship Type Identifying	0%	25%	+25%
		Attribute Identifying	0%	40%	+40%
	Identifying Procedure	Entity Type Identifying	0%	25%	+25%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	25%	+25%

Table 6.10: The pretest/posttest comparison of participant 3

- **Summary: GERM_1 & Participant_3**

According to the result of using GERM 1 of participant 3, we can conclude that GERM 1 can improve the participant_3's knowledge in the definition of some keywords and the notation of Entity Relationship Diagram. Furthermore, we also can say that GERM_1 can improve the participant_3's skill in entity relationship modelling for a case study of traditional scenario.

However, student cannot improve his skill in constructing entity relationship modelling for a case study of simulation of real world situation. Moreover, he cannot describe the procedure of identifying entity type, relationship type and attribute. Furthermore, GERM_1 cannot change some misconception for participant_3.

- **Discussion the Result: GERM_1 & Participant_3**

The participant has background knowledge in data modelling through being formulas with Entity Relationship Modelling. When he is practising GERM_1 that provides a case study of tradition scenario, which is very simple, and the combination of very simple feedback (Yes/No), he might remind his previous background knowledge about Entity Relationship Modelling.

As a result, the post-test result reveals that he has some significant improvement of his knowledge in the definition of some key words and the notation in Entity Relationship Diagram. He also can increase his knowledge in identifying entity type, relationship type and attribute within a case study of traditional scenario.

Nevertheless, he cannot change his misconception and cannot construct entity relationship modelling for a case study of simulation of the real world situation scenario. In additional, he cannot articulate process of constructing entity relationship modelling in general. It is mainly because GERM_1 provides a case study of a tradition scenario, which is far from the real world situation and a combination of simple feedback. As a result, GERM_1 is not the effective Tutoring System enough to make him learn more about the situation in the real world and the procedure of identifying entity type, relationship type, attribute. The case study from GERM_1 also cannot represent some situation that can make student changes his misconception.

- **Conclusion of the effectiveness of GERM_1**

In conclusion, GERM_1 has effected on the participant who have some background knowledge in data modelling, in particular, it can improve the knowledge in the definition, notation. Moreover, it can also improve the skill for student in constructing entity relationship modelling for a case study that represent a traditional scenario, which uses formal language. However, it cannot improve any knowledge for the participant who has no background knowledge. The detail of the effectiveness of GERM_1 is shown in Table 8.11.

Participant Background	Definition	Misconception	Notation	Traditional Case study	Simulation Case Study	Articulat of ER Modelling
No background Participant_2	×	×	×	×	×	×
Object Modelling Participant_1	√	×	√	√	×	×
ER Modelling Participant_3	√	×	√	√	×	×

Table 6.11: The Effectiveness of GERM_1

6.6.2 GERM_2: Guided Entity Relationship Modelling with a traditional scenario and a guidance feedback

GERM_2 represents the database problem in term of a formal language, which normally is used in the classroom. Also from literature review, the previous intelligent tutoring systems in teaching Data Modelling Subject: ERM-VLE (Hall & Gordon, 1998a; Hall & Gordon, 1998b; Hall & Gordon, 1998c), COLER (Constantino-Gonzalez & Suthers, 2000; Constantino-Gonzalez, et al., 2001) and KERMIT (Suraweera & Mitrovic, 2001) use a formal language for representing the database problem. However, the program employs a guidance strategy (Elsom-Cook, 1990) for teaching learners. The strategy tries to guide students to discover some knowledge in data modelling using entity relationship diagram.

6.6.2.1 Participant_4: He is the second year of an undergraduate student in computing course at the school of informatics. He has background knowledge in Data Modelling Subject using Entity Relationship Diagram from attending database module last year. But, from the interview reveals that he has quiet poor background knowledge in data modelling using entity relationship diagram.

- **Pre-test Result**

Although participant used to attend a module of entity relationship modelling, the pre-test result reveals that student just has only about 60 percentages of knowledge in the definition of some keywords and the notation of entity relationship diagram. However, the pre-test result also reveals that student has some misconception between entity type vs. entity instance and relationship type vs. relationship instance and attribute vs. value. Moreover, he also cannot describe the procedure of constructing entity relationship modelling. As a result, he has not skill enough to construct entity relationship modelling for both a traditional scenario case study and a simulation of real world scenario case study. The pre-test result detail is shown in Table 6.12.

Knowledge Types			GERM 2 & Participant 4		
			Correct	Total	(%)
Declarative Knowledge	Definition	Strong Entity Type	2	4	50%
		Weak Entity Type	2	4	50%
		Relationship Type	3	4	75%
		One-to-One Relationship	2	4	50%
		One-to-Many Relationship	2	4	50%
		Many-to-Many Relationship	2	4	50%
		Attribute	4	4	100%
		Primary Key	3	4	75%
	Misconception	Entity Type vs. instance	1	4	25%
		Attribute vs. Value	1	4	25%
		Relationship vs. instance	0	4	0%
	Symbol	Entity Type	1	2	50%
		Relationship Type	2	4	50%
		Attribute	2	2	100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Simulation Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Identifying Procedure	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	4	0%

Table 6.12: Pre-test result of participant 4 before practising GERM 2

- **Participant 4's Action in using GERM_2 (Appendix D)**

Even though the pre-test result reveals that the participant has some basic background knowledge in the basic definition keywords and notation in entity relationship modelling, in practising GERM 2 he struggled in the beginning because he picked up attribute before picking entity type. But when he realised that he should

pick entity type first before going to pick up attribute, he can construct entity relationship modelling quiet well. It is simply because GERM 2 provides a traditional scenario case study which is very simple plus a guided message feedback, which might can remind student about his previous knowledge in entity relationship modelling used to learn last year. However, he is likely to be happy with guided messages in the beginning. But he definitely ignored the guided feedback later on. It is mainly because the scenario in case study is quite simple for guessing to the correct answer. The guided messages, therefore, is not necessary for him any more.

- **Post-test Result**: Participant took the post-test examination (Table 6.13) after using GERM 2. Although student can pick up entity type, relationship type, and attribute correctly with GERM_2, the post-test result reveals that still cannot change his misconception. He also cannot explain the procedure of constructing entity relationship modelling. In additional, he cannot draw entity relationship diagram with the case study simulation of real world situation.

However, he can improves his knowledge of the definition of some keywords and notation or symbol. Moreover, he also can construct entity relationship with the case study of traditional scenario. The comparison of pre-test result and post-test result is shown in Table 6.14

Knowledge Types			GERM 2 & Participant 4		
			Correct	Total	%
Declarative Knowledge	Definition	Strong Entity Type	4	4	100%
		Weak Entity Type	4	4	100%
		Relationship Type	4	4	100%
		One-to-One Relationship	4	4	100%
		One-to-Many Relationship	4	4	100%
		Many-to-Many Relationship	4	4	100%
		Attribute	4	4	100%
		Primary Key	4	4	100%
	Misconception	Entity Type vs. instance	1	4	25%
		Attribute vs. Value	0	4	0%
		Relationship vs. instance	1	4	25%
	Notation	Entity Type	2	2	100%
		Relationship Type	4	4	100%
		Attribute	2	2	100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	3	4	100%
		Relationship Type Identifying	3	4	75%
		Attribute Identifying	15	20	75%
	Simulation Scenario	Entity Type Identifying	1	4	25%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	5	20	25%
	Identifying Procedure	Entity Type Identifying	1	4	25%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	1	4	25%

Table 6.13: Post-test result of participant 4 after practising GERM 2

Knowledge Types			GERM 2 & Participant 4		
			Pre-test	Post-test	Margin
Declarative Knowledge	Definition	Strong Entity Type	50%	100%	+50%
		Weak Entity Type	50%	100%	+50%
		Relationship Type	75%	100%	+25%
		One-to-One Relationship	50%	100%	+50%
		One-to-Many Relationship	50%	100%	+50%
		Many-to-Many Relationship	50%	100%	+50%
		Attribute	100%	100%	N\A
		Primary Key	75%	100%	+25%
	Misconception	Entity Type vs. instance	25%	25%	0%
		Attribute vs. Value	25%	0%	-25%
		Relationship vs. instance	0%	25%	25%
	Notation	Entity Type	50%	100%	+50%
		Relationship Type	50%	100%	+50%
		Attribute	100%	100%	N\A
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0%	100%	+100%
		Relationship Type Identifying	0%	75%	+75%
		Attribute Identifying	0%	75%	+75%
	Simulation Scenario	Entity Type Identifying	0%	25%	+25%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	25%	+25%
	Identifying Procedure	Entity Type Identifying	0%	25%	+25%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	25%	+25%

Table 6.14: The pretest/posttest comparison of participant 4

- **Summary: GERM_2 & Participant_4**

According to the result of using GERM 2 of participant 4, the post-test result suggests that GERM 2 can improve the participant_4's knowledge in the definition of some keywords and the notation of Entity Relationship Diagram. In additional, the post-test result also reveals that GERM_2 can increase the participant_3's skill in entity relationship modelling with a case study of traditional scenario.

However, student cannot enhance his skill in constructing entity relationship modelling with a case study of simulation of real world situation. Moreover, he cannot describe the procedure of identifying entity type, relationship type and attribute. In additional, GERM_2 cannot change some misconception for participant_4.

- **Discussion the Result: GERM_2 & Participant_4**

The participant has some background knowledge in data modelling through being formulas with Entity Relationship Modelling. When he is practising GERM_2 that provides a case study of tradition scenario and the combination of guided feedback, it can help him to recall his previous background knowledge about Entity Relationship Modelling. The post-test result, therefore, reveals that he has some significant improvement of his knowledge in the definition of some key words and the notation in Entity Relationship Diagram. He also can enhance his skill in constructing entity relationship modelling with a case study of traditional scenario.

Nonetheless, he cannot change his misconception and cannot construct entity relationship modelling with a case study of simulation of the real world situation scenario. In additional, he cannot describe the process of constructing entity relationship modelling in general. It is mainly because GERM_1 provides a case study of a tradition scenario, which is far from the real world situation. As a result, GERM_2 is not the effective Tutoring System enough to make him learn more about the situation in the real world and the procedure of constructing entity relationship modelling. The case study from GERM_2 also cannot represent some situation that can make student changes his misconception. Moreover, because of the simple case study from GERM_2, it make the guided messages was not effective and necessary for participant_4.

6.6.2.2 Participant_5: He is the third of undergraduate student in computing for business course at the school of informatics. He has some background knowledge in data modelling through being formulas with Object Oriented Data Modelling. He has no background knowledge in using Entity Relationship Diagram.

- **Pre-test Result**

The pre-test result revealed that student has about 50 percentages of background knowledge in the definition some keywords such as strong entity type, weak entity type, relationship type, attribute, and primary key etc.

However, he still has some misconception between entity type vs. entity instance and relationship type vs. relationship instance and attribute vs. value. Moreover, the pre-test result also suggests that he has no background knowledge about notation or symbol in entity relationship diagram. Furthermore, he also cannot describe the procedure of constructing entity relationship modelling. Nor can he identify an entity type, a relationship type and attribute from either the traditional case study or simulation of real world case study. The detail of the pre-test result has been shown in Table 6.15.

Knowledge Types			GERM 2 & Participant 5		
			Correct	Total	%
Declarative Knowledge	Definition	Strong Entity Type	2	4	50%
		Weak Entity Type	2	4	50%
		Relationship Type	2	4	50%
		One-to-One Relationship	3	4	75%
		One-to-Many Relationship	2	4	50%
		Many-to-Many Relationship	2	4	50%
		Attribute	2	4	50%
		Primary Key	1	4	25%
	Misconception	Entity Type vs. instance	1	4	25%
		Attribute vs. Value	0	4	0%
		Relationship vs. instance	1	4	25%
	Notation	Entity Type	0	2	0%
		Relationship Type	0	4	0%
		Attribute	0	2	0%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Simulation Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Identifying Procedure	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	4	0%

Table 6.15: Pre-test result of participant 5 before practising GERM 2

- **Participant 5's** Action in Learning GERM 2 (Appendix E) By contrast with pre-test result, student can construct entity relationship modelling correctly during his practising of GERM 2. It is simply because GERM 2 provides a traditional scenario with a feedback guidance that is quite simple for him employ his background knowledge from Object Oriented Modelling to choose the correct answer.

- **Post-test Result**: After practising GERM 2, he took the post-test examination (Table 6.16). Even though he can construct entity relationship model correctly when using GERM_2, he cannot change his misconception between some key words such as entity type vs. entity instance. Moreover, he cannot describe the process of constructing entity relationship model. He also cannot identify entity type, relationship type and attribute correctly with the simulation of real world situation. However, he improves his knowledge of the definition of key words and notation in entity relationship diagram. He also can construct entity relationship model with a case study of traditional scenario. The comparison of pre-test result and post-test result is shown in Table 6.17

Knowledge Types			GERM 2 & Participant 5		
			Correct	Total	%
Declarative Knowledge	Definition	Strong Entity Type	4	4	100%
		Weak Entity Type	4	4	100%
		Relationship Type	4	4	100%
		One-to-One Relationship	4	4	100%
		One-to-Many Relationship	4	4	100%
		Many-to-Many Relationship	3	4	75%
		Attribute	4	4	100%
		Primary Key	4	4	100%
	Misconception	Entity Type vs. instance	1	4	25%
		Attribute vs. Value	1	4	25%
		Relationship vs. instance	0	4	0%
	Notation	Entity Type	2	2	100%
		Relationship Type	4	4	100%
		Attribute	2	2	100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	3	4	75%
		Relationship Type Identifying	3	4	75%
		Attribute Identifying	15	20	75%
	Simulation Scenario	Entity Type Identifying	1	4	25%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	4	20	20%
	Identifying Procedure	Entity Type Identifying	1	4	25%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	1	4	25%

Table 6.16: Post-test result of participant 5 after practising GERM 2

Knowledge Types			GERM 2 & Participant 5		
			Pre-test	Post-test	Margin
Declarative Knowledge	Definition	Strong Entity Type	50%	100%	+50%
		Weak Entity Type	50%	100%	+50%
		Relationship Type	50%	100%	+50%
		One-to-One Relationship	75%	100%	+25%
		One-to-Many Relationship	50%	100%	+50%
		Many-to-Many Relationship	50%	75%	+25%
		Attribute	50%	100%	+50%
		Primary Key	25%	100%	+75%
	Misconception	Entity Type vs. instance	25%	25%	0%
		Attribute vs. Value	0%	25%	+25%
		Relationship vs. instance	25%	0%	-25%
	Notation	Entity Type	0%	100%	+100%
		Relationship Type	0%	100%	+100%
		Attribute	0%	100%	+100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0%	75%	+75%
		Relationship Type Identifying	0%	75%	+75%
		Attribute Identifying	0%	75%	+75%
	Simulation Scenario	Entity Type Identifying	0%	25%	+25%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	20%	+20%
	Identifying Procedure	Entity Type Identifying	0%	25%	+25%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	25%	+25%

Table 6.17: The pretest/posttest comparison of participant 5

- **Summary: GERM_2 & Participant_5**

According to the post-test result of using GERM 2 of participant 5 suggests that GERM 2 can improve participant_5's knowledge the definition of some important key words and the knowledge of notation in entity relationship diagram. Moreover, the post-test result also shows that GERM_2 can improve his skill in constructing entity relationship model with a case study of traditional scenario.

However, this system cannot change his misconception between entity type vs. entity instance, relationship type vs. relationship instance, and attribute vs. value. Moreover, the system cannot help him to articulate the procedure of constructing entity relationship model. The system also cannot enhance his skill in constructing entity relationship model with a case study of simulation of real world situation.

- **Discussion the Result: GERM_2 & Participant_5**

The participant has background knowledge in data modelling through being formulas with Object Oriented Modelling. When he is practising GERM_2 that provides a tradition scenario, which is very simple, and the combination of guided feedback, he might employ his previous background knowledge in Object Oriented Modelling and learn more about Entity Relationship Modelling. As a result, the post-test examination result reveals that GERM_2 can help the participant to have some significant improvement of his knowledge in the definition of key words and the notation in Entity Relationship Diagram. The system can also increase his knowledge in identifying entity type, relationship type and attribute with a case study of traditional scenario.

However, the system cannot help participant to change his misconception because its scenario problem cannot provide a variety of situation in which represent in the real world situation. The system also cannot improve the participant's skill for constructing entity relationship model with a case study of simulation of the real world situation scenario and the articulation of identifying procedure of entity type, relationship type, and attribute. It is simply because GERM_2 provides a tradition scenario, which is far from the real world situation. Although GERM_2 provides a guided feedback but it is not effective enough to make participant learn more about the procedure of identifying Entity type, Relationship type, attribute in general.

6.6.2.3 Participant_6: He is the first year of an undergraduate student in Computing Course at the school of informatics. He has no background knowledge in Data Modelling Subject using Entity Relationship Diagram.

- **Pre-test Result**

Even though the pre-test result reveals that student can make some correct answers in the definition of some key words, such as Entity Type, Relationship Type

and Attribute etc, it is not significant enough for conclusion that he has some background knowledge in definition. He might choose the right answer by fluke. However, he still has some misconception between entity type vs. entity instance and relationship type vs. relationship instance and attribute vs. value. Moreover, he has no background about notation or symbol in entity relationship diagram. Furthermore, he also cannot describe the procedure of identifying entity type, relationship type and attribute and identifies entity type, relationship type and attribute from both traditional case study and simulation of real world case study. The detail of the pre-test result is shown in Table 6.18.

Knowledge Types			GERM 2 & Participant 6		
			Correct	Total	(%)
Declarative Knowledge	Definition	Strong Entity Type	1	4	25%
		Weak Entity Type	0	4	0%
		Relationship Type	1	4	25%
		One-to-One Relationship	0	4	0%
		One-to-Many Relationship	1	4	25%
		Many-to-Many Relationship	1	4	25%
		Attribute	0	4	0%
		Primary Key	0	4	0%
	Misconception	Entity Type vs. instance	1	4	25%
		Attribute vs. Value	1	4	25%
		Relationship vs. instance	0	4	0%
	Symbol	Entity Type	0	2	0%
		Relationship Type	0	4	0%
		Attribute	0	2	0%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Simulation Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Identifying Procedure	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	4	0%

Table 6.18: Pre-test result of participant 6 before practising GERM 2

- **Participant 6's** Action in practising GERM 2 (Appendix F) Although the pre-test result reveals that the participant has no background knowledge in data modelling using entity relationship diagram, he can construct entity relationship diagram in using GERM 2 correctly almost all of diagram solution. However, we cannot conclude that the system can improve his knowledge in data modelling because GERM 2 provides a case study of traditional scenario, which is very simple and quite easy to guess after receiving a guided feedback from the system.
- **Post-test Result:** After using GERM 2, he took the post-test examination. The post-test examination result (Table 6.19) reveals that he can make more than 60 % correct answers in the definition part, the notation part and the case study of traditional scenario part. The comparison of pre-test examination result and post-test examination result is shown in Table 6.20

Knowledge Types			GERM 2 & Participant 6		
			Correct	Total	%
Declarative Knowledge	Definition	Strong Entity Type	4	4	100%
		Weak Entity Type	3	4	75%
		Relationship Type	3	4	75%
		One-to-One Relationship	3	4	75%
		One-to-Many Relationship	3	4	75%
		Many-to-Many Relationship	3	4	75%
		Attribute	4	4	100%
		Primary Key	4	4	100%
	Misconception	Entity Type vs. instance	1	4	25%
		Attribute vs. Value	0	4	0%
		Relationship vs. instance	0	4	0%
	Symbol	Entity Type	2	2	100%
		Relationship Type	4	4	100%
		Attribute	2	2	100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	3	4	75%
		Relationship Type Identifying	2	4	50%
		Attribute Identifying	16	20	80%
	Simulation Scenario	Entity Type Identifying	1	4	25%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	4	20	20%
	Identifying Procedure	Entity Type Identifying	1	4	25%
		Relationship Type Identifying	1	4	25%
		Attribute Identifying	0	4	0%

Table 6.19: Post-test result of participant 6 after practising GERM 2

Knowledge Types			GERM 2 & Participant 6		
			Pre-test	Post-test	Margin
Declarative Knowledge	Definition	Strong Entity Type	25%	100%	+75%
		Weak Entity Type	0%	75%	+75%
		Relationship Type	25%	75%	+50%
		One-to-One Relationship	0%	75%	+75%
		One-to-Many Relationship	25%	75%	+50%
		Many-to-Many Relationship	25%	75%	+50%
		Attribute	0%	100%	+100%
		Primary Key	0%	100%	+100%
	Misconception	Entity Type vs. instance	25%	25%	0%
		Attribute vs. Value	25%	0%	-25%
		Relationship vs. instance	0%	0%	0%
	Notation	Entity Type	0%	100%	+100%
		Relationship Type	0%	100%	+100%
		Attribute	0%	100%	+100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0%	75%	+75%
		Relationship Type Identifying	0%	50%	+50%
		Attribute Identifying	0%	80%	+80%
	Simulation Scenario	Entity Type Identifying	0%	25%	+25%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	20%	+20%
	Identifying Procedure	Entity Type Identifying	0%	25%	+25%
		Relationship Type Identifying	0%	25%	+25%
		Attribute Identifying	0%	0%	0%

Table 6.20: The pretest/posttest comparison of participant 6

- **Summary the Result: GERM_2 & Participant_6**

According to the result of using GERM 2 of participant 6, the post-test result reveals that the tutoring system can improve participant's knowledge in the part of definition, the notation and the case study of traditional scenario.

However, the tutoring system cannot improve his knowledge in constructing entity relationship model with a simulation of real world situation. Moreover, he cannot describe the procedure of identifying entity type, relationship type and attribute. Furthermore, the tutoring system cannot change the misconception of participant.

- **Discussion the Result: GERM_2 & Participant_6**

The participant has no background knowledge in data modelling using Entity Relationship Diagram. When he is practising GERM_2 that provides a tradition scenario, which is far from real world situation e.g. very simple and easy to guess, he might choose the correct answers but it does not make him learn anything more.

As a result, the post-test examination result reveals that the tutoring system cannot improve his knowledge in constructing entity relationship model with a simulation of real world situation. Moreover, he cannot describe the procedure of identifying entity type, relationship type and attribute. In additional, the tutoring system cannot change the misconception of participant.

However, the tutoring system can improve participant's knowledge in the part of definition, the notation and the case study of traditional scenario. It is simply because the tutoring system provide a guided message feedback which can help participant to discover some basic knowledge in data modelling e.g. the definition of some key words, the notation. It can also improve participant's skill in constructing entity relationship model with a traditional scenario case study.

- **Conclusion of the effectiveness of GERM_2**

In conclusion, GERM_2 can improve all three participants' knowledge in the definition, the notation. Moreover, it can also improve the skill for student in constructing entity relationship modelling for a case study that represent a traditional scenario, which uses formal language.

However, the tutoring system cannot improve their knowledge in constructing entity relationship model with a simulation of real world situation. Moreover, he

cannot describe the procedure of identifying entity type, relationship type and attribute. In additional, the tutoring system cannot change the misconception of participant. The detail of the effectiveness of GERM_2 is shown in Table 6.21

Participant Background	Definition	Misconception	Notation	Traditional Case study	Simulation Case Study	Articulate of ER Modelling
No background Participant_6	√	×	√	√	×	×
Object Modelling Participant_5	√	×	√	√	×	×
ER Modelling Participant_4	√	×	√	√	×	×

Table 6.21: The effectiveness of GERM_2

6.6.3 GERM_3: Guided Entity Relationship Modelling with a simulation of real world situation scenario and a simple feedback

From literature review, the previous intelligent tutoring systems in teaching Data Modelling Subject: ERM-VLE (Hall & Gordon, 1998a; Hall & Gordon, 1998b; Hall & Gordon, 1998c), COLER (Constantino-Gonzalez & Suthers, 2000; Constantino-Gonzalez, et al., 2001) and KERMIT (Suraweera & Mitrovic, 2001,2004) use a formal language for representing the database problem. However, the problem scenario cannot represent the situation in which takes place in the real world.

As a result, GERM_3 tries to represent the database problem in term of a simulation of real world situation, which designers have to confront with the users' requirements and also have to deal with a variety of documents of a company (Chen, 1983). However, the program employs only simple feedback, e.g. "Yes" which means you are right and "No" which means you are wrong, for helping students to learn how to construct data modelling using entity relationship diagram.

6.6.3.1 Participant_7: She is the second year of an undergraduate student in computing for business at the school of informatics. She has no background knowledge in Data Modelling Subject using Entity Relationship Diagram or Object Relation Modelling. However, she has some background in the basic of computing and business from the first year of her study.

- **Pre-test Result**

Even though the pre-test result shows that the student can choose some correct answers in the part of definition and misconception, such as strong entity type, relationship type and attribute etc, it is not significant enough to justify that she has some background knowledge in such two parts. However, she cannot draw notation or symbol in entity relationship diagram. Furthermore, she also cannot describe the procedure of identifying entity type, relationship type and attribute. Moreover, she cannot construct entity relationship model with both a traditional scenario case study and a simulation of real world case study. The pre-test result detail is shown in Table 6.22.

Knowledge Types			GERM 3 & Participant 7		
			Correct	Total	(%)
Declarative Knowledge	Definition	Strong Entity Type	1	4	25%
		Weak Entity Type	0	4	0%
		Relationship Type	1	4	25%
		One-to-One Relationship	0	4	0%
		One-to-Many Relationship	1	4	25%
		Many-to-Many Relationship	0	4	0%
		Attribute	1	4	25%
		Primary Key	0	4	0%
	Misconception	Entity Type vs. instance	0	4	0%
		Attribute vs. Value	1	4	25%
		Relationship vs. instance	0	4	0%
	Notation	Entity Type	0	2	0%
		Relationship Type	0	4	0%
		Attribute	0	2	0%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Simulation Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Identifying Procedure	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	4	0%

Table 6.22: Pre-test result of participant 7 before practising GERM 3

- **Action of Participant 7 in using GERM 3 (Appendix G)**

  - **At enterprise layer:** She collected all of requirement sources, which display on this layer screen.
  - **At identifying layer:** She extremely struggled to find out the right answer. Even thought she tried very hard, she can find out just only one entity type and three attributes. She cannot improve her correct answers with getting the simple feedback from GERM 3.
  - **At Representation Layer:** She did not move to this layer.

- **Post-test Result**: After using GERM 3, she took the post-test examination. Even though the post-test examination result (Table 6.23) reveals that she can select some more correct answers in the part of definition, it is not significant enough to justify that she can improve her knowledge in such part. Moreover, the post-test examination result also shows that she cannot make some more correct answers in the part of misconception, notation, a case study of traditional scenario, a case study of simulation of real world scenario, and the identifying procedure part. The comparison of pre-test examination result and post-test examination result is shown in Table 6.24

Knowledge Types			GERM 3 & Participant 7		
			Correct	Total	%
Declarative Knowledge	Definition	Strong Entity Type	1	4	25%
		Weak Entity Type	0	4	0%
		Relationship Type	1	4	25%
		One-to-One Relationship	1	4	25%
		One-to-Many Relationship	1	4	25%
		Many-to-Many Relationship	0	4	0%
		Attribute	1	4	25%
		Primary Key	1	4	25%
	Misconception	Entity Type vs. instance	0	4	0%
		Attribute vs. Value	1	4	25%
		Relationship vs. instance	0	4	0%
	Notation	Entity Type	0	2	0%
		Relationship Type	0	4	0%
		Attribute	0	2	0%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Simulation Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Identifying Procedure	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	4	0%

Table 6.23: Post-test result of participant 7 after practising GERM 3

Knowledge Types			GERM 3 & Participant 7		
			Pre-test	Post-test	Margin
Declarative Knowledge	Definition	Strong Entity Type	25%	25%	0%
		Weak Entity Type	0%	0%	0%
		Relationship Type	25%	25%	0%
		One-to-One Relationship	0%	25%	+25%
		One-to-Many Relationship	25%	25%	0%
		Many-to-Many Relationship	0%	0%	0%
		Attribute	25%	25%	0%
		Primary Key	0%	25%	+25%
	Misconception	Entity Type vs. instance	0%	0%	0%
		Attribute vs. Value	25%	25%	0%
		Relationship vs. instance	0%	0%	0%
	Notation	Entity Type	0%	0%	0%
		Relationship Type	0%	0%	0%
		Attribute	0%	0%	0%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0%	0%	0%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	0%	0%
	Simulation Scenario	Entity Type Identifying	0%	0%	0%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	0%	0%
	Identifying Procedure	Entity Type Identifying	0%	0%	0%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	0%	0%

Table 6.24: The pre/post-test comparison of participant 7

- **Summary the Result: GERM_3 & Participant_7**

According to the result of using GERM 3 of participant 7, the post-test examination result shows that she cannot improve any knowledge in every part of examination paper e.g. the definition, the misconception, the notation, the case study of traditional scenario, the case study of simulation of real world scenario, and the identifying the procedure of constructing entity relationship model. However, she

slightly increase some more correct answers in the part of definition but it is not significant enough to conclusion that he can improve his knowledge in such parts.

- **Discussion the Result: GERM_3 & Participant_7**

The participant has no background knowledge in data modelling using Entity Relationship Diagram. When he is practising GERM_3 that provides a case study of real world situation scenario, which is very complicated, but using the simple feedback (Yes/No), it might make her more confuse rather than can learn anything more. As a result, the post-test examination result reveals that she has no a significant improvement of any knowledge in data modelling using Entity Relationship Diagram.

6.6.3.2 Participant_8: She is the fourth year of an undergraduate student in computing science course at the school of informatics. She used to attend data modelling module through being formulas with Object Oriented Data Modelling. However, the interview reveals that she has no confidant in her background knowledge in data modelling. Furthermore, she has no any background knowledge about Entity Relationship Diagram.

Pre-test Result

Although the result of pre-test examination shows that the participant can choose the correct answers around 25 percentages of the definition part which tests the definition of some keywords of entity relationship modelling such as strong entity type, weak entity type, relationship type, attribute, and primary key etc.

Nevertheless, the pre-test result reveals that she still has misconception between entity type vs. entity instance and relationship type vs. relationship instance and attribute vs. value. Moreover, the pre-test examination result also suggests that she has no background knowledge about notation or symbol in entity relationship diagram. Furthermore, she also cannot describe the procedure of constructing entity relationship modelling. She also has no any skill in constructing entity relationship

model with either the traditional case study or simulation of real world case study. The result of pre-test examination is shown in Table 6.25.

Knowledge Types			GERM 3 & Participant 8		
			Correct	Total	%
Declarative Knowledge	Definition	Strong Entity Type	2	4	50%
		Weak Entity Type	0	4	0%
		Relationship Type	1	4	25%
		One-to-One Relationship	1	4	25%
		One-to-Many Relationship	1	4	25%
		Many-to-Many Relationship	0	4	0%
		Attribute	2	4	50%
		Primary Key	1	4	25%
	Misconception	Entity Type vs. instance	0	4	0%
		Attribute vs. Value	0	4	0%
		Relationship vs. instance	0	4	0%
	Notation	Entity Type	0	2	0%
		Relationship Type	0	4	0%
		Attribute	0	2	0%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Simulation Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Identifying Procedure	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	4	0%

Table 6.25: Pre-test result of participant 8 before practising GERM 3

- **Action of participant 8 in using GERM 3 (Appendix H)**

➢ **At enterprise layer:** She collected only useful sources e.g. director's statement, manager' statement, sale's statement, staff form, branch report, member report, order form, video report etc.

➢ **At identifying layer:** At the beginning, She struggled to find out the right answer but after trial and error with the simple feedback from the system she can select the right entity type, attribute. Nevertheless, she still struggled to find out the right relationship type. Moreover, sometimes she selected entity

instance as an entity type and cannot choose the right entity type with getting the simple feedback from the system.

➢ **At Representation Layer:** At the beginning, he struggled to find out the right notation. However, he can learn the notation quite well and picked up the right notation for constructing entity relationship diagram at last.

- **Post-test Result:** After practising GERM 3, she took the post-test examination (Table 8.26). The result of post-test examination reveals that she can make some more correct answers about 100% in the notation part, 38 % in the case study of simulation scenario, 34 % in the definition part, and 23% in the case study of traditional scenario part.

However, she cannot increase more correct answers in the rest of two parts e.g. Misconception, and Identifying procedure. The comparison of pre-test result and post-test result is shown in Table 6.27

Knowledge Types			GERM 3 & Participant 8		
			Correct	Total	%
Declarative Knowledge	Definition	Strong Entity Type	3	4	75%
		Weak Entity Type	2	4	50%
		Relationship Type	3	4	75%
		One-to-One Relationship	2	4	50%
		One-to-Many Relationship	2	4	50%
		Many-to-Many Relationship	2	4	50%
		Attribute	3	4	75%
		Primary Key	2	4	50%
	Misconception	Entity Type vs. instance	0	4	0%
		Attribute vs. Value	0	4	0%
		Relationship vs. instance	0	4	0%
	Notation	Entity Type	2	2	100%
		Relationship Type	4	4	100%
		Attribute	2	2	100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	1	4	25%
		Relationship Type Identifying	1	4	25%
		Attribute Identifying	4	20	20%
	Simulation Scenario	Entity Type Identifying	2	4	50%
		Relationship Type Identifying	1	4	25%
		Attribute Identifying	8	20	40%
	Identifying Procedure	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	4	0%

Table 6.26: Post-test result of participant 8 after practising GERM 3

Knowledge Types			GERM 3 & Participant 8		
			Pre-test	Post-test	Margin
Declarative Knowledge	Definition	Strong Entity Type	50%	75%	+25%
		Weak Entity Type	0%	50%	+50%
		Relationship Type	25%	75%	+50%
		One-to-One Relationship	25%	50%	+25%
		One-to-Many Relationship	25%	50%	+25%
		Many-to-Many Relationship	0%	50%	+50%
		Attribute	50%	75%	+25%
		Primary Key	25%	50%	+25%
	Misconception	Entity Type vs. instance	0%	0%	0%
		Attribute vs. Value	0%	0%	0%
		Relationship vs. instance	0%	0%	0%
	Notation	Entity Type	0%	100%	+100%
		Relationship Type	0%	100%	+100%
		Attribute	0%	100%	+100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0%	25%	+25%
		Relationship Type Identifying	0%	25%	+25%
		Attribute Identifying	0%	20%	+20%
	Simulation Scenario	Entity Type Identifying	0%	50%	+50%
		Relationship Type Identifying	0%	25%	+25%
		Attribute Identifying	0%	40%	+40%
	Identifying Procedure	Entity Type Identifying	0%	0%	0%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	0%	0%

Table 6.27: The pretest/posttest comparison of participant 8

- **Summary: GERM_3 & Participant_8**

According to the post-test result of using GERM 3 of participant 8 suggests that GERM 3 can improve participant_8's knowledge in the knowledge of notation in entity relationship diagram, the definition of some important key words. Moreover, the post-test result also shows that GERM_3 can improve her skill in constructing entity relationship model with both a case study of simulation of real world scenario

and traditional scenario. However, GERM 3 cannot change her misconception between entity type vs. entity instance, relationship type vs. relationship instance, and attribute vs. value. Furthermore, GERM 3 cannot help her to describe the procedure of constructing entity relationship model.

- **Discussion the Result: GERM_3 & Participant_8**

The participant has background knowledge in data modelling through being formulas with Object Oriented Modelling. When she is practising GERM_3 that provides a case study of real world simulation scenario alongside a combination of simple feedback (Yes/No) and separates an entity relationship modelling into three simple steps: enterprise, identifying, representation. She might apply her previous background knowledge in Object Oriented Modelling and learn more about Entity Relationship Modelling. As a result, the post-test examination result reveals that GERM_3 can help the participant to have some significant improvement of his knowledge in the notation in Entity Relationship Diagram and the definition of key words.

Moreover, the program can also increase her skill in constructing entity relationship model with both a case study of traditional scenario and simulation of real world scenario. It is simply because the case study of GERM 3 can represent a variety of real world situation, such as the requirements of uses and a number of documents, which can make participant to learn more and improve her skill in data modelling for the real world situation.

However, even though the case study of GERM 3 provides a variety of real world situations, it cannot help participant to change her misconception and articulate the procedure of constructing entity relationship modelling. It is mainly because GERM 3 uses a simple feedback (Yes/No) which cannot help student to learn properly within a very complicates simulation of real world situation scenario.

6.6.3.3 Participant_9: He is the fourth of an undergraduate student in computer science course at the school of informatics. He has some background knowledge in Data Modelling Subject using Entity Relationship Diagram from attending database module in the first year. However, the interview revealed that he has no confidant about his background knowledge in data modelling using entity relationship diagram. Moreover, he has got a poor result with the examination in the data modelling module.

- **Pre-test Result**

Although participant used to attend a module of entity relationship modelling, the pre-test examination result reveals that student just has only about 25% percentages of knowledge in the definition of entity type, relationship type, attribute.

However, the pre-test result also shows that the student has some misconception between entity type vs. entity instance and relationship type vs. relationship instance and attribute vs. value. Moreover, he cannot draw any notations nor describe the procedure of constructing entity relationship modelling. As a result, he has not skill enough to construct entity relationship modelling for both a traditional scenario case

study and a simulation of the real world case study. The pre-test result detail is shown in Table 6.28.

Knowledge Types			GERM 3 & Participant 9		
			Correct	Total	(%)
Declarative Knowledge	Definition	Strong Entity Type	1	4	25%
		Weak Entity Type	1	4	25%
		Relationship Type	1	4	25%
		One-to-One Relationship	0	4	0%
		One-to-Many Relationship	0	4	0%
		Many-to-Many Relationship	0	4	0%
		Attribute	1	4	25%
		Primary Key	1	4	25%
	Misconception	Entity Type vs. instance	0	4	0%
		Attribute vs. Value	0	4	0%
		Relationship vs. instance	0	4	0%
	Notation	Entity Type	0	2	0%
		Relationship Type	0	4	0%
		Attribute	0	2	0%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Simulation Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Identifying Procedure	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	4	0%

Table 6.28: Pre-test result of participant 9 before practising GERM 3

- **Action of participant 9 in using GERM 3 (Appendix I)**

  - **At enterprise layer:** He collected only useful sources e.g. director's statement, manager' statement, sale's statement, staff form, branch report, member report, order form, video report etc.

  - **At identifying layer:** At the beginning, he struggled to find out the right answer but after trial and error with the feedback from GERM 3 he can select the right entity type, attribute. However, he struggled to find out the right relationship type. Furthermore, sometimes he selected entity instance as an entity type and cannot choose the right entity type with getting the simple feedback from GERM 3.

  - **At Representation Layer:** At the beginning, he struggled to find out the right notation. However, he can learn the notation quite well and picked up the right notation for constructing entity relationship diagram at last.

- **Post-test Result**: After practising GERM 3, he took the post-test examination (Table 6.29). The result of post-test examination reveals that he can make some more correct answers about 100% in the notation part, 66 % in the definition part, 53% in the case study of traditional scenario, 50 % in the case study of simulation scenario.

However, he cannot increase more correct answers in the rest of two parts e.g. Misconception, and Identifying procedure. The comparison of pre-test result and post-test result is shown in Table 6.30

Knowledge Types			GERM 3 & Participant 9		
			Correct	Total	%
Declarative Knowledge	Definition	Strong Entity Type	4	4	100%
		Weak Entity Type	3	4	75%
		Relationship Type	4	4	100%
		One-to-One Relationship	3	4	75%
		One-to-Many Relationship	3	4	75%
		Many-to-Many Relationship	2	4	50%
		Attribute	4	4	100%
		Primary Key	3	4	75%
	Misconception	Entity Type vs. instance	0	4	0%
		Attribute vs. Value	0	4	0%
		Relationship vs. instance	0	4	0%
	Notation	Entity Type	2	2	100%
		Relationship Type	4	4	100%
		Attribute	2	2	100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	2	4	50%
		Relationship Type Identifying	2	4	50%
		Attribute Identifying	12	20	60%
	Simulation Scenario	Entity Type Identifying	2	4	50%
		Relationship Type Identifying	2	4	50%
		Attribute Identifying	10	20	50%
	Identifying Procedure	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	4	0%

Table 6.29: Post-test result of participant 9 after practising GERM 3

Knowledge Types			GERM 3 & Participant 9		
			Pre-test	Post-test	Margin
Declarative Knowledge	Definition	Strong Entity Type	25%	100%	+75%
		Weak Entity Type	25%	75%	+50%
		Relationship Type	25%	100%	+75%
		One-to-One Relationship	0%	75%	+75%
		One-to-Many Relationship	0%	75%	+75%
		Many-to-Many Relationship	0%	50%	+50%
		Attribute	25%	100%	+75%
		Primary Key	25%	75%	+50%
	Misconception	Entity Type vs. instance	0%	0%	0%
		Attribute vs. Value	0%	0%	0%
		Relationship vs. instance	0%	0%	0%
	Notation	Entity Type	0%	100%	+100%
		Relationship Type	0%	100%	+100%
		Attribute	0%	100%	+100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0%	50%	+50%
		Relationship Type Identifying	0%	50%	+50%
		Attribute Identifying	0%	60%	+60%
	Simulation Scenario	Entity Type Identifying	0%	50%	+50%
		Relationship Type Identifying	0%	50%	+50%
		Attribute Identifying	0%	50%	+50%
	Identifying Procedure	Entity Type Identifying	0%	0%	0%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	0%	0%

Table 6.30: The pre/post-test comparison of participant 9

- **Summary: GERM_3 & Participant_9**

According to the post-test result of using GERM 3 of participant 9 reveals that GERM 3 can increase participant_9's knowledge about the notations in entity relationship diagram, the definition of some important key words. In additional, the post-test result also suggests that GERM_3 can enhance his skill in constructing entity relationship model with both a case study of simulation of real world scenario and traditional scenario.

Nevertheless, the system cannot help participant to change his misconception between entity type vs. entity instance, relationship type vs. relationship instance, and attribute vs. value. Moreover, it cannot assist the participant to learn how to articulate the general procedures of constructing entity relationship model.

- **Discussion the Result: GERM_3 & Participant_9**

The participant used to study the module of data modelling with Entity Relationship Modelling three years ago. When he is practising GERM_3, which separates a learning step for data modelling into three simple layers: enterprise layer, identifying layer, and represent layer, it might recall his previous background knowledge. As a result, the post-test examination result reveals that GERM_3 can assist the participant to have some significant improvement of his knowledge in the notation in Entity Relationship Diagram and the definition of some key words.

Furthermore, because of providing a case study of real world situation, such as the requirements of uses and a number of documents, GERM 3 might can assist the participant to learn more and increase his skill in data modelling with the real world situation. The result of post-test examination, therefore, reveals that the program can enhance participant' skill in constructing entity relationship model with both a case study of traditional scenario and simulation of real world scenario.

However, because of using a very simple feedback within a very complicates simulation of real world situation scenario, GERM 3 cannot effect on participant to change his misconception and learn how to describe the general procedures of constructing entity relationship modelling.

- **Conclusion of the effectiveness of GERM_3**

In conclusion, GERM_3 has effected on the participants who have some background knowledge in data modelling with using either object modelling or entity relationship modelling, in particular, in the part of definition and the notation. Moreover, it can also improve the skill of student, who have background knowledge, in constructing entity relationship modelling with both a case study of traditional scenario and simulation of real world scenario.

However, has not effected on the participant who has no background in data modelling. It is also not good enough to help the participants, who have background knowledge, to change their misconception and learn how to articulate the general procedures of constructing entity relationship modelling. The detail of the effectiveness of GERM_3 is shown in Table 6.31

Participant Background	Definition	Misconception	Notation	Traditional Case study	Simulation Case Study	Articulate of ER Modelling
No background Participant_7	×	×	×	×	×	×
Object Modelling Participant_8	√	×	√	√	√	×
ER Modelling Participant_9	√	×	√	√	√	×

Table 6.31 The effectiveness of GERM_3

6.6.4 GERM_4: Guided Entity Relationship Modelling with a simulation of real world situation scenario and a guidance feedback

Basically, GERM_4 has been developed by providing the database problem in term of a simulation of real world situation, which designers have to confront with the users' requirements and also have to deal with a variety of documents of a company (Chen, 1983). Moreover, the program employs a guidance feedback (Elsom-Cook, 1990) for helping students to learn and discover the knowledge in construct data modelling using entity relationship diagram.

However, the previous intelligent tutoring systems in teaching Data Modelling Subject from literature review: ERM-VLE (Hall & Gordon, 1998a; Hall & Gordon, 1998b; Hall & Gordon, 1998c), COLER (Constantino-Gonzalez & Suthers, 2000; Constantino-Gonzalez, et al., 2001) and KERMIT (Suraweera & Mitrovic, 2001)

normally provide a formal language in representing a case study of database problems that cannot represent the real world situation.

6.6.4.1 Participant_10: She is the first year of an undergraduate student in computing science course at the school of informatics. She has no background knowledge in Data Modelling Subject using Entity Relationship Diagram or Object Relation Modelling.

- **Pre-test Result**

Although the pre-test examination result shows that the student can choose some correct answers in the part of definition, such as strong entity type, relationship type and attribute etc, it is not significant enough to justify that she has some background knowledge in the definition part.

Nevertheless, she cannot draw notation or symbol in entity relationship diagram and has a misconception between entity type vs. entity instance, relationship type vs. relationship instance, and attribute vs. value. Furthermore, she also cannot describe the procedure of identifying entity type, relationship type and attribute. Moreover, she cannot construct entity relationship model with both a traditional scenario case study and a simulation of real world case study. The pre-test result detail is shown in Table 6.32.

Knowledge Types			GERM 4 & Participant 10		
			Correct	Total	(%)
Declarative Knowledge	Definition	Strong Entity Type	1	4	25%
		Weak Entity Type	0	4	0%
		Relationship Type	1	4	25%
		One-to-One Relationship	1	4	25%
		One-to-Many Relationship	1	4	25%
		Many-to-Many Relationship	0	4	0%
		Attribute	1	4	25%
		Primary Key	0	4	0%
	Misconception	Entity Type vs. instance	0	4	0%
		Attribute vs. Value	0	4	0%
		Relationship vs. instance	0	4	0%
	Notation	Entity Type	0	2	0%
		Relationship Type	0	4	0%
		Attribute	0	2	0%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Simulation Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Identifying Procedure	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	4	0%

Table 6.32: Pre-test result of participant 10 before practising GERM 4

- **Action of participant 10 in using GERM 4 (Appendix J)**

  - **At enterprise layer:** She collected all of requirement sources in this layer.
  - **At identifying layer:** At the beginning, she extremely struggled to find out the right answer. However, after trying to concentrate on guidance messages from GERM 4 she can select the right entity type, attribute. She looks so happy. However, she still struggled to find out the right relationship type. Furthermore, sometimes she selected entity instance

as an entity type but when he guidance messages, she can choose the right one.

- **At Representation Layer:** She did not try to move to this layer.

- **Post-test Result:** After using GERM 4, she took the post-test examination. The result of post-test examination (Table 6.33) reveals that she can select some more correct answers in the part of definition and misconception, it is significant enough to justify that she can improve her knowledge in such two parts.

However, the post-test examination result shows that she cannot make some more correct answers in the part of notation, a case study of traditional scenario, a case study of simulation of real world scenario, and the identifying procedure part. The comparison of pre-test examination result and post-test examination result is shown in Table 6.34

Knowledge Types			GERM 4 & Participant 10		
			Correct	Total	%
Declarative Knowledge	Definition	Strong Entity Type	4	4	100%
		Weak Entity Type	2	4	50%
		Relationship Type	3	4	75%
		One-to-One Relationship	3	4	75%
		One-to-Many Relationship	3	4	75%
		Many-to-Many Relationship	2	4	50%
		Attribute	4	4	100%
		Primary Key	2	4	50%
	Misconception	Entity Type vs. instance	3	4	75%
		Attribute vs. Value	4	4	100%
		Relationship vs. instance	3	4	75%
	Notation	Entity Type	0	2	0%
		Relationship Type	0	4	0%
		Attribute	0	2	0%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Simulation Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Identifying Procedure	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	4	0%

Table 6.33: Post-test result of participant 10 after practising GERM 4

Knowledge Types			GERM 4 & Participant 10		
			Pre-test	Post-test	Margin
Declarative Knowledge	Definition	Strong Entity Type	25%	100%	+75%
		Weak Entity Type	0%	50%	+50%
		Relationship Type	25%	75%	+50%
		One-to-One Relationship	25%	75%	+50%
		One-to-Many Relationship	25%	75%	+50%
		Many-to-Many Relationship	0%	50%	+50%
		Attribute	25%	100%	+75%
		Primary Key	0%	50%	+50%
	Misconception	Entity Type vs. instance	0%	75%	+75%
		Attribute vs. Value	0%	100%	+100%
		Relationship vs. instance	0%	75%	+75%
	Notation	Entity Type	0%	0%	0%
		Relationship Type	0%	0%	0%
		Attribute	0%	0%	0%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0%	0%	0%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	0%	0%
	Simulation Scenario	Entity Type Identifying	0%	0%	0%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	0%	0%
	Identifying Procedure	Entity Type Identifying	0%	0%	0%
		Relationship Type Identifying	0%	0%	0%
		Attribute Identifying	0%	0%	0%

Table 6.34: The pre/post-test comparison of participant 10

- **Summary the Result: GERM_4 & Participant_10**

According to the result of using GERM 4 of participant 10, the post-test examination result suggests that that she can improve her knowledge in the part of definition and misconception. However, she cannot increase her knowledge in other four parts e.g. the notation, the case study of traditional scenario, the case study of

simulation of real world scenario, and the identifying the procedure of constructing entity relationship model.

- **Discussion the Result: GERM_4 & Participant_10**

The participant has no background knowledge in data modelling using Entity Relationship Diagram. When he is practising GERM_4 that provides a case study of real world situation scenario, which is quit complicated but can represent a variety of situations in the real world, alongside with the guidance feedback (Elsom-Cook, 1990), it might help her to learn something more, in particular in the term of the definition of some key words and changing her misconception. As a result, the post-test examination result reveals that she has a significant improvement of her knowledge in the definition part and the misconception part.

However, because of the difficulty of a case study, she cannot enhance her knowledge in other four parts e.g. the notation, the case study of traditional scenario, the case study of simulation of real world scenario, and the identifying the procedure of constructing entity relationship model.

6.6.4.2 Participant_11: She is the fourth year of an undergraduate student in computing science course at the school of informatics. She used to attend data modelling module through being formulas with Object Oriented Data Modelling. Nevertheless, the interview reveals that she has no confidant in her background knowledge in data modelling and has no any background knowledge about Entity Relationship Diagram before.

- **Pre-test Result**

The result of pre-test examination reveals that the participant can choose 30% of the correct answers of the definition part which tests the definition of some keywords of entity relationship modelling such as strong entity type, weak entity type, relationship type, attribute, and primary key etc.

However, she still has misconception between entity type vs. entity instance and relationship type vs. relationship instance and attribute vs. value.

Moreover, the pre-test examination result also suggests that she has no background knowledge about notation or symbol in entity relationship diagram. Furthermore, she also cannot describe the procedure of constructing entity relationship modelling. She also has no any skill in constructing entity relationship model with either the traditional case study or simulation of real world case study. The result of pre-test examination is shown in Table 6.35.

Knowledge Types			GERM 4 & Participant 11		
			Correct	Total	%
Declarative Knowledge	Definition	Strong Entity Type	2	4	50%
		Weak Entity Type	0	4	0%
		Relationship Type	2	4	50%
		One-to-One Relationship	2	4	50%
		One-to-Many Relationship	1	4	25%
		Many-to-Many Relationship	0	4	0%
		Attribute	2	4	50%
		Primary Key	1	4	25%
	Misconception	Entity Type vs. instance	0	4	0%
		Attribute vs. Value	0	4	0%
		Relationship vs. instance	0	4	0%
	Notation	Entity Type	0	2	0%
		Relationship Type	0	4	0%
		Attribute	0	2	0%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Simulation Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Identifying Procedure	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	4	0%

Table 6.35: Pre-test result of participant 11 before practising GERM 4

- **Action of participant 11 in using GERM 4 (Appendix K)**

➢ **At enterprise layer:** She can collect only useful sources e.g. director's statement, manager' statement, sale's statement, staff form, branch report, member report, order form, video report etc.

➢ **At identifying layer:** At the beginning, she struggled to find out the right answer but after getting guidance messages from GERM 4 she can select the right entity type, attribute. However, she took quite a long time to find out the right relationship type. Furthermore, sometimes she selected entity instance as an entity type but when he guidance messages from GERM 4, she can choose the right one.

➢ **At Representation Layer:** At the beginning, she struggled to find out the right notation. However, she can learn the notation very well and pick up the right notation for constructing entity relationship diagram at last.

- **Post-test Result**: After practising GERM 4, she took the post-test examination (Table 6.36). The result of post-test examination reveals that she can improve her correct answers in every parts of exam papers as follows: 100 % of the notation part, ~83% in the misconception part, ~ 73 % in the case study of simulation scenario, ~ 67% in the identifying procedure part, and ~ 61% in the case study of traditional scenario part, ~ 44 % in the definition part. The comparison of pre-test result and post-test result is shown in Table 6.37

Knowledge Types			GERM 4 & Participant 11		
			Correct	Total	%
Declarative Knowledge	Definition	Strong Entity Type	4	4	100%
		Weak Entity Type	2	4	50%
		Relationship Type	4	4	100%
		One-to-One Relationship	4	4	100%
		One-to-Many Relationship	4	4	100%
		Many-to-Many Relationship	3	4	75%
		Attribute	4	4	100%
		Primary Key	3	4	75%
	Misconception	Entity Type vs. instance	3	4	75%
		Attribute vs. Value	4	4	100%
		Relationship vs. instance	3	4	75%
	Notation	Entity Type	2	2	100%
		Relationship Type	4	4	100%
		Attribute	2	2	100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	3	4	75%
		Relationship Type Identifying	2	4	50%
		Attribute Identifying	12	20	60%
	Simulation Scenario	Entity Type Identifying	3	4	75%
		Relationship Type Identifying	3	4	75%
		Attribute Identifying	14	20	70%
	Identifying Procedure	Entity Type Identifying	3	4	75%
		Relationship Type Identifying	2	4	50%
		Attribute Identifying	3	4	75%

Table 6.36: Post-test result of participant 11 after practising GERM 4

Knowledge Types			GERM 4 & Participant 11		
			Pre-test	Post-test	Margin
Declarative Knowledge	Definition	Strong Entity Type	50%	100%	+50%
		Weak Entity Type	0%	50%	+50%
		Relationship Type	50%	100%	+50%
		One-to-One Relationship	50%	100%	+50%
		One-to-Many Relationship	25%	100%	+75%
		Many-to-Many Relationship	0%	75%	+75%
		Attribute	50%	100%	+50%
		Primary Key	25%	75%	+50%
	Misconception	Entity Type vs. instance	0%	75%	+75%
		Attribute vs. Value	0%	100%	+100%
		Relationship vs. instance	0%	75%	+75%
	Notation	Entity Type	0%	100%	+100%
		Relationship Type	0%	100%	+100%
		Attribute	0%	100%	+100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	0%	75%	+75%
		Relationship Type Identifying	0%	50%	+50%
		Attribute Identifying	0%	60%	+60%
	Simulation Scenario	Entity Type Identifying	0%	75%	+75%
		Relationship Type Identifying	0%	75%	+75%
		Attribute Identifying	0%	70%	+70%
	Identifying Procedure	Entity Type Identifying	0%	75%	+75%
		Relationship Type Identifying	0%	50%	+50%
		Attribute Identifying	0%	75%	+75%

Table 6.37: The pre/post test comparison of participant 11

- **Summary: GERM_4 & Participant_11**

According to the post-test result of using GERM 4 of participant 11 suggests that GERM 4 can improve participant_11's knowledge in the knowledge of notation in entity relationship diagram, the definition of some important key words. Moreover, the post-test result also shows that GERM_4 can improve her skill in constructing entity relationship model with both a case study of simulation of real world scenario and traditional scenario. GERM 4 can also change her misconception between entity

type vs. entity instance, relationship type vs. relationship instance, and attribute vs. value and to help her to describe the procedure of constructing entity relationship model.

- **Discussion the Result: GERM_4 & Participant_11**

The participant has background knowledge in data modelling through being formulas with Object Oriented Modelling. When she is practising GERM_4, which separates the learning of entity relationship modelling into three simple layers: enterprise, identifying, and representation. GERM 4 also provides a case study of real world simulation scenario alongside a guidance feedback (Elsom-Cook, 1990), she might apply her previous background knowledge in Object Oriented Modelling and learn more about Entity Relationship Modelling.

As a result, the post-test examination result reveals that GERM_4 can help the participant to have some significant improvement of his knowledge in the notation in Entity Relationship Diagram and the definition of key words.

Furthermore, the program can also increase her skill in constructing entity relationship model with both a case study of traditional scenario and simulation of real world scenario. It is simply because the case study of GERM 4 can represent a variety of real world situation, such as the requirements of uses and a number of documents, which can make participant to learn more and improve her skill in data modelling for the real world situation.

Moreover, because of the combination of a variety of real world situations and a guidance feedback (Elsom-Cook, 1990), GERM 4 can assist the participant to change her misconception between entity type vs. entity instance, relationship type vs. relationship instance, and attribute vs. value. It also can help her to articulate the general procedures of constructing entity relationship modelling.

6.6.4.3 Participant_12: He is the third of an undergraduate student in computer science course at the school of informatics. He has some background knowledge in Data Modelling Subject using Entity Relationship Diagram from attending database module in the first year. The interview revealed that he has a confidant about his background knowledge in data modelling using entity relationship diagram and he also has got a quit good result with the examination in the data modelling module.

- **Pre-test Result**

Because the participant used to attend a module of entity relationship modelling, the result of pre-test examination reveals that he still has very good knowledge in the part of definition and notation or symbol and also has a very good skill in constructing entity relationship model with a traditional case study. However, the pre-test result also shows that the student has some misconception between entity type vs. entity instance and relationship type vs. relationship instance and attribute vs. value. Moreover, he cannot describe the procedure of constructing entity relationship modelling properly. He also has no skill enough to construct entity relationship modelling with a simulation of the real world case study. The pre-test result detail is shown in Table 6.38.

Knowledge Types			GERM 4 & Participant 12		
			Correct	Total	(%)
Declarative Knowledge	Definition	Strong Entity Type	4	4	100%
		Weak Entity Type	4	4	100%
		Relationship Type	4	4	100%
		One-to-One Relationship	4	4	100%
		One-to-Many Relationship	4	4	100%
		Many-to-Many Relationship	4	4	100%
		Attribute	4	4	100%
		Primary Key	4	4	100%
	Misconception	Entity Type vs. instance	2	4	50%
		Attribute vs. Value	2	4	50%
		Relationship vs. instance	2	4	50%
	Notation	Entity Type	2	2	100%
		Relationship Type	4	4	100%
		Attribute	2	2	100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	4	4	100%
		Relationship Type Identifying	4	4	100%
		Attribute Identifying	20	20	100%
	Simulation Scenario	Entity Type Identifying	0	4	0%
		Relationship Type Identifying	0	4	0%
		Attribute Identifying	0	20	0%
	Identifying Procedure	Entity Type Identifying	1	4	25%
		Relationship Type Identifying	1	4	25%
		Attribute Identifying	1	4	25%

Table 6.38: Pre-test result of participant 12 before practising GERM 4

- **Action of participant 12 in using GERM 4 (Appendix L)**

➢ **At Enterprise Layer:** He collected only useful sources e.g. director's statement, manager' statement, sale's statement, staff form, branch report, member report, order form, video report etc.

➢ **At Identifying Layer:** He can select the right entity type, attribute within a short periods of time. However, sometimes he selected entity instance as an entity type but when he guidance messages from GERM 4, he can choose the right one. Moreover, he has some problems in find out some relationship types but after get the guidance messages he can choose the right one.

➢ **At Representation Layer:** He can pick up the right notation for constructing entity relationship diagram very easily.

- **Post-test Result**: After practising GERM 4, he took the post-test examination (Table 6.39). The result of post-test examination reveals that he can make some more correct answers about 77 % in the case study of simulation scenario, 50% in the part of misconception and the identifying of the entity relationship modelling.

However, because of the strong basic background knowledge of the participant, the pre/post-test result cannot justify the improvement of the participant knowledge in the other three parts e.g. the notation part, the definition part, the case study of traditional scenario. The comparison of pre-test result and post-test result is shown in Table 6.40

Knowledge Types			GERM 4 & Participant 12		
			Correct	Total	%
Declarative Knowledge	Definition	Strong Entity Type	4	4	100%
		Weak Entity Type	4	4	100%
		Relationship Type	4	4	100%
		One-to-One Relationship	4	4	100%
		One-to-Many Relationship	4	4	100%
		Many-to-Many Relationship	4	4	100%
		Attribute	4	4	100%
		Primary Key	4	4	100%
	Misconception	Entity Type vs. instance	4	4	100%
		Attribute vs. Value	4	4	100%
		Relationship vs. instance	4	4	100%
	Natation	Entity Type	2	2	100%
		Relationship Type	4	4	100%
		Attribute	2	2	100%
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	4	4	100%
		Relationship Type Identifying	3	4	100%
		Attribute Identifying	20	20	100%
	Simulation Scenario	Entity Type Identifying	3	4	75%
		Relationship Type Identifying	3	4	75%
		Attribute Identifying	16	20	80%
	Identifying Procedure	Entity Type Identifying	3	4	75%
		Relationship Type Identifying	3	4	75%
		Attribute Identifying	3	4	75%

Table 6.39: Post-test result of participant 12 after practising GERM 4

Knowledge Types			GERM 4 & Participant 12		
			Pre-test	Post-test	Margin
Declarative Knowledge	Definition	Strong Entity Type	100%	100%	N/A
		Weak Entity Type	100%	100%	N/A
		Relationship Type	100%	100%	N/A
		One-to-One Relationship	100%	100%	N/A
		One-to-Many Relationship	100%	100%	N/A
		Many-to-Many Relationship	100%	100%	N/A
		Attribute	100%	100%	N/A
		Primary Key	100%	100%	N/A
	Misconception	Entity Type vs. instance	50%	100%	+50%
		Attribute vs. Value	50%	100%	+50%
		Relationship vs. instance	50%	100%	+50%
	Notation	Entity Type	100%	100%	N/A
		Relationship Type	100%	100%	N/A
		Attribute	100%	100%	N/A
Procedural Knowledge	Traditional Scenario	Entity Type Identifying	100%	100%	N/A
		Relationship Type Identifying	100%	100%	N/A
		Attribute Identifying	100%	100%	N/A
	Simulation Scenario	Entity Type Identifying	0%	75%	+75%
		Relationship Type Identifying	0%	75%	+75%
		Attribute Identifying	0%	80%	+80%
	Identifying Procedure	Entity Type Identifying	25%	75%	+50%
		Relationship Type Identifying	25%	75%	+50%
		Attribute Identifying	25%	75%	+50%

Table 6.40: The pre/post-test comparison of participant 12

- **Summary: GERM_4 & Participant_12**

According to the post-test result of using GERM 4 of participant 12 reveals that GERM 4 can increase participant_12's skill in constructing entity relationship model with a case study of simulation of real world scenario. It also can help the participant to change his misconception and to describe the process of constructing entity relationship model.

Nevertheless, because of the excellent basic background knowledge of the participant, we cannot conclude the improvement of the participant knowledge in the other three parts e.g. the notation part, the definition part, the case study of traditional scenario.

- **Discussion the Result: GERM_4 & Participant_12**

The participant has very good background knowledge in data modelling with Entity Relationship Modelling. When he is practising GERM_4, which separates a learning step for data modelling into three simple layers: enterprise layer, identifying layer, and represent layer, it might recall his previous background knowledge.

As a result, the post-test examination result reveals that GERM_4 can assist the participant to how to articulate the general procedures of constructing entity relationship model e.g. identifying entity type, identifying relationship, and attribute.

Furthermore, because of providing a case study of real world situation, such as the requirements of uses and a number of documents, GERM 4 might can assist the participant to learn more and increase his skill in data modelling with the real world situation. The result of post-test examination, therefore, reveals that the program can enhance participant' skill in constructing entity relationship model with a case study of simulation of real world scenario.

Moreover, because of the combination of a variety of real world situations and a guidance feedback (Elsom-Cook, 1990), GERM 4 can assist the participant to change his misconception between entity type vs. entity instance, relationship type vs. relationship instance, and attribute vs. value.

- **Conclusion of the effectiveness of GERM_4**

In conclusion, GERM_4 has effected on the participants who have some background knowledge in data modelling with using either object modelling or entity relationship modelling, in particular, in the part of definition, the notation, the misconception part, and the identifying procedure part. Furthermore, it can also improve the skill of students, who have background knowledge, in constructing entity relationship modelling with both a case study of traditional scenario and simulation of real world scenario.

However, GERM 4 can only improve the knowledge of the participant, who has no background in data modelling, in the definition part. The detail of the effectiveness of GERM_4 is shown in Table 6.41

Participant Background	Definition	Misconception	Notation	Traditional Case study	Simulation Case Study	Articulate of ER Modelling
No background Participant_10	√	√	×	×	×	×
Object Modelling Participant_11	√	√	√	√	√	√
ER Modelling Participant_12	N/A	√	N/A	√	√	√

Table 6.41 The effectiveness of GERM_4

6.7 Lecturers' View

The aim of this evaluation is to cross check with the results from the students in order to confirm the effectiveness of each GERM version in each topics e.g. definition, misconception, notation, traditional case study, simulation case study, and articulating of entity relationship procedure.

6.7.1 Participants

Evaluator A: He has a bachelor's degree and a master's degree in computer science. He is a lecturer at the university. He has experience in teaching data modelling using entity relationship modelling & object relation modelling for 10 years. He now is studying PhD. in database area.

Evaluator B: She has a bachelor's degree in computer science and a master's degree in computer science. She is a lecturer. She has experience in working for software company for 4 years and in teaching data modelling using entity relationship modelling & object relation modelling for 5 years. She now is studying PhD. in area artificial intelligent and education (AIED).

Evaluator C: He has a bachelor's degree and a doctor's degree in computer science. He has experience in working for software company as a database designers for 4 years and in teaching data modelling using entity relationship modelling & object relation modelling for 12 years. He is now a lecturer in area of database.

6.7.2 Procedure

- **Initial set up:** In this first step, the observer had to give important information to evaluator such as the detail of all step of evaluation procedure to make sure that evaluator were clear in every steps of evaluation procedure. Furthermore, the observer gave a chance for evaluator to ask any questions until they were happy.

- **Collecting Background Information:** The observer handed out background information paper sheet to evaluators to fill in their personal information such as surname, gender course study etc and also fill in their background knowledge/experience in data modelling using Entity Relationship Diagram. The observer also interviewed evaluator if they did not give the relevant background information.

- **Informed Consent Form:** The observer handed out evaluators informed consent form to read and sign to ensure that they are willing to be volunteers.

- **Training:** We developed a simple program that has the same features as the GERM Tutoring System for evaluator to practise before starting work with the real GERM Tutoring systems to ensure that they did not have any usability problems in using GERM Tutoring System.

- **Evaluation Process:** In this step, evaluators are practising all of four GERM versions. They can ask observer if they are not clear about each version. They also can take note about the detail of each GERM version.

- **Questionnaire:** In this step, observer handed out the questionnaire. Evaluator has to make decision and select the version of GERM for teaching each topic e.g. definition, misconception, notation, traditional case study, simulation case study, and articulating procedure by categorising learners into three levels e.g. no background, object relation modelling background, and entity relationship modelling background.

- **Interview:** After finishing the questionnaire, observer interviewed the evaluators to elicit the overall comments from them. Observer took notes the information of the interview.

6.7.3 Results

Evaluator A

A.1 The definition: The answer from the questionnaire about the tutoring system, which should use for teaching the definition, is shown in Table 6.42.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	√	×	×
Object Modelling	×	√	×	×
ER Modelling	×	√	×	√

Table 6.42 Evaluator A on the definition

Comments: Selecting GERM 2 for novice and students, who have some background about Object Relationship Modelling because GERM 2 provided a very simple scenario, which is suitable for them to learn about the definition. However, GERM 4 is look promising for teaching the students, who have background knowledge because it given a scenario, which similar with the real world situation. It might motivate students to learn about the definition and the real world problems as the same time.

A.2 The misconception: The answer from the questionnaire about the tutoring system, which should use for helping to change their basic misconception, is shown in Table 6.43.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	×	×	√
Object Modelling	×	×	×	√
ER Modelling	×	×	×	√

Table 6.43 Evaluator A on the Misconception

Comment: Obviously, GERM 4 can help all levels of students to change their basic misunderstanding because its scenario given a number of situations, which can help students to distinguish between the meaning of some basic terms such as entity type vs. entity instance etc. Even thought, its scenario is quite complicated but it separates steps of learning into three, which can help students to learn. It also provided a quite good guidance messages.

A.3 The notation: The answer from the questionnaire about the tutoring system, which should use for teaching the notation, is shown in Table 6.44.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	√	×	×
Object Modelling	×	√	×	×
ER Modelling	×	√	×	×

Table 6.44 Evaluator A on the Notation

Comment: No doubt about that GERM 2 is useful for teaching all levels of students about Notation because it provided a simple and precise scenario that is not complicated to pick up the correct answer and then students can learn about notation with a good guidance.

A.4 The tradition scenario case study: The answer from the questionnaire about the tutoring system, which should use for improving learners' skills in traditional case study, is shown in Table 6.45.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	√	×	×
Object Modelling	×	√	×	√
ER Modelling	×	√	×	√

Table 6.45 Evaluator A on the traditional case study

Comment: Obviously, GERM 2 is a good tutoring for increasing novices' skill in constructing ERM with the traditional case study because it provided a scenario that is the same scenario with the traditional case study. However, for students, who have background knowledge it is hard to choose between GERM 2 and GERM 4 because GERM 2 has the same scenario with the traditional case study whereas GERM 4 can challenge students with the complicated scenario that similar with the real world situation. It might be an interesting question.

A.5 The simulation scenario case study: The answer from the questionnaire about the tutoring system, which should use for improving learners' skills in simulation case study, is shown in Table 6.46.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	√(1)	×	√(2)
Object Modelling	×	×	×	√
ER Modelling	×	×	×	√

Table 6.46 Evaluator A on the simulation case study

Comment: For the students, who have some background knowledge in Data Modelling, GERM 4 might be useful and more challenge for them to learn to deal with the real world situation. They can then improve their skill in constructing ERM with a simulation case study. However, in order to increase novices' skill in constructing Entity Relationship Modelling with the simulation case study, they should practise with GERM 2 it provided a simple scenario and follow by GERM 4, which provided the complicated scenario that similar with the real world situation.

A.6 The articulation of entity relationship modelling: The answer from the questionnaire about the tutoring system, which should use for improving learners' skills in articulation of entity relationship modelling, is shown in Table 6.47.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	√	×	√
Object Modelling	×	×	×	√
ER Modelling	×	×	×	√

Table 6.47 Evaluator A on the articulation of ERM Process

Comments: It is quite hard to make decision for teaching novice between GERM 2 and GERM 4. GERM 2 provided a very simple scenario with guidance messages, which is suitable for them but its scenario cannot represent a variety of situations whereas GERM 4 can provided a variety of situations and different layers of learning, which can make students clear more about the procedure. However, for the students, who have background knowledge GERM 4 is quite useful because it can represent different kinds of the real world situations, which can make students clear all of steps of constructing Entity Relationship Modelling. It also can help students to realise about the real world problems.

Evaluator B

B.1 The definition: The answer from the questionnaire about the tutoring system, which should use for teaching the definition, is shown in Table 6.48.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	√	×	×
Object Modelling	×	×	×	√
ER Modelling	×	×	×	√

Table 6.48 Evaluator B on the definition

Comment: Selecting GERM 2 for novice is simply because GERM 2 provided a very simple scenario which is suitable for novice. Selecting GERM 4 for teaching the students, who have background knowledge because it provides a complicated scenario in which similar with the real world situation. It also can help students to realise about the real world problems.

B.2 The misconception: The answer from the questionnaire about the tutoring system, which should use for helping to change their basic misconception, is shown in Table 6.49.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	×	×	√
Object Modelling	×	×	×	√
ER Modelling	×	×	×	√

Table 6.49 Evaluator B on the Misconception

Comment: Selecting GERM 4 for help students to change their basic misunderstanding because its scenario can represent some situations in which can help students to distinguish between the meaning of some basic terms such as entity type vs. entity instance etc.

B.3 The notation: The answer from the questionnaire about the tutoring system, which should use for teaching the notation, is shown in Table 6.50.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	√	×	×
Object Modelling	×	×	×	√
ER Modelling	×	×	×	√

Table 6.50 Evaluator B on the Notation

Comment: Selecting GERM 2 for teaching novice about Notation because it provided a simple scenario that is easy to choose the correct answer and then students can learn about notation within the same screen. However, GERM 4 is suitable for students who have background knowledge because it can challenge students with the complicated scenario that similar with the real world situation.

B.4 The tradition scenario case study: The answer from the questionnaire about the tutoring system, which should use for improving learners' skills in traditional case study, is shown in Table 6.51.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	√	×	×
Object Modelling	×	×	×	√
ER Modelling	×	×	×	√

Table 6.51 Evaluator B on the traditional case study

Comment: Selecting GERM 2 for improving novices' skill in constructing ERM with the traditional case study because it provided a simple scenario that is the same scenario with the traditional case study. However, GERM 4 is useful for students, who have background knowledge because it can challenge students with the complicated scenario that similar with the real world situation. I do believe that if students can learn to deal with the difficult problems, they can apply their experience to sort out the simple problems very easily.

B.5 The simulation scenario case study: The answer from the questionnaire about the tutoring system, which should use for improving learners' skills in simulation case study, is shown in Table 6.52.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	√(1)	×	√(2)
Object Modelling	×	×	×	√
ER Modelling	×	×	×	√

Table 6.52 Evaluator B on the simulation case study

Comment: In order to enhance novices' skill in constructing Entity Relationship Modelling with the simulation case study, they should practise with GERM 2 first because it provided a simple scenario that is easy to learn in the beginning stage after that they can use GERM 4 because it provides the complicated scenario that similar with the real world situation. However, for the students, who have some background knowledge in Data Modelling, GERM 4 might be useful and more motivate for them to learn to deal with the real world situation. Therefore, they can start with GERM 4.

B.6 The articulation of entity relationship modelling: The answer from the questionnaire about the tutoring system, which should use for improving learners' skills in articulation of entity relationship modelling, is shown in Table 6.53.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	√	×	×
Object Modelling	×	×	×	√
ER Modelling	×	×	×	√

Table 6.53 Evaluator B on the articulation of ERM Process

Comment: Selecting GERM 2 for novice is simply because GERM 2 provided a very simple scenario with guidance messages. Even though the simple scenario cannot provide a variety of situations, it is suitable for the novice and the guidance messages might help students to know about the procedures of constructing Entity Relationship Modelling. However, GERM 4 is suitable for the students, who have background knowledge because it can represent different kinds of the real world

situations, which can make students clear all of steps of constructing Entity Relationship Modelling. It also can help students to realise about the real world problems.

Evaluator C

C.1 The definition: The answer from the questionnaire about the tutoring system, which should use for teaching the definition, is shown in Table 6.54.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	√	×	×
Object Modelling	×	×	×	√
ER Modelling	×	×	×	√

Table 6.54 Evaluator C on the definition

Comment: The reason for choosing GERM 2 for novice is because the scenario of GERM 2 represented database requirement in term of describing all of requirement of organisation together, which is easy and motivate for novice student to pick up the right answer. However, the scenario of GERM 4 is suitable for the students, who have background knowledge because it provides a scenario that separated a variety of requirements in the different sources in which similar with the real world situation. It might be challenging and motivating for the students, who have background knowledge. It also can help students to realise about the real world problems before going to work for the real company.

C.2 The misconception: The answer from the questionnaire about the tutoring system, which should use for helping to change their basic misconception, is shown in Table 6.55.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	√(1)	×	√(2)
Object Modelling	×	√(1)	×	√(2)
ER Modelling	×	√(2)	×	√(2)

Table 6.55 Evaluator C on the Misconception

Comment: For students, who have basic misconception should begin with practising GERM 2 until they have background knowledge. After that they can then practising GERM 4 because its scenario provided some situations and

guidance in which can make students clear about the meaning of some basic terms such as entity type vs. entity instance etc.

C.3 The notation: The answer from the questionnaire about the tutoring system, which should use for teaching the notation, is shown in Table 6.56.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	√	×	×
Object Modelling	×	×	×	√
ER Modelling	×	×	×	√

Table 6.56 Evaluator C on the Notation

Comment: Selecting GERM 2 for teaching novice about Notation because its scenario is not complicated to choose the correct answer and then students can learn about any kinds of notations within the same interface screen. However, GERM 4 might be suitable for students, who have background knowledge. Although its scenario is quit complicated, it might motivate students to learn with the real world situation. Moreover, its interface is divided into three layers: enterprise, identifying, and representation. Students, therefore, can learn only notation in the representation layer.

C.4 The tradition scenario case study: The answer from the questionnaire about the tutoring system, which should use for improving learners' skills in traditional case study, is shown in Table 6.57.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	√	×	×
Object Modelling	×	√	×	×
ER Modelling	×	√	×	×

Table 6.57 Evaluator C on the traditional case study

Comment: Selecting GERM 2 to enhance students' skill in constructing Entity Relationship Modelling with the traditional case study because it provided a simple scenario that is the same scenario with the traditional case study. Moreover, GERM 2 also has some guidance to help students.

C.5 The simulation scenario case study: The answer from the questionnaire about the tutoring system, which should use for improving learners' skills in simulation case study, is shown in Table 6.58.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	√(1)	×	√(2)
Object Modelling	×	×	×	√
ER Modelling	×	×	×	√

Table 6.58 Evaluator C on the simulation case study

Comment: For the students, who have some background knowledge in Data Modelling, GERM 4 might be useful and more challenge for them. Because GERM 4 provided the simulation of real world situations in which students have to handle with many kinds of requirement sources. So they can learn to deal with the real world situation. However, in order to increase novices' skill in constructing Entity Relationship Modelling with the simulation case study, they should learn with GERM 2 first because it is easy to learn in the beginning stage after that they can move to learn GERM 4 because it provide the complicated scenario that similar with the real world situation.

C.6 The articulation of entity relationship modelling: The answer from the questionnaire about the tutoring system, which should use for improving learners' skills in articulation of entity relationship modelling, is shown in Table 6.59.

Participant Background	All versions of GERM			
	GERM 1	GERM 2	GERM 3	GERM 4
No background	×	√	×	×
Object Modelling	×	×	×	√
ER Modelling	×	×	×	√

Table 6.59 Evaluator C on the articulation of ERM Process

Comment: No doubt about that GERM 4 is useful for the students, who have background knowledge because it given different kinds of the real situations, which can make students clear all of procedures of constructing Entity Relationship Modelling. GERM 4 also provided a very good guidance. However,

GERM 2 is suitable for novices. Although the simple scenario cannot represent a variety of situations, it is suitable for the novice and the guidance messages might help students to know about the procedures of constructing Entity Relationship Modelling.

6.8 Discussion of Data Collection Approach

6.8.1 Qualitative Method: Because our chosen evaluation approach involved observing participants' interaction over an extended period of time, large numbers of subjects would have been unwieldy to observe (and would have led to very large amounts of qualitative data). Thus, this study was better suited to a small number of participants which, in turn, means that investigation of the data through inferential statistics is inappropriate (the sample size being too small for such techniques). Thus we selected a qualitative approach for collecting data in order to be able to study learning as a process rather than taking a snapshot view. We studied subjects interacting with the tutoring systems over an extended period of time which meant that the small group of participants allowed a detailed investigation of the learning process for individual. In all, around 48 hours were spent in observation of the two data sources: twelve students (36 hours of observational data) and three lecturers (12 hours of observational data).

6.8.2 Participants: Because of the uncontrolled nature of participant selection, we have a variety of participant backgrounds and characteristics that are quite hard to compare and generalise results from. However, we can compare and justify their knowledge improvement from the pre-test and post-test results.

6.8.3 Instruments: Some participants had no background in data modelling. Therefore, they had some difficulty in using of the GERM system which may have had an effect on the results of our study. However, the evaluation protocol contained a training section to allow participants to familiarise themselves with the program and get rid of some errors in using the system.

6.9 Summary

The results of the evaluation of the four GERM versions indicate how effective each version was in helping learners with the six main knowledge types: the basic definition, the basic misconception, the basic notation, the traditional case study, the

simulation case study, and the articulation of entity relationship procedure. A summary of the main results for each version of the system is given below.

GERM 1

The GERM 1 tutoring system was shown to improve declarative knowledge for the participants who had some background knowledge in data modelling (either entity relationship modelling or object modelling); in particular, it improved knowledge in definitions and notation. It was also shown to improve procedural knowledge of constructing entity relationship modelling for a case study in using a traditional scenario for those participants who had some background knowledge in data modelling. However, no improvement was seen across any of the knowledge types for the participants who had no background knowledge of data modelling.

GERM 2

The GERM 2 system was shown to improve declarative knowledge for all participants (regardless of their data modelling background) in particular for the definition and notation types. Moreover, it also led to improved procedural knowledge for participants in constructing entity relationship modelling for a case study based on a traditional scenario. However, it did not improve procedural knowledge in constructing entity relationship models for the simulation situation, or for describing the procedure for identifying entity type, relationship type and attribute

GERM 3

The GERM 3 tutoring system was shown to be effective for participants with some background data modelling knowledge in improving their declarative knowledge, in particular, for definitions and notations. It was also shown to improve procedural knowledge in constructing entity relationship modelling in both the traditional scenario and simulation scenario. However, participants with no background in data modelling did not benefit from using GERM 3.

GERM 4

The GERM 4 system was shown to improve participants' declarative knowledge (in particular, definition, notation, misconception knowledge) for the participants with background knowledge of data modelling. Furthermore, for these participants, the system also led to improvements in their procedural knowledge of constructing entity relationship modelling, and in articulating the procedure of entity relationship modelling both in the traditional scenario and the real world simulation scenario.

However, for the participants who had no background knowledge of data modelling GERM 4 only led to improvement in definition knowledge.

In the next chapter we will discuss the meaning and implications of these results and will reflect upon the problems and limitations of our methodological approach.

CHAPTER 7

CONCLUSION AND FURTHER WORK

7.1 Summary of Research carried out

This research was carried out in order to answer two main research questions. First, to what extent can a simulation of a real world situation improve the quality of learning in database design? Second, the extent to which guided discovery teaching strategy can enhance the learning of database design within a real world context? The summary of the work is as follows:

7.1.1 Investigate & Design of a framework for simulating database requirements in a real world situation

We began the study by investigating the structure of an organisation in the real world and designing a framework for simulating the information of this organisation. We proposed that the information structure of real world organisations should be divided into three layers: executive, management, and operational. Each layer consists of two main information sources: users' requirement and document systems. Therefore, we implemented this framework into our tutoring system called GERM.

7.1.2 Investigate & Design of guided discovery strategies for teaching data modelling within a real world context

From the investigation of learning theory used in developing tutoring systems, we chose a constructivist theory as the mosgt approprite approach , and guided discovery learning as a teaching strategy within a simulation of a real world situation. We proposed two specific teaching strategies for constructing entity relationship diagrams(ERM) within a guided discovery learning environment. Firstly, giving some guidance to help the leaner to get rid of non-relevant information for constructing ERM. Secondly, providing some guidance messages about some basic knowledge e.g. definition to assist learner to construct ERM.

7.1.3 Implementation of four versions of GERMs

In order to evaluate the effectiveness of our simulation framework and the value of guided discovery learning (GDL) approach, four tutoring systems called GERM $_1$, GERM $_2$, GERM $_3$, and GERM $_4$ were developed, variously incorporating a

traditional scenario, a simulation scenario, a GDL approach, and a non-GDL approach. A summary of the strategies employed by the four GERM systems is given in Table 7.1.

Version	Requirement Scenario	Pedagogical Strategies
GERM 1	Traditional Scenario	Simple feedback (Yes/No)
GERM 2	Traditional Scenario	Guided Discovery Strategy
GERM 3	Simulation Scenario	Simple feedback (Yes/No)
GERM 4	Simulation Scenario	Guided Discovery Strategy

Table 7.1 The summary of four versions of GERMs

7.1.4 Evaluation Method

In order to study the learners' interactions and learning processes a qualitative approach was chosen which also allowed some quantitative analysis. Around 48 hours of observational data were collected from two data sources: Twelve learners (36 hours) and three lecturers (12 hours). We divided the twelve learners into three groups. Group A consisted of those with no background of data modelling. Group B contained learners who had some background in data modelling but have no background in entity relationship diagrams. Group C is composed of who had a background in data modelling with entity relationship diagrams. Each group was tested with all four versions of GERM. The group of three lecturers also used all four versions of GERM and gave detailed feedback. Therefore, we can bring data from two sources to cross check the results and draw conclusions. In term of data analysis, each learner's work was analysed in relation to six basic knowledge items. Three aspects of declarative knowledge e.g. definition, misconception, and notation. Another three aspects of procedural knowledge e.g. skill of constructing ERM with a traditional case study, skill of constructing ERM with a simulation case study, and skill in articulating ERM procedure. In term of knowledge measurement, we use pre/post test approach in measuring the improvement of each kind of learners' knowledge. The correct answers from pre/post test examination results will be calculated into percentage of correct answers. The margin of percents between pre-test examination result and post-test examination result, therefore, is the effectiveness of each topics in paper test.

7.1.5 Evaluation Results

Overall, the results of the evaluation study suggests that a traditional teaching scenario using GDL is useful for novice students for improving their knowledge of definitions and notation, and their skills in solving a traditional case study. However, the simulation scenario with GDL is suitable for all students for improving their misconception knowledge, their skill in solving a simulation-based case study, and their skill in articulating the process of constructing entity relationship diagrams. A summary of the results is given below in Table 7.2 which shows the combinations of teaching scenario and guidance strategy that led to knowledge improvement in two classes of learner: those with background knowledge of data modelling and those with no background knowledge of data modelling.

Learners' Background	Declarative Knowledge			Procedural Knowledge		
	Definition	Mis-conception	Notation	Traditional Case Study	Simulation Case Study	Articulation Of ERM
No	**T&G**	**S&G**	**T&G**	**T&G**	**T&G ⇒ S&G**	**T&G ⇒ S&G**
Yes	**S&G**	**S&G**	**S&G**	**T&G Or S&G**	**S&G**	**S&G**

Table 7.2: The summary of the evaluation result

T = Traditional Scenario
S = Simulation Scenario
G = Guided Discovery Approach
& = Combination
⇒ = Followed by

7.2 Contributions of the research

From the results of our study, we can state the contributions of this work in terms of the effectiveness of the simulation scenario, the traditional scenario, and guidance strategies in teaching data modelling by categorising the results into two knowledge types: declarative and procedural. The details of the contributions are discussed below.

7.2.1 Effect on the declarative knowledge

- **Definition knowledge:** The study suggest that a traditional scenario with a guided discovery learning strategy is useful for teaching the basic definitions of data modeling with entity relationship diagrams for novice

students because the scenario is simple to understand and can motivate them to learn. The strategy also can assist them to find out correct anrwers. However, the simulation scenario with a guidance feedback strategy might be more suitable for students who have some prior knowledge of data modelling and who need to improve their definition knowledge – this is because the simulation scenario can motivate and challenge them to learn.

- **Misconceptions:** The study suggests that a simulation scenario with a guided discovery learning strategy is better at helping students change their misconceptions because it can provide a variety of situations in which the system can support students to realise that they have some misconceptions. The tutoring system, therefore, should provide students with a simulation scenario to help them change their basic misconception. However, for novice students (no prior knowledge of data modelling), it might still be useful for them to learn the basic concepts with a traditional scenario follow this with a simulation scenario in order to change their misconceptions.
- **Notation:** The study suggests that the traditional scenario with a guided discovery learning strategy is useful for teaching the basic data modelling notations for novice students because the scenario is simple to understand and can motivate them to select up the correct entity types, relationship types, and attributes. The strategy also can guide them to learn about the basic definition. However, a simulation scenario with guidance feedback may be more suitable for students who have some background knowledge and need to improve their notation knowledge because the simulation scenario can motivate and challenge them to learn. the same things from the different scenario.

7.2.2 Effect on the procedural knowledge

- **The Traditional Case Study:** The research suggests that a tutoring system should use a traditional scenario (formal language) with guidance feedback to improve novice learners' skill in constructing entity relationship models. However, a simulation scenario with guidance feedback is useful for improving this skill in students who have some background in data modelling.

- **The Simulation Case Study:** The results of the study suggest that a tutoring system should provide a simulation scenario with guidance feedback to improve students' skill in constructing entity relationship models in a real world situation. However, for novice students, it might be more useful for them to learn the basic concept with the traditional scenario and follow this with the simulation scenario in order to improve their skill at managing real world situation.
- **Articulation of the ER modelling process:** The study suggests that tutoring systems should provide a simulation scenario with guidance feedback to help students develop skills in articulating the process of constructing entity relationship models. Nevertheless, for novice students, it might still be better for them to begin with the traditional scenario, which is simple to learn followed by the simulation scenario, which can provide a variety of real world situations, to help them develop their knowledge about the entity relationship modelling process.

7.2.3 Contribution to the knowledge for implementing a tutoring System for teaching ERM

The four GERM systems themselves are an important contribution of this research. By providing a common framework in which both simulation and traditional case studies can be presented with a guidance feedback or simple feedback strategy, they offer a useful platform for future experiments which need to compare teaching and guidance strategies for tutoring systems. The GERM designs can also be used as a model for the design of future tutoring systems as lessons can be learnt from the participants' experience with their interfaces.

7.3 Limitations and Reflections

7.3.1 Design of a Simulation of a Real World Organisation

In general, a real world organisation consists of five departments (Laurie, 1999): Personnel, Production, Marketing, Financial and Research & Development. Each department is separated into three layers of information: Operational, Managerial and Executive (Leonard & Joseph., 1999). We want students to learn how to construct entity relationship diagrams by considering these layers first. Therefore, our simulation of the organisation was not designed to support a simulation of all five

departments. However, we realise that it is also very useful for students to learn a more realistic model of an organisation later. Of course, not all organisations are neatly partitioned into five departments, so it was more instructive in this research to focus on the managerial, operational, and executive layers of information.

7.3.2 Design of pedagogical strategy

We designed our pedagogical strategy around a guided discovery leaning approach, which is based on constructivist theory. Jonassen (1994) proposed eight characteristics of constructivist learning environments: multiple representations of reality, representing the complexity of the real world, an emphasis on knowledge construction, emphasising authentic tasks in a meaningful context rather than abstract instruction out of context, providing real-world settings or case-based learning instead of predetermined sequences of instruction, encouraging thoughtful reflection on experience, emphasising context and content dependent knowledge construction, and supporting collaborative construction of knowledge through social negotiation. It was beyond the scope of our research to support collaborative learning. This aspect should be addressed in future work.

7.3.3 Implementation Tool

Because the focus of the research was on comparing different teaching and feecback strategies within a common tutoring system environment, Visual Basic (VB) and Microsoft agent were chosen for implementing the GERM systems because they allowed the four prototypes to be built in a reasonable timescale. Because of this, the systems have some remaining constraints, namely they cannot run on every operating system platform and it is not straightforward to create intelligent modules such as the learner model. Therefore, for the next phase of the research it is proposed to move to a Prolog-based implementation to raise the system into a professional level of ITS.

7.3.4 Evaluation Method

7.3.4.1 Evaluation Approach: Although we have two sources of participants (students and lecturers) which allows more in-depth analysis of the results, the qualitative approach taken meant the number of participants was small. This makes quantitative inferential statistical analysis of the results unsuitable. Future studies could be conducted with larger numbers of participants in a hypothesis testing approach which would allow a richer picture to emerge as well as triangulation with the results of this study.

7.3.4.2 Recruitment of Participants: Because of the recruitment method (an invitation emil) it was not possible to control for the characteristics of the subjects. However, the use of pre- and post-tests reduced the problems associated with this. A future study (especially a quantitative one) would need a more randomly selected and representative set of subjects.

7.3.4.3 Instrument: Because some parts of the paper tests used multiple choice and true/false-type questions to evaluate participants' knowledge, it was possible to get correct answers by guessing. In future, this could be controlled by adopting a negative marking scheme (deducting marks for incorrect answers), or by offering more open questions which reduce the scope for guesswork. Also, with a larger number of participants, answers could be checked for evidence of guesswork by using statistical techniques such as the χ^2 test. However, the open-end answer paper test can be demotivating because they can take longer to answer.

7.4 Further Work

7.4.1 Quantitative Evaluation

In order to allow statistical analysis of the results, it is planned to conduct a second evaluation of the four GERM systems a larger number of participants. The results of the quantitative evaluation can be used to cross check the qualitative evaluation in this thesis.

7.4.2 Extending the Learning Environment

One difficulty with database design is the complexity of application domain. In the real world there are many kinds of organisations in which designers have to learn. This work, therefore, should be extended to investigate and design a framework for simulating more kinds of real world organisation; this would allow the creation of learning environments that are much closer to the real world situations they represent.

7.4.3 Design the Curriculum Framework for Teaching ERM

The complexity of entity relationship modelling task (such as the complexity of relationship degrees) should be assessed (perhaps by a survey of learners) so that the degree of complexity can be categorised and together with the results of this research (see Table 7.2). This would provide a strong curriculum framework for the future design and development of tutoring systems for entity relationship modelling.

7.4.4 Developing Tutoring System for Teaching Data Modelling

Generally, a student cannot learn all the subject matter in a substantial and complex domain in one step. The subject matter, therefore, must be divided into units, each unit dealing with a part of the whole spectrum, and ordered in sequence that can be traversed by the learner. In an educational learning environment, we have to create a progression of models in which a gradual transition from novice to expert is made (White, 1990). This work would bring knowledge gained from this research to the development of future intelligent tutoring systems for teaching data modelling.

This thesis has indicated that a simulation of a real world situation is capable of improving the quality of learning in database design. Specifically, the indications are that when students have some background in database design with entity relationship modelling or object oriented relational modelling then a simulation of the real world situation may be highly effective in supporting them to change their basic misconceptions and also to enhance their skills in database design in a the real world situation. A further result is that database design novices might profit more from a guided discovery approach within a more traditional scenario. Furthermore, the evidance from the result of the study (See Table 7.2) shows that a guided discovery approach can work alongside both a traditional scenario and a simulation scenario better than providing only simple feedback.

The two major implications for future systems are: 1) there are significant benefits in developing systems that teach learners in a maner that respects the real world context, and 2) that guided discovery learning can be effective but that this depends on a very careful analysis of the situation. Further, there has to be some care taken to ensure that learners have sufficient experience of the domain to manage the more complex simulation scenario.

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APPENDIX A

The Action of Participant 1 in practising GERM 1

#	Scenario Area Action (Click)	GERM Action	Notation Area Action (Click)	GERM Action	Drawing Area Action (Click)	GERM Action
1	Videos	Yes				
2				Yes		
3					Space area	Yes
4	Staffs	Yes				
5				Yes		
6					Space area	Yes
7	Member	Yes				
8				Yes		
9					Space Area	Yes
10	Order	Yes				
11				Yes		
12					Space Area	Yes
13	Supplier	Yes				
14				Yes		
15					Space Area	Yes
16	Branch	Yes				
17				Yes		
18					Space Area	Yes
19	ID:branch	Yes				
20				Yes		
21					Branch	Yes
22	Name: branch	Yes				
23				Yes		
24					Branch	Yes
25	Address:branch	Yes				
26				Yes		
27					Branch	Yes
28	Phone:branch	Yes				
29				Yes		
30					Branch	Yes
31	Fax:branch	Yes				
32				Yes		
33					Branch	Yes
34	ID: video	Yes				
35				Yes		
36					Video	Yes
37	Title: video	Yes				
38				Yes		
39					Video	Yes
40	Genre: video	Yes				
41				Yes		
42					Video	Yes
43	Length: video	Yes				
44				Yes		
45					Video	Yes
46	ID: staff	Yes				
47				Yes		
48					Staff	Yes

49	Name: staff	Yes				
50				Yes		
51					Staff	Yes
52	Address: staff	Yes				
53				Yes		
54					Staff	Yes
55	Position: staff	Yes				
56				Yes		
57					Staff	Yes
58	Salary: staff	Yes				
59				Yes		
60					Staff	Yes
61	ID: Member	Yes				
62				Yes		
63					Member	Yes
64	Name: Member	Yes				
65				Yes		
66					Member	Yes
67	Address: member	Yes				
68				Yes		
69					Member	Yes
70	Jointdate	Yes				
71				Yes		
72					Member	Yes
73	ID: order	Yes				
74				Yes		
75					Order	Yes
76	Orderdate	Yes				
77				Yes		
78					Order	Yes
79	Requiredate	Yes				
80				Yes		
81					Order	Yes
82	ID: supplier	Yes				
83				No		
84				Yes		
85					Supplier	Yes
86	Name:supplier	Yes				
87				Yes		
88					Supplier	Yes
89	Address: supplier	Yes				
90				Yes		
91					Supplier	Yes
92	Phone: supplier	Yes				
93				Yes		
94					Supplier	Yes
95	Fax: supplier	Yes				
96				Yes		
97					Supplier	Yes

APPENDIX B

The Action of Participant 2 in practising GERM 1

#	Scenario Area Action (Click)	GERM Action	Notation Area Action (Click)	GERM Action	Drawing Area Action (Click)	GERM Action
1	Title	Yes				
2				No		
3	Information	No				
4	Branch	Yes				
5			1 — 1	No		
6				No		
7				Yes		
8					Space Area	Yes
9	Data	No				
10	Name: branch	Yes				
11				No		
12				Yes		
13					Branch	Yes
14	Staff	Yes				
15				No		
16			N — 1	No		
17				No		
18			N — M	No		
19				Yes		
20					Space Area	Yes
21	Videos	Yes				
22				No		
23			N — 1	No		
24			N — M	No		
25				No		
26				Yes		
27					Space Area	Yes
28	Order	Yes				
29			1 — N	No		
30				Yes		
31					Space Area	Yes
32	Phone: branch	Yes				
33				No		
34				No		
35				Yes		
36					Branch	Yes
37	Fax: branch	Yes				
38				Yes		
39					Branch	Yes
40	Company	No				
41	Address: staff	Yes				
42				Yes		
43					Staff	Yes
44	Member	Yes				
45				No		
46				No		

47				Yes		
48					Space Area	Yes
49	Supplier	Yes				
50				Yes		
51					Space Area	Yes
52	ID: supplier	Yes				
53				No		
54				Yes		
55					Supplier	Yes
56	ID: order	Yes				
57				Yes		
58					Order	Yes
59	ID: Member	Yes				
60				Yes		
61					Member	Yes
62	ID: Staff	Yes				
63				Yes		
64					Staff	Yes
65	Data	No				
66	Hold	No				
67	On	No				
68	Name: Member	Yes				
69				No		
70				Yes		
71					Member	Yes
72	Orderdate	Yes				
73				No		
74				Yes		
75					Order	Yes
76	Also	No				
77	Orderdetail	Yes				
78				No		
79				No		
80				Yes		
81					Space Area	Yes
82	ItemID	Yes				
83				Yes		
84					Orderdetail	Yes
85	VideoTitle	Yes				
86				No		
87				Yes		
88					Orderdetail	Yes
89	Quantity	Yes				
90				Yes		
91					Orderdetail	Yes
92	UnitPrice	Yes				
93				Yes		
94					Orderdetail	Yes
95	Any	No				
96	Will	No				
97	Buy	Yes				
98			1 N	No		
99			N 1	Yes		
100					Order/Supplier	Yes
101	From	No				
102	The	No				
103	Detail	No				
104	Is	No				
105	Composed	No				
106	Address:supplier	Yes				
107				Yes		

108					Supplier	Yes
109	Phone:supplier	Yes				
110				Yes		
111					Supplier	Yes
112	Throughout	No				
113	UK	No				
114	Each	No				
115	ID:branch	Yes				
116				Yes		
117					Branch	Yes
118	Address:branch	Yes				
119				Yes		
120					Branch	Yes
121	Stock	No				
122	ID: video	Yes				
123				Yes		
124					Video	Yes
125	Title: video	Yes				
126				Yes		
127	Genre: video	Yes			Video	Yes
128				Yes		
129					Video	Yes
130	Length: video	Yes				
131				Yes		
132					Video	Yes
133	Who	No				
134	Work for	Yes				
135			1 — 1	No		
136			1 — N	No		
137			N — 1	Yes		
138					Staff/branch	Yes
139	Name: Staff	Yes				
140				Yes		
141					Staff	Yes
142	Position: Staff	Yes				
143				Yes		
144					Staff	Yes
145	Salary: Staff	Yes				
146				Yes		
147					Staff	Yes
148	Register	Yes				
149			N — 1	Yes		
150					Member/staff	Yes
151	Rent	Yes				
152			N — 1	No		
153			1 — N	Yes		
154					Staff/video	Yes
155	Address:member	Yes				
156				Yes		
157					Member	Yes
158	Joindate	Yes				
159				Yes		
160					Member	Yes
161	Require	Yes				
162			N — 1	No		
163			N — M	Yes		
164					Video/order	Yes
165	Make	Yes				
166			1 — 1	No		
167			1 — N	Yes		
168					Staff/order	Yes

169	Requiredate	Yes				
170				Yes		
171					Order	Yes
172	Name:supplier	Yes				
173				Yes		
174					Supplier	Yes
175	Fax: supplier	Yes				
176				Yes		
177					Supplier	Yes
178	So	No				

APPENDIX C

The Action of Participant 3 in practising GERM 1

#	Scenario Area Action (Click)	GERM Action	Notation Area Action (Click)	GERM Action	Drawing Area Action (Click)	GERM Action
1	Company	No				
2	Branch	Yes				
3				Yes		
4					Space Area	Yes
5	ID:branch	Yes				
6				Yes		
7					Branch	Yes
8	Name: branch	Yes				
9				Yes		
10					Branch	Yes
11	Address:branch	Yes				
12				Yes		
13					Branch	Yes
14	Phone:branch	Yes				
15				Yes		
16					Branch	Yes
17	Stock	No				
18	Videos	Yes				
19				Yes		
20					Space area	Yes
21	ID: video	Yes				
22				Yes		
23					Video	Yes
24	Title: video	Yes				
25				Yes		
26					Video	Yes
27	Genre: video	Yes				
28				Yes		
29					Video	Yes
30	Length: video	Yes				
31				Yes		
32					Video	Yes
33	Staffs	Yes				
34				Yes		
35					Space area	Yes
36	ID: staff	Yes				
37				Yes		
38					Staff	Yes
39	Name: staff	Yes				
40				Yes		
41					Staff	Yes
42	Address: staff	Yes				
43				Yes		
44					Staff	Yes
45	Position: staff	Yes				
46				Yes		
47					Staff	Yes
48	Salary: staff	Yes				
49				Yes		
50					Staff	Yes

51	Member	Yes				
52				Yes		
53					Space Area	Yes
54	register	Yes				
55			1 N	No		
56			N 1	Yes		
57					Member/staff	Yes
58	rent	Yes				
59			1 1	No		
60			1 N	Yes		
61					Member/video	Yes
62	ID: Member	Yes				
63				Yes		
64					Member	Yes
65	Name: Member	Yes				
66				Yes		
67					Member	Yes
68	address: member	Yes				
69				Yes		
70					Member	Yes
71	Jointdate	Yes				
72				Yes		
73					Member	Yes
74	Order	Yes				
75				Yes		
76					Space Area	Yes
77	required	Yes				
78			1 1	No		
79			N 1	No		
80			N M	Yes		
81					Video/order	Yes
82	make	Yes				
83			1 N	Yes		
84					Staff/order	Yes
85	ID: order	Yes				
86				Yes		
87					Order	Yes
88	orderdate	Yes				
89				Yes		
90					Order	Yes
91	requiredate	Yes				
92				Yes		
93					Order	Yes
94	Order detail	Yes				
95				No		
96				Yes		
97					Space Area	Yes
98	has	Yes				
99			1 1	Yes		
100					Order/detail	Yes
101	Item	Yes				
102				Yes		

103					Order detail	Yes
104	Videotitle	Yes				
105				Yes		
106					Order detail	Yes
107	Quantity	Yes				
108				Yes		
109					Order detail	Yes
110	unitprice	Yes				
111				Yes		
112					Order detail	Yes
113	supplier	Yes				
114				Yes		
115					Space Area	Yes
116	buy	Yes				
117			N M	No		
118			N 1	Yes		
119					Order/supplier	Yes
120	ID: supplier	Yes				
121				No		
122				Yes		
123					Supplier	Yes
124	Name:supplier	Yes				
125				Yes		
126					Supplier	Yes
127	Address: supplier	Yes				
128				Yes		
129					Supplier	Yes
130	Phone: supplier	Yes				
131				Yes		
132					Supplier	Yes
133	Fax: supplier	Yes				
134				Yes		
135					Supplier	Yes
136	Work for	Yes				
137			N 1	Yes		
138					Staff/branch	Yes

APPENDIX D

The Action of Participant 4 in practising GERM 2

#	Scenario Area Action (Click)	GERM Action	Notation Area Action (Click)	GERM Action	Drawing Area Action (Click)	GERM Action
1	Company	Guidance				
2	ID: branch	Yes				
3				No		
4				No		
5				No		
6				Yes		
7					Space Area	No
8	Name: branch	Yes				
9				No		
10				Yes		
11					Space Area	No
12	Is	Guidance				
13	Has	Guidance				
14	Consists	Guidance				
15	Address:branch	Yes				
16				Yes		
17					Space Area	No
18	Phone:branch	Yes				
19				Yes		
20					Space Area	No
21	Fax:branch	Yes				
22				Yes		
23					Space Area	No
24	Videos	Yes				
25				No		
26				No		
27				Yes		
28	ID: video	Yes				
29				Yes		
30					Video	Yes
31	Title	Yes				
32				No		
33				Yes		
34					Video	Yes
35	Genre	Yes				
36				Yes		
37					Video	Yes
38	Length	Yes				
39				Yes		
40					Video	Yes
41	Staffs	Yes				
42				Yes		
43					Space area	Yes
44	ID: staff	Yes				
45				Yes		
46					Staff	Yes

47	Name: staff	Yes				
48				Yes		
49					Staff	Yes
50	Address	Yes				
51				Yes		
52					Staff	Yes
53	Position	Yes				
54				Yes		
55					Staff	Yes
56	Salary	Yes				
57				Yes		
58					Staff	Yes
59	Member	Yes				
60				Yes		
61					Space area	Yes
62	ID: Member	Yes				
63				Yes		
64					Member	Yes
65	Name: Member	Yes				
66				Yes		
67					Member	Yes
68	address: member	Yes				
69				Yes		
70					Member	Yes
71	Jointdate	Yes				
72				Yes		
73					Member	Yes
74	Order	Yes				
75				Yes		
76					Space Area	Yes
77	ID: order	Yes				
78				Yes		
79					Order	Yes
80	Orderdate	Yes				
81				Yes		
82					Order	Yes
83	Requiredate	Yes				
84				Yes		
85					Order	Yes
86	Order detail	Yes				
87				Yes		
88					Space Area	Yes
89	Item_ID	Yes				
90				Yes		
91					Order detail	Yes
92	Videotitle	Yes				
93				Yes		
94					Order detail	Yes
95	Quantity	Yes				
96				Yes		
97					Order detail	Yes
98	Unitprice	Yes				
99				Yes		
100					Order detail	Yes
101	Supplier	Yes				
102				Yes		
103					Space Area	Yes

104	ID: supplier	Yes				
105				No		
106				Yes		
107					supplier	Yes
108	Name:supplier	Yes				
109				Yes		
110					Supplier	Yes
111	Address: supplier	Yes				
112				Yes		
113					supplier	Yes
114	Phone: supplier	Yes				
115				Yes		
116					supplier	Yes
117	Fax: supplier	Yes				
118				Yes		
119					supplier	Yes

APPENDIX E

The Action of Participant 5 in practising GERM 2

#	Scenario Area Action (Click)	GERM Action	Notation Area Action (Click)	GERM Action	Drawing Area Action (Click)	GERM Action
1	Company	Guidance				
2	Branch	Yes				
3				Yes		
4					Space Area	Yes
5	Address:branch	Yes				
6				Yes		
7					Branch	Yes
8	Phone:branch	Yes				
9				Yes		
10					Branch	Yes
11	Fax:branch	Yes				
12				Yes		
13					Branch	Yes
14	Stock	Guidance				
15	Videos	Yes				
16				No		
17				Yes		
18					Space Area	Yes
19	ID: video	Yes				
20				No		
21				Yes		
22					Video	Yes
23	Title	Yes				
24				Yes		
25					Video	Yes
26	Genre	Yes				
27				Yes		
28					Video	Yes
29	Staffs	Yes				
30				Yes		
31					Space area	Yes
32	ID: staff	Yes				
33				No		
34				Yes		
35					Staff	Yes
36	Name: staff	Yes				
37				Yes		
38					Staff	Yes
39	Address:staff	Yes				
40				Yes		
41					Staff	Yes
42	Position	Yes				
43				Yes		
44					Staff	Yes
45	Salary	Yes				
46				Yes		
47					Staff	Yes
48	Member	Yes				

49				Yes		
50					Space area	Yes
51	ID: Member	Yes				
52				Yes		
53					Member	Yes
54	Name: Member	Yes				
55				Yes		
56					Member	Yes
57	Address: member	Yes				
58				Yes		
59					Member	Yes
60	Jointdate	Yes				
61				Yes		
62					Member	Yes
63	Required	Yes				
64			1 N	No		
65			N M	Yes		
66					Videos/member	No
67	Order	Yes				
68				Yes		
69					Space Area	Yes
70	ID: order	Yes				
71				Yes		
72					Order	Yes
73	Orderdate	Yes				
74				Yes		
75					Order	Yes
76	Requiredate	Yes				
77				Yes		
78					Order	Yes
79	Item_ID	Yes				
80				Yes		
81					Order	No
82	Videotitle	Yes				
83				Yes		
84					Order	Yes
85	Consist	Guidance				
86	Order detail	Yes				
87				No		
88				Yes		
89					Space Area	Yes
90	Item_ID	Yes				
91				Yes		
92					Order detail	Yes
93	Videotitle	Yes				
94				Yes		
95					Order detail	Yes
96	Quantity	Yes				
97				Yes		
98					Order detail	Yes
99	Unitprice	Yes				
100				Yes		
101					Order detail	Yes
102	Supplier	Yes				
103				Yes		

104					Space Area	Yes
105	ID: supplier	Yes				
106				No		
107				Yes		
108					Supplier	Yes
109	Name:supplier	Yes				
110				Yes		
111					Supplier	Yes
112	Address: supplier	Yes				
113				Yes		
114					Supplier	Yes
115	Phone: supplier	Yes				
116				Yes		
117					Supplier	Yes
118	Fax: supplier	Yes				
119				Yes		
120					Supplier	Yes
121	Work for	Yes				
122			1 — 1	No		
123			1 — N	No		
124			N — 1	Yes		
125					Staff/branch	Yes

APPENDIX F

The Action of Participant 6 in practising GERM 2

#	Scenario Area Action (Click)	GERM Action	Notation Area Action (Click)	GERM Action	Drawing Area Action (Click)	GERM Action
1	Company	Guidance				
2	Videos	Yes				
3				Yes		
4					Space Area	Yes
5	Register	Yes				
6			N M	No		
7	Member	Yes				
8			1 1	No		
9				Yes		
10					Space area	Yes
11	Jointdate	Yes				
12				No		
13				Yes		
14					Member	Yes
15	Branch	Yes				
16			N 1	No		
17				No		
18				No		
19				Yes		
20					Space Area	Yes
21	Composed	Guidance				
22	Staffs	Yes				
23				No		
24				No		
25				Yes		
26					Space area	Yes
27	Quantity	Yes				
28			1 1	No		
29	Supplier	Yes				
30				Yes		
31					Space Area	Yes
32	ID: video	Yes				
33			N M	No		
34				No		
35				No		
36				No		
37			1 N	No		
38			1 1	No		
39				Yes		
40					Video	Yes
41	Item_ID	Yes				
42			1 1	No		
43				Yes		
44					Video	No
45	Address: supplier	Yes				
46				No		

47				No		
48			N 1	No		
49				Yes		
50					Supplier	Yes
51	Phone: supplier	Yes				
52				Yes		
53					Supplier	Yes
54	Fax: supplier	Yes				
55				Yes		
56					Supplier	Yes
57	Name:supplier	Yes				
58				Yes		
59					Supplier	Yes
60	ID: Member	Yes				
61				No		
62				Yes		
63					Member	Yes
64	Name: Member	Yes				
65				No		
66				Yes		
67					Member	Yes
68	Address: member	Yes				
69				No		
70				No		
71				Yes		
72					Member	Yes
73	ID: branch	Yes				
74				No		
75				Yes		
76					Branch	Yes
77	Name: branch	Yes				
78				No		
79				Yes		
80					Branch	Yes
81	Address:branch	Yes				
82				Yes		
83					Branch	Yes
84	Phone:branch	Yes				
85				Yes		
86					Branch	Yes
87	Fax:branch	Yes				
88				Yes		
89					Branch	Yes
90	Title	Yes				
91				Yes		
92					Video	Yes
93	Genre	Yes				
94				Yes		
95					Video	Yes
96	Length	Yes				
97				Yes		
98					Video	Yes
99	ID: staff	Yes				
100				Yes		
101					Staff	Yes
102	Name: staff	Yes				
103				Yes		
104				Yes		
105					Staff	Yes

106	Address:staff	Yes				
107				Yes		
108					Staff	Yes
109	Position	Yes				
110				Yes		
111					Staff	Yes
112	Salary	Yes				
113				Yes		
114					Staff	Yes
115	Order	Yes				
116				Yes		
117					Space Area	Yes
118	Item_ID	Yes				
119				No		
120				Yes		
121					Order	No
122	Order detail	Yes				
123				No		
124				Yes		
125					Space Area	Yes
126	Item_ID	Yes				
127				Yes		
128					Order detail	Yes
129	Videotitle	Yes				
130				Yes		
131					Order detail	Yes
132	Quantity	Yes				
133				Yes		
134					Order detail	Yes
135	ID: order	Yes				
136				Yes		
137					Order	Yes
138	Orderdate	Yes				
139				Yes		
140					Order	Yes
141	Requiredate	Yes				
142				Yes		
143					Order	Yes
144	Work for	Yes				
145				No		
146				No		
147				No		
148			1 — 1	No		
149			M — N	No		
150			1 — N	No		
151			N — 1	Yes		
152					Staff/branch	Yes
153	Register	Yes				
154			1 — N	No		
155			N — 1	Yes		
156					Member/Staff	Yes
157	Required	Yes				
158			N — 1	No		
159			1 — N	No		
160				No		
161				No		

162			N —◇— M	Yes		
163					Videos/member	No
164	Buy	Yes				
165			N —◇— M	No		
166			N —◇— 1	Yes		
167					Order/supplier	Yes

APPENDIX G

The Action of Participant 7 in practising GERM 3

Layer	Participants' Action	GERM's Action
Enterprise	Collecting "Director's statement"	Yes
Enterprise	Collecting "Manager's statement"	Yes
Enterprise	Collecting "Saleperson's statement"	Yes
Enterprise	Collecting "General staff's statement"	Yes
Enterprise	Collecting "Policy"	Yes
Enterprise	Collecting "company plan"	Yes
Enterprise	Collecting "organisation chart"	Yes
Enterprise	Collecting "staff registration form"	Yes
Enterprise	Collecting "Branch list report"	Yes
Enterprise	Collecting "Member List Report"	Yes
Enterprise	Collecting "Order Form"	Yes
Enterprise	Collecting "Video Renting List Report"	Yes
Enterprise	Collecting "Supplier List Report"	Yes
Identifying	Selecting "John Brown" and "Entity Storage"	No
Identifying	Selecting "company" and "Entity Storage"	No
Identifying	Selecting "system" and "Attribute Storage"	No
Identifying	Selecting "Staff" and "Entity Storage"	Yes
Identifying	Selecting "manager" and "Entity Storage"	No
Identifying	Selecting "I" and "Entity Storage"	No
Identifying	Selecting "saleperson" and "Entity Storage"	No
Identifying	Selecting "information" and "Attribute Storage"	No
Identifying	Selecting "they" and "Relationship Storage"	No
Identifying	Selecting "John Brown" and "Relationship Storage"	No
Identifying	Selecting "Mark" and "Entity Storage"	No
Identifying	Selecting "everybody" and "Entity Storage"	No
Identifying	Selecting "document" and "Entity Storage"	No
Identifying	Selecting "Director" and "Entity Storage"	No
Identifying	Selecting "David Henry" and "Entity Storage"	No
Identifying	Selecting "Jam Bond" and "Attribute Storage"	No
Identifying	Selecting "StaffID" and "Attribute Storage"	Yes
Identifying	Selecting "StaffName" and "Attribute Storage"	Yes
Identifying	Selecting "Position" and "Attribute Storage"	Yes
Identifying	Selecting "Newcastle1" and "Attribute Storage"	No
Identifying	Selecting "Seattle" and "Attribute Storage"	No
Identifying	Selecting "Plymouth" and "Attribute Storage"	No
Identifying	Selecting "Cast a way" and "Attribute Storage"	No
Identifying	Selecting "A pretty Women" and "Attribute Storage"	No

APPENDIX H

The Action of Participant 8 in practising GERM 3

Layer	Participants' Action	GERM's Action
Enterprise	Collecting "Director's statement"	yes
Enterprise	Collecting "Manager's statement"	yes
Enterprise	Collecting "Saleperson's statement"	yes
Enterprise	Collecting "staff registration form"	yes
Enterprise	Collecting "Branch list report"	yes
Enterprise	Collecting "Member List Report"	yes
Enterprise	Collecting "Order Form"	yes
Enterprise	Collecting "Video Renting List Report"	yes
Enterprise	Collecting "Supplier List Report"	yes
Identifying	Selecting "Information" and "Entity storage"	No
Identifying	Selecting "director" and "Entity storage"	No
Identifying	Selecting "David Wood" and "Entity storage"	No
Identifying	Selecting "John William" and "Attribute storage"	No
Identifying	Selecting "Form" and "Entity storage"	No
Identifying	Selecting "Staff" and "Entity storage"	Yes
Identifying	Selecting "StaffID" and "Entity storage"	No
Identifying	Selecting "StaffID" and "Attribute storage"	Yes
Identifying	Selecting "StaffName" and "Attribute storage"	Yes
Identifying	Selecting "StaffAddress" and "Attribute storage"	Yes
Identifying	Selecting "Position" and "Attribute storage"	Yes
Identifying	Selecting "Salary" and "Attribute storage"	Yes
Identifying	Selecting "Branch" and "Entity storage"	Yes
Identifying	Selecting "BranchID" and "Attribute storage"	Yes
Identifying	Selecting "BranchName" and "Attribute storage"	Yes
Identifying	Selecting "BranchAddress" and "Attribute storage"	Yes
Identifying	Selecting "PhoneNumber" and "Attribute storage"	Yes
Identifying	Selecting "FaxNumber" and "Attribute storage"	Yes
Identifying	Selecting "Members" and "Entity storage"	Yes
Identifying	Selecting "MemberID" and "Attribute storage"	Yes
Identifying	Selecting "MemberName" and "Attribute storage"	Yes
Identifying	Selecting "MemberAddress" and "Attribute storage"	Yes
Identifying	Selecting "JointedDate" and "Attribute storage"	Yes
Representation	Selecting "Staff" and "Entity Notation"	Yes
Representation	Selecting "StaffID" and "Attribute Notation"	No
Representation	Selecting "StaffID" and "Primary Key Notation"	Yes
Representation	Selecting "StaffName" and "Attribute Notation"	Yes
Representation	Selecting "StaffAddress" and "Attribute Notation"	Yes
Representation	Selecting "Position" and "Attribute Notation"	Yes
Representation	Selecting "Salary" and "Attribute Notation"	Yes
Representation	Selecting "Branch" and "Entity Notation"	Yes
Representation	Selecting "BranchID" and "Primary Key Notation"	Yes

Representation	Selecting "BranchName" and "Attribute Notation"	Yes
Representation	Selecting "BranchAddress" and "Attribute Notation"	Yes
Representation	Selecting "PhoneNumber" and "Attribute Notation"	Yes
Representation	Selecting "FaxNumber" and "Attribute Notation"	Yes
Representation	Selecting "Members" and "Entity Notation"	Yes
Representation	Selecting "MemberID" and "Primary Key Notation"	Yes
Representation	Selecting "MemberName" and "Attribute Notation"	Yes
Representation	Selecting "MemberAddress" and "Attribute Notation"	Yes
Representation	Selecting "JointedDate" and "Attribute storage Notation"	Yes

APPENDIX I

The Action of Participant 9 in practising GERM 3

Layer	Participants' Action	GERM's Action
Enterprise	Collecting "Manager's statement"	yes
Enterprise	Collecting "Saleperson's statement"	yes
Enterprise	Collecting "staff registration form"	yes
Enterprise	Collecting "Branch list report"	yes
Enterprise	Collecting "Member List Report"	yes
Enterprise	Collecting "Order Form"	yes
Enterprise	Collecting "Video Renting List Report"	yes
Enterprise	Collecting "Supplier List Report"	yes
Enterprise	Collecting "Director's statement"	yes
Identifying	Selecting "Information" and "Entity storage"	No
Identifying	Selecting "Manager" and "Entity storage"	No
Identifying	Selecting "saleperson" and "Entity storage"	No
Identifying	Selecting "Stock" and "Entity storage"	No
Identifying	Selecting "Members" and "Entity storage"	Yes
Identifying	Selecting "MemberID" and "Attribute storage"	Yes
Identifying	Selecting "MemberName" and "Attribute storage"	Yes
Identifying	Selecting "MemberAddress" and "Attribute storage"	Yes
Identifying	Selecting "JointedDate" and "Attribute storage"	Yes
Identifying	Selecting "Branch" and "Entity storage"	Yes
Identifying	Selecting "BranchID" and "Attribute storage"	Yes
Identifying	Selecting "BranchName" and "Attribute storage"	Yes
Identifying	Selecting "BranchAddress" and "Attribute storage"	Yes
Identifying	Selecting "PhoneNumber" and "Attribute storage"	Yes
Identifying	Selecting "FaxNumber" and "Attribute storage"	Yes
Identifying	Selecting "Staff" and "Entity storage"	Yes
Identifying	Selecting "StaffID" and "Attribute storage"	Yes
Identifying	Selecting "StaffName" and "Attribute storage"	Yes
Identifying	Selecting "StaffAddress" and "Attribute storage"	Yes
Identifying	Selecting "Position" and "Attribute storage"	Yes
Identifying	Selecting "Salary" and "Attribute storage"	Yes
Representation	Selecting "Members" and "Entity Notation"	Yes
Representation	Selecting "MemberID" and "Primary Key Notation"	Yes
Representation	Selecting "MemberName" and "Attribute Notation"	Yes
Representation	Selecting "MemberAddress" and "Attribute Notation"	Yes
Representation	Selecting "JointedDate" and "Attribute storage Notation"	Yes
Representation	Selecting "Branch" and "Entity Notation"	Yes
Representation	Selecting "BranchID" and "Primary Key Notation"	Yes
Representation	Selecting "BranchName" and "Attribute Notation"	Yes

Representation	Selecting "BranchAddress" and "Attribute Notation"	Yes
Representation	Selecting "PhoneNumber" and "Attribute Notation"	Yes
Representation	Selecting "FaxNumber" and "Attribute Notation"	Yes
Representation	Selecting "Staff" and "Entity Notation"	Yes
Representation	Selecting "StaffID" and "Primary Key Notation"	Yes
Representation	Selecting "StaffName" and "Attribute Notation"	Yes
Representation	Selecting "StaffAddress" and "Attribute Notation"	Yes
Representation	Selecting "Position" and "Attribute Notation"	Yes
Representation	Selecting "Salary" and "Attribute Notation"	Yes

APPENDIX J

The Action of Participant 10 in practising GERM 4

Layer	Participants' Action	GERM's Action
Enterprise	Collecting "Manager's statement"	yes
Enterprise	Collecting "Saleperson's statement"	yes
Enterprise	Collecting "General staff's statement"	yes
Enterprise	Collecting "Policy"	yes
Enterprise	Collecting "company plan"	yes
Enterprise	Collecting "organisation chart"	yes
Enterprise	Collecting "staff registration form"	yes
Enterprise	Collecting "Branch list report"	yes
Enterprise	Collecting "Member List Report"	yes
Enterprise	Collecting "Order Form"	yes
Enterprise	Collecting "Video Renting List Report"	yes
Enterprise	Collecting "Supplier List Report"	yes
Enterprise	Collecting "Director's statement"	yes
Identifying	Selecting "B003" and "Relationship storage"	Strategy 1(R)
Identifying	Selecting "B003" and "Attribute storage"	Strategy 2 (A)
Identifying	Selecting "ST930016" and "Attribute storage"	Strategy 2 (A)
Identifying	Selecting "David Henry" and "Relationship storage"	Strategy 1(R)
Identifying	Selecting "Manager" and "Entity storage"	Strategy 2 (E)
Identifying	Selecting "Staff" and "Entity storage"	Yes
Identifying	Selecting "StaffID" and "Attribute storage"	Yes
Identifying	Selecting "StaffName" and "Attribute storage"	Yes
Identifying	Selecting "StaffAddress" and "Attribute storage"	Yes
Identifying	Selecting "Position" and "Attribute storage"	Yes
Identifying	Selecting "Salary" and "Attribute storage"	Yes
Identifying	Selecting "Branch" and "Entity storage"	Yes
Identifying	Selecting "BranchID" and "Attribute storage"	Yes
Identifying	Selecting "BranchName" and "Attribute storage"	Yes
Identifying	Selecting "BranchAddress" and "Attribute storage"	Yes
Identifying	Selecting "PhoneNumber" and "Attribute storage"	Yes
Identifying	Selecting "FaxNumber" and "Attribute storage"	Yes

APPENDIX K

The Action of Participant 11 in practising GERM 4

Layer	Participants' Action	GERM's Action
Enterprise	Collecting Saleperson's statement	yes
Enterprise	Collecting staff registration form	yes
Enterprise	Collecting Branch list report	yes
Enterprise	Collecting Member List Report	yes
Enterprise	Collecting Order Form	yes
Enterprise	Collecting Video Renting List Report	yes
Enterprise	Collecting Supplier List Report	yes
Enterprise	Collecting Director's statement	yes
Enterprise	Collecting Manager's statement	yes
Identifying	Selecting "director" and "Entity storage"	Strategy 2 (E)
Identifying	Selecting "David Wood" and "Entity storage"	Strategy 2 (E)
Identifying	Selecting "John William" and "Attribute storage"	Strategy 2 (E)
Identifying	Selecting "Staff" and "Entity storage"	Yes
Identifying	Selecting "ST930016" and "Attribute storage"	Strategy 2 (A)
Identifying	Selecting "StaffID" and "Attribute storage"	Yes
Identifying	Selecting "David Henry" and "Attribute storage"	Strategy 2 (A)
Identifying	Selecting "StaffName" and "Attribute storage"	Yes
Identifying	Selecting "StaffAddress" and "Attribute storage"	Yes
Identifying	Selecting "Position" and "Attribute storage"	Yes
Identifying	Selecting "Salary" and "Attribute storage"	Yes
Identifying	Selecting "Branch" and "Entity storage"	Yes
Identifying	Selecting "BranchID" and "Attribute storage"	Yes
Identifying	Selecting "Plymouth" and "Attribute storage"	Strategy 2 (A)
Identifying	Selecting "BranchName" and "Attribute storage"	Yes
Identifying	Selecting "BranchAddress" and "Attribute storage"	Yes
Identifying	Selecting "PhoneNumber" and "Attribute storage"	Yes
Identifying	Selecting "FaxNumber" and "Attribute storage"	Yes
Identifying	Selecting "Members" and "Entity storage"	Yes
Identifying	Selecting "MemberID" and "Attribute storage"	Yes
Identifying	Selecting "Jam Bond" and "Attribute storage"	Strategy 2 (A)
Identifying	Selecting "MemberName" and "Attribute storage"	Yes
Identifying	Selecting "MemberAddress" and "Attribute storage"	Yes
Identifying	Selecting "JointedDate" and "Attribute storage"	Yes
Identifying	Selecting "keep" and "Relationship storage"	Strategy 2 (R)
Identifying	Selecting "work for" and "Relationship storage"	Yes
Representation	Selecting "Members" and "Attribute Notation"	No
Representation	Selecting "Members" and "Entity Notation"	Yes
Representation	Selecting "MemberID" and "Attribute Notation"	No
Representation	Selecting "MemberID" and "Primary Key Notation"	Yes
Representation	Selecting "MemberName" and "Attribute Notation"	Yes

Representation	Selecting "MemberAddress" and "Attribute Notation"	Yes
Representation	Selecting "JointedDate" and "Attribute storage Notation"	Yes
Representation	Selecting "Branch" and "Entity Notation"	Yes
Representation	Selecting "BranchID" and "Primary Key Notation"	Yes
Representation	Selecting "BranchName" and "Attribute Notation"	Yes
Representation	Selecting "BranchAddress" and "Attribute Notation"	Yes
Representation	Selecting "PhoneNumber" and "Attribute Notation"	Yes
Representation	Selecting "FaxNumber" and "Attribute Notation"	Yes
Representation	Selecting "Staff" and "Entity Notation"	Yes
Representation	Selecting "StaffID" and "Primary Key Notation"	Yes
Representation	Selecting "StaffName" and "Attribute Notation"	Yes
Representation	Selecting "StaffAddress" and "Attribute Notation"	Yes
Representation	Selecting "Position" and "Attribute Notation"	Yes
Representation	Selecting "Salary" and "Attribute Notation"	Yes

APPENDIX L

The Action of Participant 12 in practising GERM 4

Layer	Participants' Action	GERM's Action
Enterprise	Collecting staff registration form	yes
Enterprise	Collecting Branch list report	yes
Enterprise	Collecting Member List Report	yes
Enterprise	Collecting Order Form	yes
Enterprise	Collecting Video Renting List Report	yes
Enterprise	Collecting Supplier List Report	yes
Enterprise	Collecting Director's statement	yes
Enterprise	Collecting Manager's statement	yes
Enterprise	Collecting Saleperson's statement	yes
Identifying	Selecting "Jam Band" and "Entity storage"	Strategy 2 (E)
Identifying	Selecting "Members" and "Entity storage"	Yes
Identifying	Selecting "M002" and "Attribute storage"	Strategy 2 (A)
Identifying	Selecting "MemberID" and "Attribute storage"	Yes
Identifying	Selecting "MemberName" and "Attribute storage"	Yes
Identifying	Selecting "MemberAddress" and "Attribute storage"	Yes
Identifying	Selecting "JointedDate" and "Attribute storage"	Yes
Identifying	Selecting "Newcastle1" and "Entity storage"	Strategy 2 (E)
Identifying	Selecting "Branch" and "Entity storage"	Yes
Identifying	Selecting "B003" and "Attribute storage"	Strategy 2 (A)
Identifying	Selecting "BranchID" and "Attribute storage"	Yes
Identifying	Selecting "BranchName" and "Attribute storage"	Yes
Identifying	Selecting "BranchAddress" and "Attribute storage"	Yes
Identifying	Selecting "PhoneNumber" and "Attribute storage"	Yes
Identifying	Selecting "FaxNumber" and "Attribute storage"	Yes
Identifying	Selecting "David Henry" and "Entity storage"	Strategy 2 (E)
Identifying	Selecting "Staff" and "Entity storage"	Yes
Identifying	Selecting "ST930016" and "Attribute storage"	Strategy 2 (A)
Identifying	Selecting "StaffID" and "Attribute storage"	Yes
Identifying	Selecting "StaffName" and "Attribute storage"	Yes
Identifying	Selecting "StaffAddress" and "Attribute storage"	Yes
Identifying	Selecting "Manager" and "Attribute storage"	Strategy 2 (A)
Identifying	Selecting "Position" and "Attribute storage"	Yes
Identifying	Selecting "Salary" and "Attribute storage"	Yes
Identifying	Selecting "sure" and "Relationship storage"	Strategy 2 (R)
Identifying	Selecting "work for" and "Relationship storage"	Yes
Representation	Selecting "Members" and "Entity Notation"	Yes
Representation	Selecting "MemberID" and "Primary Key Notation"	Yes
Representation	Selecting "MemberName" and "Attribute Notation"	Yes
Representation	Selecting "MemberAddress" and "Attribute Notation"	Yes
Representation	Selecting "JointedDate" and "Attribute storage Notation"	Yes

Representation	Selecting "Branch" and "Entity Notation"	Yes
Representation	Selecting "BranchID" and "Primary Key Notation"	Yes
Representation	Selecting "BranchName" and "Attribute Notation"	Yes
Representation	Selecting "BranchAddress" and "Attribute Notation"	Yes
Representation	Selecting "PhoneNumber" and "Attribute Notation"	Yes
Representation	Selecting "FaxNumber" and "Attribute Notation"	Yes
Representation	Selecting "Staff" and "Entity Notation"	Yes
Representation	Selecting "StaffID" and "Primary Key Notation"	Yes
Representation	Selecting "StaffName" and "Attribute Notation"	Yes
Representation	Selecting "StaffAddress" and "Attribute Notation"	Yes
Representation	Selecting "Position" and "Attribute Notation"	Yes
Representation	Selecting "Salary" and "Attribute Notation"	Yes

APPENDIX M

THE BASIC CONCEPT OF DATABASE DESIGN

Database Design is a task that entails the translation of data semantics of an application in the real world into a data representation that matches the underlying data model of the database management system (Chen, 1977). This Chapter describes the basic concept of database design in particular data modeling using entity relationship diagram and introduces the complexity of database design task.

1.1 Database Design

In general, the database design task is divided into four stages: *requirement specification*, *conceptual design*, *logical design* and *physical design* (Story and Goldstein, 1993). The detail of each stage is described in the following sections.

1.1.1 Requirement Specification

This step involves eliciting the initial set of information and processing requirements from users. This process is concerned with identifying the information needs of various users or groups (Batini, et al, 1986). The input to requirement specification is knowledge of the application. A database designer obtains this information: examining existing documentation; interviewing users; and observing information processing operations within the organisation etc. The design usually obtains a description of how information is used in decision making, what reports are generated, which data is used for different types of decisions, and how the data is processed. The output is a preliminary specification of the users' information needs that may be expressed in a natural language. Because the database design for an entire organisation is likely to be quite large and complex, one common approach is to generate user views for each task or function.

This stage is both an interactive and iterative phase, involving a dialog between an end-user and database design expert. The database design expert must possess the ability to extract the user's requirements, patience, and the ability to interpret non-verbal behaviour. The expertise necessary for this phase involves information elicitation techniques. In general, the designers are usually unfamiliar with the

application domain and, therefore, must learn about it from the end-users, who may have difficulty articulating their information needs.

Requirements analysis is a cognitive process involving human skills and experience. The acquisition of requirements from end users is carried out in natural language, which can lead to multiple interpretations or wrong impressions. The designer might start with incomplete and imperfect knowledge. In addition, the real world can be modelled by different database schemas and still be correct. There are completeness and consistency problems; a designer needs to decide whether he or she has enough knowledge to begin the design of the schema. Finally, the difficulty of a design increases with the size of the application (Bouzeghoub, M 1992).

1.1.2 Conceptual Design

The objective of conceptual database design is to gain a high-level of database management system (DBMS) by starting from a number of requirements that describe the reality (Batini, Ceri, Navathe ,1992). During conceptual database design, the data elicited during requirement analysis is transformed into a high-level representation with the most commonly used model being the entity-relationship model (Chen, 1976). This stage can involve the integration of the views of multiple users, who entails the resolution of conflicting terminology and elimination of redundancy. It can also require inter-schema properties to be examined for possible conflicts and redundancy. The challenge to the database designer during conceptual design is to determine how to represent the user's requirements using the constructs of the chosen conceptual model. For example, one might need to decide whether a concept should be represented as an entity or as a relationship. However, interaction with the end-user is limited, but may be required if the designers need clarification to assist in resolving conflicts between different user views.

1.1.3 Logical Design

During logical design, the conceptual model is translated into the logical data model of the selected Database Management System. If the conceptual model is expressed as an Entity Relationship Model (ER Model) and the relational model chosen as the logical model, then the entities, relationships, and attributes of the ER Model must be represented as relations. Logical design is always carried out within the context of some data model, using the constructs defined for that model. When the

model is changed, different transformation rules must be used to obtain the resulting design. The main problem that can occur during this phase is the loss of information when translating a conceptual design to a logical design.

1.1.4 Physical Design

In the physical design phase, the logical design is translated into a form compatible with the particular database management system that will be used. For example, in a DBMS using the SQL language, the design would be expressed as a set of Create Table statements. Physical storage assignments, index generation, and integrity constraints are also specified.

Even though, Database design is divided into four steps: requirements specification, conceptual design, logical design and physical design (Story and Goldstein, 1993), this study will focus on the domain knowledge of the conceptual design stage by using the Entity-Relationship Modelling technique (Chen, 1976).

1.2 Entity Relationship Modelling

The Entity-Relationship Modelling technique (Chen, 1976) is typically the first step in modeling database requirements. Among the conceptual modeling techniques, the technique has been shown to lead to superior performance in many experiments (e.g. Juhn and Naumann, 1985; Jarvenpaa and Machesky, 1989; Batra, Hoffer, and Bostrom, 1990; Bock and Ryan, 1993). Entity Relationship Modelling is a top-down approach to the design of database systems. It begins with identifying the crucial data called Entities and Relationships between the data that must be represented in the model. Moreover, the details of the information that we want to hold about the entities and relationships called attributes of the entities and relationships.

1.2.1 Entity Type

- **Entity Type** (Chen, 1976) "is a thing which can be distinctly identified in our minds and is of interest to the enterprise. There are many things in the real world. Some of them are of interest to the enterprise; the rest are not. It is the responsibility of the database designer to select the entity types that are important to his or her company. A specific person, company, or event is an example of an entity."

- **Entity Type** (Barker, 1990) "is a thing or object of significance, whether real or imagined, about which information needs to be known or held. Each entity must be uniquely identifiable so that each instance of the entity is separate and distinctly identifiable from all other instances of that type of entity. The unique identifier may be an attribute or a combination of attributes."
- **Entity Type** (Willitts, 1992) "is some class of thing in the broadest sense. A 'thing' includes objects and concepts including events, activities and states that are important to the organization and about which it wishes to keep information other than solely what the thing is. Examples of entity types are: customer, supplier, loan, purchase, and book. Specifying an entity as 'book' signifies that you wish to keep information about book. "
- **Entity Type** (Connolly & Begg , 2000) "A set of objects in the real world with the same properties that are identified by a user or company as having an independent existence. Each object, which should be uniquely identifiable within the set, is called an entity occurrence. An entity has an independent existence and can represent a set of objects with a physical or real existence or a set of objects with a conceptual or abstract existence."

In general, an entity has an independent existence and can represent a set of objects with a physical existence such as customer, staff, product etc or a set of objects with a conceptual existence such as order, training etc. However, from entity relationship modelling point of view, an entity has been categorised into two types as follows:

1.2.1.1 Strong Entity Type

A characteristic of a strong entity type is that each entity occurrence is uniquely identifiable using the primary key attributes of that entity type For example; we can uniquely identify each member of employee using the employee-id attribute, which is the primary key for the employee entity type. Strong entity is sometimes referred to as parent, owner or dominant entities.

1.2.1.2 Weak Entity Type

A characteristic of a weak entity is that each entity occurrence cannot be uniquely identified using only the attributes associated with that entity type. For example, if "order" is a strong entity type for company, "order detail" might be a weak entity type, which depends on the existing of the order entity.

1.2.2 Relationship Type

- **A relationship Type** (Chen, 1976) "is an association among entities. There are many types of relationships between entities, and some of them may not be of interest to the enterprise; the database designer is responsible for the selection of the relationship types relevant to the enterprise. He should also specify the types of mapping of relationship types (e.g., one-to-one, one-to-many, and many-to-many). For instance, father-son is a relationship between two person entities."
- **A relationship Type** (Barker, 1990) "is a named, significant association between two entities."
- **A relationship Type** (Willitts, 1992) "is some association between two entities which is meaningful to the organization and which, in conformity with the organization's wishes, must be recorded. For example, 'Doctor' may be associated with 'Patient' through the relationship 'Prescribes_for'. If entities are often suggested by *nouns* in an organization's description of its activities, then relationships are indicated by *verbal expressions*."
- **A relationship Type** (Connolly & Begg, 2000) "is a set of associations among participating entities. As with entities, each association should be uniquely identifiable within the set. A uniquely identifiable association is called a relationship occurrence. Each relationship is given a name that describes its function. For example, the *Actor* entity is associated with the *Role* entity through a relationship called *Plays*, and the *Role* entity is associated with the *Video* entity through a relationship called *Features*. "

In summary, a relationship type is a set of associations among participating entities. A uniquely identifiable association is called a relationship occurrence or instance. Each relationship is given a name that describes its function. The entities involved in a particular relationship are referred to as participants in that relationship. The number of participants in a relationship is called the degree of that relationship. Therefore, the degree of a relationship indicates the number of entities that are involved in a relationship. The degree of a relationship has been explained in more detail as follows.

1.2.2.1 Binary Relationship

A relationship of degree two that is called Binary Relationship. An example of a binary relationship is the "has" relationship with two participating entities namely, Staff and Branch. This binary relationship has been shown in Figure 1.1.

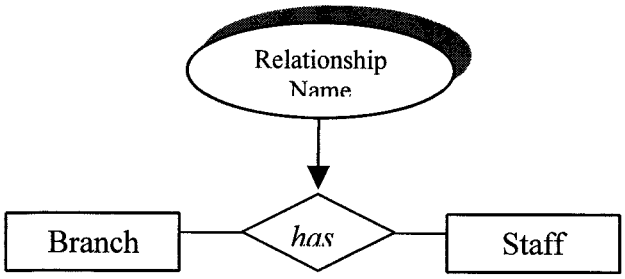

Figure 1.1 Binary Relationship

1.2.2.2 Ternary Relationship

A relationship of degree three is called Ternary relationship. An example of a ternary relationship, which has been shown in Figure 2.2, is *Registers* with three participating entities, namely *Staff*, *Branch*, and *Client*. This relationship represents the registration of a client by a member of staff at a branch. The term complex relationship is used to describe relationships with degrees higher than binary. This type of relationship has been shown in Figure 1.2.

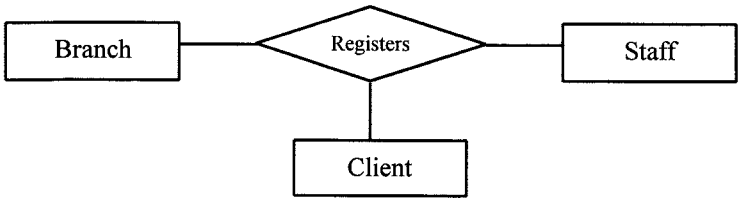

Figure 1.2 Ternary Relationship

1.2.2.3 Recursive Relationship

A relationship where the same entity participates more than once in different roles is called *Recursive relationship*. Let's consider a recursive relationship called *Supervised*, which represents an association of staff with a supervisor where the supervisor is also a member of staff, as shown in Figure 2.3. In other word, the staff entity participates twice in the *Supervises* relationship: the first participation as a

supervisor, and the second participation as a member of staff who is supervised: supervisee.

Recursive relationships are sometimes called *unary* relationships. Relationships may be given role names to indicate the purpose that each participating entity plays in a relationship. Role names are important for recursive relationships to determine the function of each participating entity. The use of role names to describe the Supervises recursive relationship is shown in Figure 1.3. The first participation of the Staff entity in supervises relationship is given the role name Supervisor and the second participation is given the role name Supervisee.

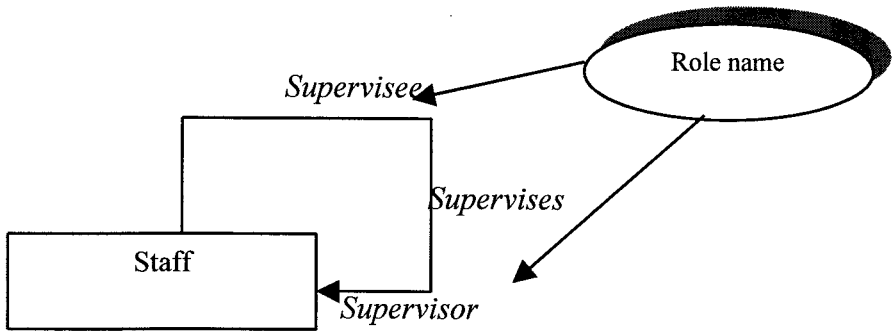

Figure 1.3 Recursive Relationship

1.2.2.4 Complexity of structural Constraints on Relationship

The constraints, which may be placed on entities participating in a relationship, can reflect the restrictions on the relationships as perceived in the real world. The type of constraint on relationships is called *Multiplicity*: the number or range of possible occurrences of an entity type that may relate to a single occurrence of an associated entity type through a particular relationship.

Multiplicity is a representation of the policies that are established by the users or company, and is referred to as a business rule. Ensuring that all appropriate business rules are identified and represented is an important part of data modelling of a company. In general, the most common degree of for relationships is binary. The multiplicity for a binary relationship is generally referred to as one-to-one (1:1), one-to-many (1:*), or many-to-many (*:*). We will explain these three types of relationships by using the following business rules: A member of staff manages a branch, A branch has members of staff, and Actors play in Videos.

- ***One-to-One (1:1) Relationship***

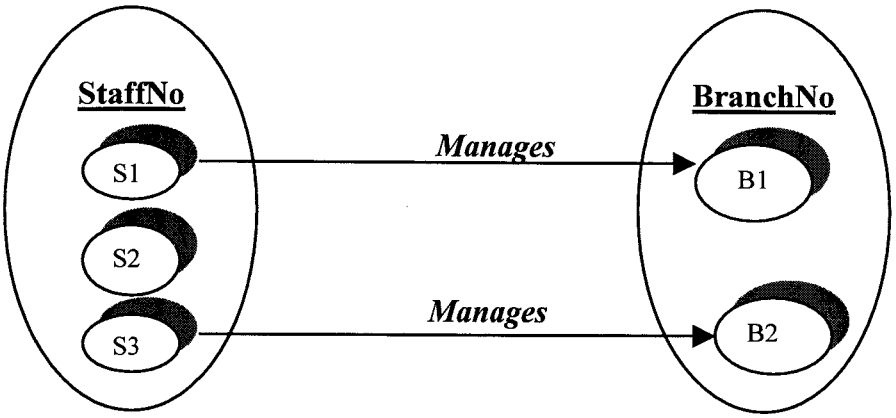

Figure 1.4 One-to-One

Let's consider the relationship called Manages, which relates the staffs and branch entities as shown in Figure 1.4. We can see that staffNo S1 manages branchNo B1 and staffNo S3 manages branchNo B2, but staffNo S2 does not manage any branch. In other word, a member of staff can manages zero or one branch and each branch is manages by a single member of staff. As there is a maximum of one branch for each member of staff and a maximum of one member of staff for each branch involved in the relationship, we refer to this type of relationship as one-to-one, which we usually abbreviate as (1:1)

- **One-to-many (1:*) relationship**

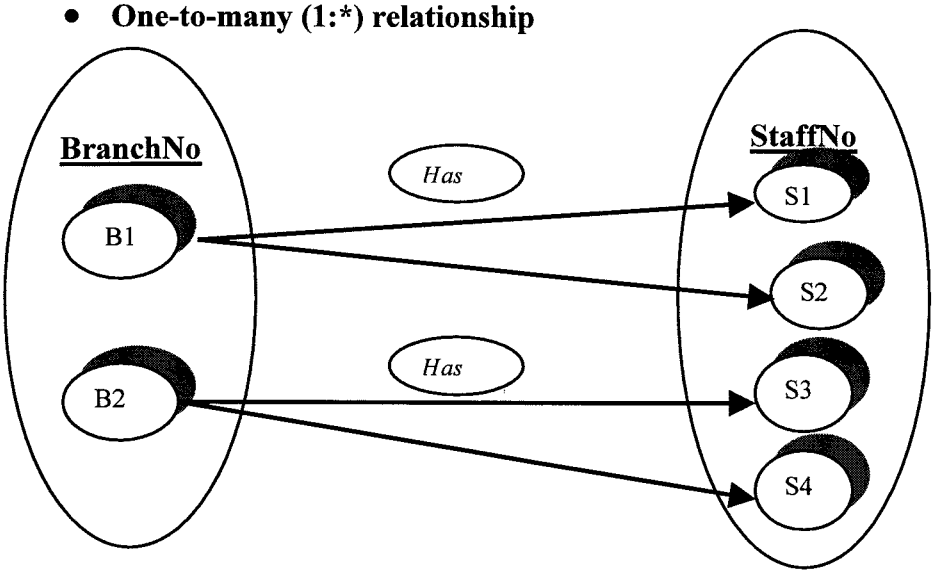

Figure 1.5 One-to-Many

Let's consider the relationship called Has in Figure 1.5, which relates the branch and Staff entities. We can see that branchNo B1 has staffNo S1 and S2, and branchNo B2 has staffNo S3 and S4. Therefore, each branch has one or more members of staff and each member of staff works at a single branch. As one branch can have many staff, we refer to this type of relationship as one-to-many, which we usually abbreviate as (1:*).

- **Many-to-Many (*:*) relationship**

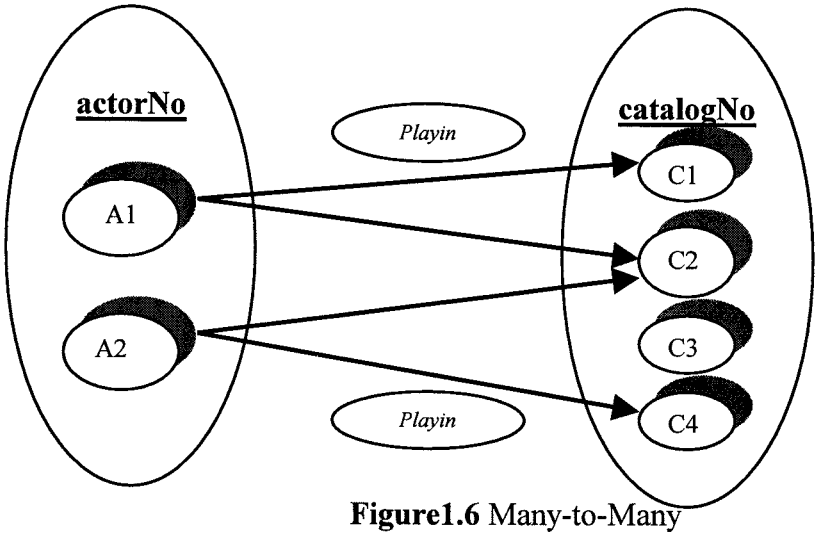

Figure1.6 Many-to-Many

Let's consider the relationship called Playin in Figure 1.6, which relates the Actor and Viedo entities. We can see that actorNo A1 plays in video catalogNo C1 and C2, and actorNo A2 plays in video catalogNo C2 and C1. In other word, a single actor can play in one or more videos. We also see that video catalogNo C2 has two starring actors but catalogNo C3 does not have any actors in it, and so we conclude that a single video can start zero or more actors.

In summery, the PlayIn relationship is 1:* from the viewpoint of both the Actor and Video entities. We represent this relationship as two 1:* relationships in both directions, which are collectively referred to as a many-to-many relationship, which we usually abbreviate as (*.*).

1.2.3 Attribute

- **An Attribute** (Chen, 1976) " is the information about an entity or a relationship is obtained by observation or measurement, and is expressed by a set of attribute-value pairs. 3, red, Peter, and Johnson are values. Values are classified into different value sets, such as FEET, COLOR, FIRST-NAME, and LAST-NAME. There is a predicate associated with each value set to test whether a value belongs to it. A value in a value set may be equivalent to another value in a different value set. For example, 12 in value set INCH are equivalent to 1 in value set FEET. "
- **An Attribute** (Barker R, 1990) " is any detail that serves to qualify, identify, classify, quantify or express the state of an entity or any description of a thing of significance. An attribute could be text, numbers, a picture, a feel, a smell, and so on, as required. For data processing purposes we tend to concentrate on text and numbers, but other attribute types could be critical to the success of running your business; for example, the professionalism of members of the Information Systems Department."
- **An Attribute** (Willitts, 1992) "is facets, characteristics or properties of an entity type. These characteristics constitute the informational elements of the entity. For example, the attribute types of a book include title, statement of responsibility, edition, and so forth. Those of a car include engine size, color and registration number. No information is kept about an attribute other than its value. Specifying an attribute as 'title' for the entity 'book' signifies that you wish to keep information on the titles of books."
- **An Attribute** (Connolly & Begg, 2000) "The particular properties of entities are called attributed. Attributes represent what we want to know about entities. For example, a *Video* entity may be described by the *catalogNo*, *title, category, dailyRental,* and *price* attributes. These attributes hold values that describe each video occurrence, and represent the main source of data stored in the database."

In general, we can classify attributes as being: simple or composite; single-valued or multi-valued; or derived attributes.

1.2.3.1 Simple Attribute

An attribute composed of a single component. In other word, it cannot be further subdivided. Examples of simple attributes include the category and price attributes for a video. Simple attributes are sometimes called atomic attributes.

1.2.3.2 Composite Attribute

An attribute composed of multiple single components. In other word, it can be further divided to yield smaller components with an independent existence. For example, the name attribute of the Member entity with the value 'David Clark' can be subdivided into Fname (David) and Lname (Clark). However, the decision to model the name attribute as a simple attribute or to subdivide the attribute into Fname and Lname is dependent on whether the users' transactions access the name attribute as a single unit or as individual components.

1.2.3.3 Single-valued Attribute

Single-valued attribute is an attribute that holds a single value for an entity occurrence. The majority of attributes are single-valued for a particular entity. For example, each occurrence of the Video entity has a single value for the catalogNo attribute (for example, C1 in Figure 1.6), and therefore the catalogNo attribute is referred to as being single-valued.

1.2.3.4 Multi-valued Attribute

In contrast with single valued attribute, some attributes, which are called multi-valued attribute, have multiple values for a particular entity. For example, each occurrence of the Branch entity type can have multiple values for the telNo attribute. For example, branch number B003 has telephone numbers 0191-2437603 and 0191-2437604. Therefore, the telNo attribute in this case is multi-valued. A multi-valued attribute may have a set of numbers with upper and lower limits. For example, the telNo attribute of the Branch entity type has between one and three values. In other word, a branch may have a minimum of a single telephone number to a maximum of three telephone numbers.

1.2.3.5 Derived Attribute

An attribute that represents a value that is derivable from the value of a related attribute, not necessarily in the same entity. For example, the age of a member

of staff is derivable from the date of birth (DOB) attribute, and therefore the age and DOB attributes are related. We refer to the age attribute as a derived attribute, the value of which is derived from the DOB attribute. Therefore, age is not normally stored in a database because it would have to be updated regularly. On the other hand, as date of birth never changes and age can be derived from date of birth (DOB), which is stored instead, and age is derived from the DOB attribute when it is needed.

1.2.3.6 Key Attribute

In general, this group of attributes has been chosen for identifying each unique entity instance or occurrence. These types of attributes can be categorised into four groups as follows.

- **Super-key:** An attribute, or set of attributes that uniquely identifies each entity occurrence.
- **Candidate key:** A super-key that contains only the minimum number of attributes necessary for unique identification.
- **Primary key:** The candidate key that is selected to identify each entity occurrence.
- **Alternate keys:** The candidate keys that are not selected as the primary key of the entity.

1.2.4 Notations in Entity Relationship Modelling

In the previous sections, we introduce the definition of main objects such as entity type, relationship type, and attribute etc, which use in entity relationship modelling. However, entity relationship modelling technique uses diagram to represent the database requirements. Therefore, the basic notations for representing each objects has been shown in Figure 1.7.

Objects	*Notation*
Strong Entity Type	
Weak Entity Type	
Attribute Type	
Primary Key	
Relationship Type	
One-to-One	1 1
One-to-Many	1 M
Many-to-Many	N M

Figure 1.7 Basic Notation in Entity Relationship Modelling

1.3 Complexity of Entity Relationship Modelling

In general, the quality of an ER diagram depends on the accuracy of the entities, the relationships, and the attributes represented. The task of the ER modeler is to analyze a textual description of a given scenario, to identify the salient elements of that scenario, and to assign each of these to one of the three ER construct types: entity, relationship, and attribute by using a diagrammatic notation. However, it is a complex task, and novice modelers make many mistakes when creating it (Batra and Antony, 1994).

1.3.1 Complexity of real world Domain Application

The difficulty of database design increases with the size of the application domain (Bouzeghoub, M 1992). The combinatorial complexity arises because of the number of entities and then a large number of relationships are possible (Dullea and Song, 1997). Therefore, the complexity of the database design task usually depends on the size of the application domain. Moreover, some domain applications

particularly in business area usually have some difficult terminology, which is hard to understand. It can make designers get confuse and make some mistakes in constructing Entity Relationship Model. A protocol study on novice designers seems to confirm this observation (Batra and Antony, 1994). It is reported that for a problem involving 5 entities, the 31 subjects came up with 26 distinct solutions. Furthermore, in the real world situation, the database requirements are rarely available in a form that can be used by students in a classroom environment. The requirements may be also distributed across many sources such as a variety kind of users (e.g. director, manager etc) and company's document system used in the company (e.g. forms, report etc.)

1.3.2 Identifying Entity Difficulty

Basically, entities (Hall and Gordon, 1998) are often confused with both relationships and attributes because students lack understanding of the subject domain and are also unfamiliar with the application domain. Storey and Goldstein (1988, 1989) also pointed out that novice database designers have experienced problems in identifying entity types, distinguishing entities from attributes, and distinguishing entities and attributes from relationships.

In general, an entity has an independent existence and can represent a set of objects with a physical (or real) existence or a set of objects with a conceptual (or abstract) existence. From our experience students do not have problems in identifying a physical existence entity because it is obvious to have a justification. However, most of them still have problems to specify a conceptual existence entity because it is an abstract thing and it can also make students easily get confuse with relationships and attributes.

1.3.3 Identifying Relationship Difficulty

A relationship is a set of associations between one or more participating entities. Each relationship is given a name that describes its function. The entities involved in a particular relationship are referred to as participants in that relationship. The number of participants in a relationship is called the degree of that relationship. However, the modeling of relationships is a difficult problem for novices (Batra and Antony, 1994) because they have to identify the degree for each relationship: binary, ternary, and recursive, which is sometimes very hard to justify.

Furthermore, they have to identify the number or range of possible occurrences of an entity type called multiplicity that may relate to a single occurrence of an associated entity type through a particular relationship. The multiplicity for a binary relationship is generally referred to as one-to-one (1:1), one-to-many (1:*), or many-to-many (*:*).

1.3.4 Identifying Attribute Difficulty

Due to the fact that attributes are the details of information of entity types or relationship types, designers may confuse with entity type and relationship type. Moreover, there are a number of attribute types such as simple attribute, composite attribute, single-valued attribute, multi-valued attribute, derived attributes, and key attribute. Therefore, it is quite hard work for novice designers to select the right types of attributes.