Multimedia-Based Learning System for Database Modeling and Design

Lester W. Yee

The University of Hong Kong

Waiman Cheung

The Chinese University of Hong Kong

Abstract

Underlying modern information systems are database systems. As such their learning and understanding are important elements to the core studies for an information systems student. Unfortunately, the learning curve for the associated database modeling methodologies and their corresponding Computer Aided Software Engineering (CASE) tools have made this aspect difficult for students to grasp. These are significant as modeling aspects for database systems to a high degree determines the quality design of databases. Addressing the learning of information systems students has led to the research and development of a multimedia learning system. The system incorporates two component elements: a concepts tutorial and a business example utilising a CASE tool. Both parts of the learning system utilise multimedia elements of graphics, sound and animation to guide the learner in understanding the modeling concepts and software tools. The software system itself is distributed for use on popular PCs under the MS-Windows operating system — standard for many PCs available in university and home environments. Thus, there are two primary objectives of this action learning-based research. The first objective is the development of the multimedia learning environment itself. The environment supports a self-paced interactive computer medium where students are able to reinforce their learning of database modeling and development. This learning environment also incorporates a simple business case study that allows the students to walk through the database modeling and design process iteratively and view the results of their learning. The second objective is to determine the value of the multimedia learning methods utilised in the system. Specifically, this objective incorporates an evaluation instrument to register learning performance and system performance. An analysis is done to identify factors attributed to its success and the sources of problems as culled from survey data and other supporting feedback. The results provide insight to future development of similar learning environments in the domain of information systems courses.

Introduction

Databases are ubiquitous in modern information systems. Thus their proper design is critical to of many information systems. Furthermore, the nature of database design is such that there is much human judgment involved, particularly in the aspect of database modeling. Thus, understanding database modeling and design poses challenges for both the teacher and students. Consider that for a given business case associated with the development of a database, there can exist multiple database designs that are considered suitable solutions.

This abstraction of multiple solutions in database modeling and design creates some cognitive dissonance for students, as many seek and expect definitive answers to such problems. The tendency of students to seek definitive solutions to problems tend to be the norm for many technical and scientific courses. To alleviate some of these anxieties, students themselves have

requested that additional supporting materials and examples supplement their class lectures (as elicited from previous student feedback sessions). From the perspective of the teachers, such difficulties pose challenges to the teaching of this particular topic.

A solution presented in this paper is the development and evaluation of a multimedia learning system to supplement the teaching of the subject as well as support students' learning. This solution has two specific aims:

1. development of a learning environment using a computer-based medium where students are able to interactively learn database modeling and design. This learning approach incorporates a sample case study that allows the student to iteratively see results of their learning and can support learning at the student's own pace.
2. determine the value of the multi-media learning methods utilised in the learning system. Specifically, the identification of factors attributed to its success and source of problems as accrued from standard survey instruments and other feedback data. The results of which will provide insight to future efforts towards such learning systems.

The Learning System

Based on some understanding on existing work on multimedia learning systems (Akpinar and Hartley, 1996; Courtway, 1995; Edelson, 1996; Oram, 1996; Woolf, 1996; Yang and Moore, 1996), two modules were developed for the system. The first module deals with the concepts portion associated with database modeling. The second module corresponds to a matching tutorial of a software application that implements the concepts of database modeling in the first module. The details of the two modules will be presented.

Module 1 - The Modeling Concepts

The concepts module went over the topics associated with database modeling using the popular generic Entity-Relationship modeling methodology and a richer variant of it, the Two-Stage Entity-Relationship (TSER) approach (Hsu, 1985). This TSER methodology was chosen for its ease of understanding and simplicity over other modeling methodologies. In implementation, this learning module hosted voice (sound) support as a secondary channel of guidance, in addition to the interactive graphics.

Module 2 - The Business Case Walkthrough

A companion Computer-Aided Software Engineering (CASE) tool called the Information-Based Modeling System (IBMS) that employs the TSER database modeling methodology was used as the basis of this learning module. This particular CASE tool is an academic-supported free software available for all to use and is accessible from the Internet. Thus, the learning system will have a wide base of users, and does not identify itself to a particular commercial concept or software. The IBMS CASE Tool is available at http://viu.eng.rpi.edu.

A simple business case dealing with a mail-order retailing company was used to demonstrate both the simplicity in the modeling methodology and the ability to handle a few complexities (knowledge modeling and semantic equivalence — in database terminology) using the software. This module employs graphical animation to guide the users in the mail-order case analysis, database modeling and design activities.

The Development Platform

The actual development of the modules required some evaluation of multimedia authoring tools available for the project. This aspect was important, as choosing the wrong development tools can adversely affect the development process in terms of development time, capability in achieving the original design and the associated learning curve. This evaluation considered the following multimedia authoring environments: Microsoft Visual Basic, Asymetrix Toolbook CBT and Macromedia Director. After some trials and evaluation, Macromedia Director v4.0 was selected as the development tool.

Macromedia Director was chosen for its ease of use. It was also the leading multimedia authoring environment in the market. In addition, Macromedia Director allows for the development of stand-alone and distributable multimedia applications. This factor is another reason for its adoption, as students can be given copies to take home to use on their own PCs. Since Director is available on both the PC and Macintosh platforms, the PC was chosen for both the development and distribution platforms. This choice was very practical as PCs are ubiquitous in Hong Kong and students are likely to only have PC experience. Five students have been recruited for the design and development effort over the past year.

Design Criteria for the Learning System

Some of the basic criteria of the learning system were that it can incorporate multimedia where thought to be appropriate (Ellis et al., 1996; Hays, 1996; Large et al., 1996); introduce interactivity where students can be directly involved in the process of database modeling and design (Durbridge, 1996; Milhem, 1996); and that the system not be too lengthy as to be boring, and that an execution time of not more than 20-30 minutes be sufficient for a single sitting — representing a reasonable attention span (Akpinar and Hartley, 1996). Another issue that came about was the distribution size of the learning system. A prototype version that had incorporated lengthy audio expanded the size of the software to the point that it required a handful of diskettes in order to be portable. This version was scaled back so as to be reasonably distributable and yet be enriching in multimedia.

The Evaluation Process

Objective of the Evaluation

Three themes were evaluated in terms of the learning system:

1. Students perception of themselves in learning to use software
2. The usefulness of the software (IBMS)
3. The ease of use of the software (IBMS).

One of the objectives of the survey is to determine if the learning system was helpful and whether the ease / difficulty in database modeling and design tasks was due to the CASE software itself. Therefore, the analysis of data collected from the surveys can draw an assessment of the value and impact of the effort.

Evaluation Measures

One of the objectives of this research project is to be able to evaluate the learning involved with the system (Plowman, 1996; Taylor, 1996; Weller, 1996; Wild, 1996). A review of the literature on this aspect has led to the identification of scale factors appropriate for research on learning. Specifically:

> Self-efficacy is defined as people's judgment of their capabilities to organize and execute courses of action required to attain designated types of performances. It is concerned not with the skills one has but with the judgments of what one can do with whatever skills one possesses, (Bandura, 1986).

Self-efficacy, in the context of this study, refers to the judgment of one's capability to use a computer. The purpose of the self-efficacy instrument is to obtain the information of the subjects' initial confidence level in handling database modeling and design. This particular test instrument by Compeau and Higgins (1995) will be repeated in three stages of the evaluation process which will be detailed later.

Since the evaluation process includes the actual use of the database modeling and design software (IBMS), there exists the potential for side-effects associated directly with the software itself. Specifically, since IBMS is a computer-based system, the design, features and user-friendliness of IBMS would have a great impact on the subject's perception of using the database methodology.

Two additional instruments were therefore used to evaluate the software quality of the database design software (IBMS). The two instruments address the usefulness (Appendix B) and ease-of-use (Appendix C) scale factors for evaluation of software quality. These two instruments were developed and presented by Davis (1989) and have been adopted in this study. The following are his definitions for these scale factors:

> Perceived usefulness refers to the degree to which a person believes that using a particular system would enhance his or her performance (Davis, 1989).

The concept here is to identify if something (software) can benefit a person to do his/her job in terms of personal benefits. These benefits can be bonuses, extra time, less stress, etc.

> Perceived ease-of-use can be defined as the degree to which a person believes that using a particular system would be free of effort (Davis, 1989).

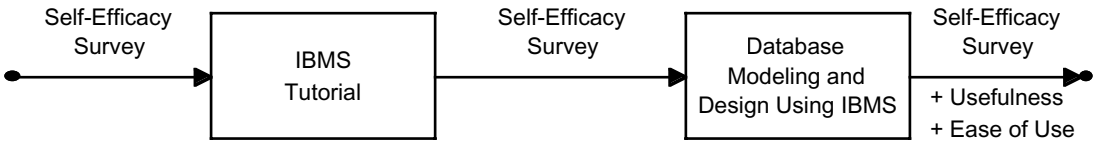
The general idea here is that if a particular system (software) is easy to use it is likely to be acceptable to the users.

These two scales are used to measure the software quality of IBMS. In doing so, the software quality effect of IBMS software to TSER methodology can be measured. The choice in the use of the established and publicly available instruments is due to their having been tested through in terms of construct validity for their measurement scales.

The Methodology

A systematic stepwise survey was used to test the subjects' learning of database modeling and design. The survey was divided into five stages (Figure 1).

Figure 1: The Five Stages



In the first stage, a self-efficacy instrument will be distributed to the subjects (students) prior to an exposure to the learning system and the IBMS software. The second stage is the students' trial through the multimedia learning system for database modeling and design. In stage three, the students are again requested to complete the self-efficacy test. Data collected at this stage will be compared with the first stage to check the relative effectiveness of the learning system. In the fourth stage, students are required to use the actual database modeling and design software for a separate class assignment that will be graded. A different and more comprehensive business case was given to the students for this work. This case allowed them to have direct hands-on experience with the database modeling concepts learned along with the matching software. The concluding fifth stage caps off the evaluation process with the self-efficacy instrument for the third time, plus the two instruments for usefulness and ease-of-use.

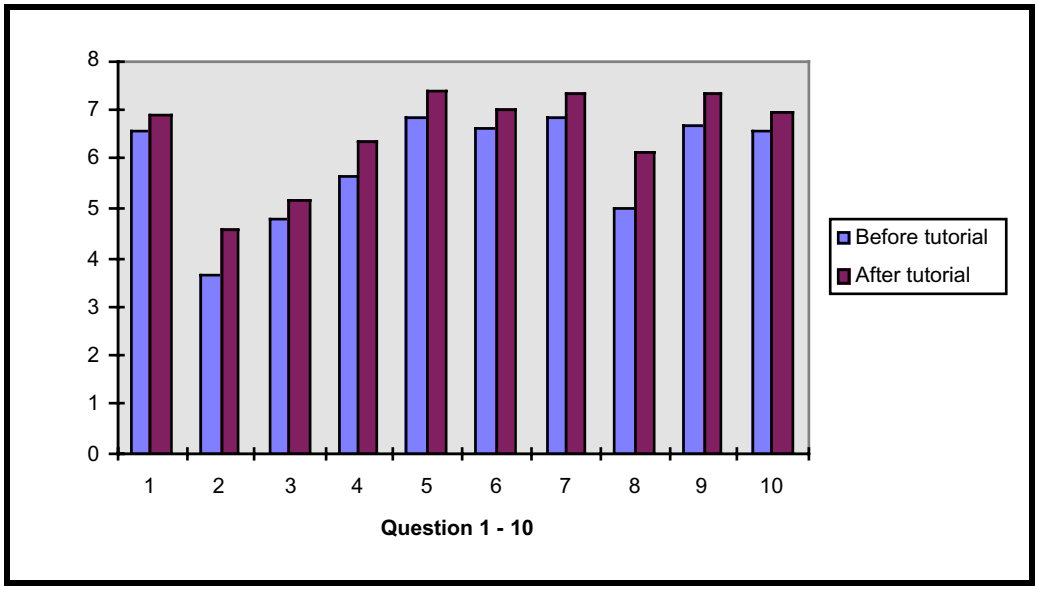
The Subjects

The survey group represented 2nd year information systems major students at Hong Kong University. Thus they have a fair amount of exposure to computers and computing technology compared to the balance of the student body in the University. Twenty-six students volunteered to take part in the survey and correspondingly, survey data was collected on this group. The analysis of the survey is presented in the next section.

Analysis of the Data

From the five stages of the survey methodology, the self-efficacy test was given to each student three times: before using the multimedia tutorial, after using the tutorial and after doing a data modeling project using IBMS. The self-efficacy test consists of ten questions (see Appendix A). A statistical t-test was performed on the average self-efficacy score of the students (average score of the ten questions in a self-efficacy test) before and after using the tutorial. (See Figure 2) After calculating the scores before and after the tutorial was taken, the average score after the tutorial was taken was shown to be the higher score of the two. (6.5 vs. 5.9 on a scale of 0-10 with confidence level of 99.76%).

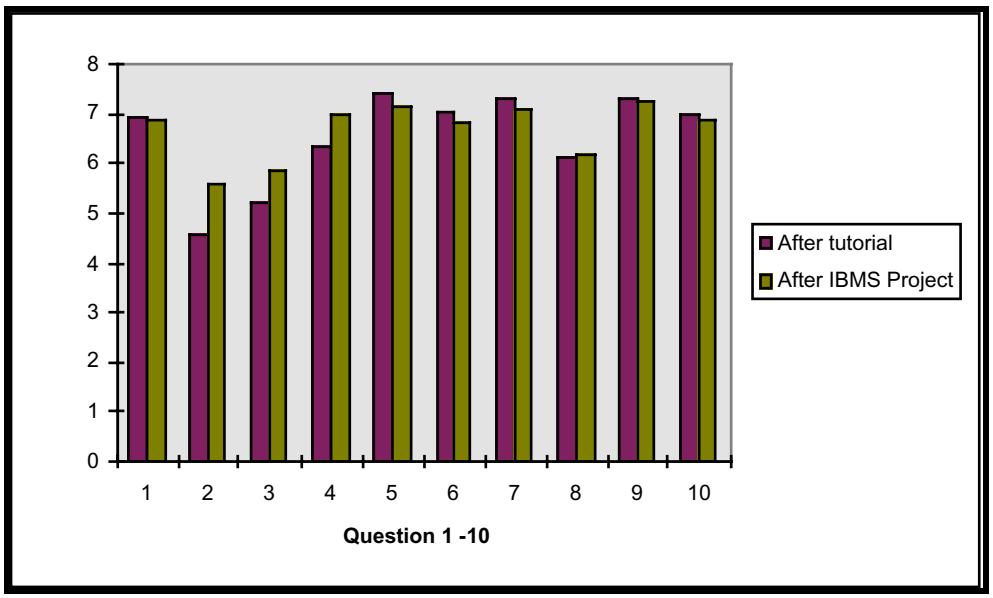
Figure 2: Self-Efficacy Test Comparison 1



However, a comparison between the results of the efficacy survey given after the learning system and at the completion of the database design assignment did not show improvement for the

students. In fact, the statistics indicate no significant difference on scores for individual questions within a test (Figure 3). In the same comparison, the average score on each self-efficacy survey also fails to show improvement after the IBMS project.

Figure 3: Self-Efficacy Test Comparison 2



One explanation for any differences in improvement in the above comparison of efficacy tests is that the IBMS software itself could be a limiting factor in terms of ease-of-use and usefulness. Thus, two other instruments are administered exactly for this purpose. The results from the use of these instruments support the explanation that although the IBMS database design software is useful, it is not easy-to-use.

Figure 4: Test of Usefulness

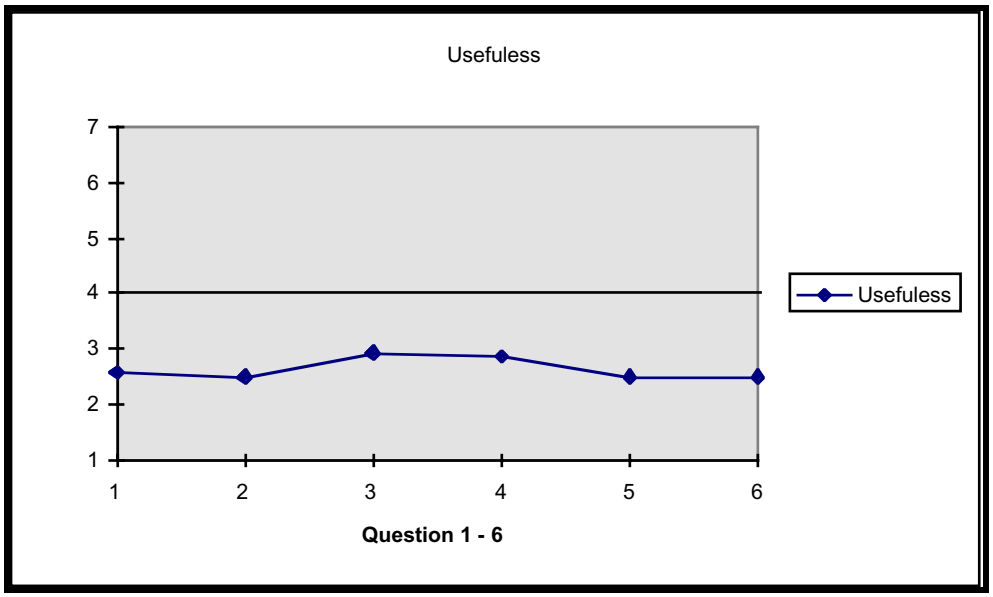
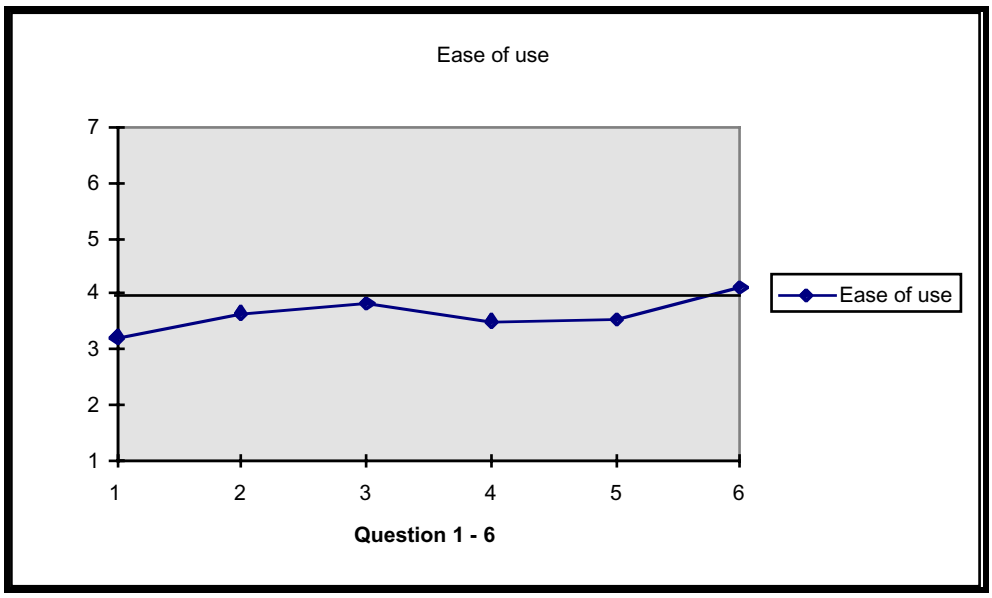


Figure 5: Test of Ease-of-Use



General Comments on the Learning System

The survey given included space for student comments regarding the learning system. The following table shows some popular comments received along with the number of times (at least 2) that a particular theme was cited. This compilation of student comments provides some direct feedback that can contribute to the next round of refinements for future versions of the learning system.

Rank	Comment	Citations
1	easy to understand	5
2	too slow	4
3	not enough detail	4
4	need more user guidance	3
5	enjoy the graphical presentation	2
6	like the GUI interface	2
7	desire less interactivity	2

From the above table of comments, the materials presented appear to have been at an appropriate level. The liberal use of graphics and multimedia also created positive comments from the students. However, the system itself was considered slow by some users. The degree of interactivity also appeared to be too demanding to a few users.

Conclusion

In summary, the multimedia learning system was significant in helping students / users gain confidence in using the database modeling and design software (the IBMS CASE tool). However, it was also determined that the IBMS software was found to be difficult to use albeit useful in the tasks.

Adjustments to the learning system can be made in accordance to the comments received from the students. Furthermore, a survey specific to the above factors of the learning system will be developed or adopted in future evaluations of the learning system to determine if these changes were effective. Thus, we can expect the development of formal guidelines to pave the way for the future development of such systems. Finally, the creators of the freeware IBMS software tool for database modeling and design will be informed that the software may need improvements in terms of its ease-of-use.

Appendix A

Computer Self-Efficacy Measure

Often in our jobs we are told about software packages that are available to make work easier. For the following questions, imagine that you were given a new software package (e.g., IBMS) for some aspect of your work (e.g., database modeling and design). It does not matter specifically what this software package does, only that it is intended to make your job easier and that you have never used it before.

The following questions ask you to indicate whether you could use this unfamiliar software package under a variety of conditions. For each of the conditions, please indicate whether you think you would be able to complete the job using the software package. Then, for each condition that you answered 'yes', please rate your confidence about your first judgment, by circling a number from 1 to 10, where 1 indicates 'Not at all confident', 5 indicates 'Moderately confident', and 10 indicates 'Totally confident'.

For example, consider the following sample item.

I could complete a data modeling and design job using the IBMS CASE software ...

			NOT AT ALL CONFIDENT			MODERATELY CONFIDENT				TOTALLY CONFIDENT	
			---			---					---
Q.	...if there was someone giving me step by step instructions.	(YES) ...	1	2	3	4	(5)	6	7	8	9	10
		NO										

The sample response shows that the individual felt he or she could complete the job using the software with step by step instructions (YES in circled), and was moderately confident that he or she could do so (5 is circled).

Computer Self-Efficacy Measure

Complete the following sentence and circle the most suitable confidence value that describes you best.

I could complete a data modeling and design job using the IBMS CASE software ...

			NOT AT ALL CONFIDENT ---				MODERATELY CONFIDENT ---					TOTALLY CONFIDENT ---
Q-1	...if there was someone to tell me what to do as I go.	YES.... NO	1	2	3	4	5	6	7	8	9	10
Q-2	...if I had never used a package like it before.	YES.... NO	1	2	3	4	5	6	7	8	9	10
Q-3	...if I had only the software manuals for reference.	YES.... NO	1	2	3	4	5	6	7	8	9	10
Q-4	...if I had seen someone else using it before trying it myself.	YES.... NO	1	2	3	4	5	6	7	8	9	10
Q-5	...if I could call someone for help if I got stuck.	YES.... NO	1	2	3	4	5	6	7	8	9	10
Q-6	...if someone else had helped me get started.	YES.... NO	1	2	3	4	5	6	7	8	9	10
Q-7	...if I had a lot of time to complete the job for which the software was provided.	YES.... NO	1	2	3	4	5	6	7	8	9	10
Q-8	...if I had just built-in help facility for assistance.	YES.... NO	1	2	3	4	5	6	7	8	9	10
Q-9	...if someone showed me how to do it first.	YES.... NO	1	2	3	4	5	6	7	8	9	10
Q-10	...if I had used similar packages before this one to do the same job.	YES.... NO	1	2	3	4	5	6	7	8	9	10

Appendix B

Perceived Usefulness

Evaluate each of the 6 statements and *circle* the one that best *describes* you if data modeling and database design was your job.

Example:

Using IBMS would improve data modeling and design performance.

• Extremely Likely	• Quite Likely	• Slightly Likely	• Neither	• Slightly Unlikely	• Quite Unlikely	• Extremely Unlikely

---

1. Using IBMS in my job would enable me to accomplish data modeling and design more quickly.

• Extremely Likely	• Quite Likely	• Slightly Likely	• Neither	• Slightly Unlikely	• Quite Unlikely	• Extremely Unlikely

2. Using IBMS would improve data modeling and design performance.

• Extremely Likely	• Quite Likely	• Slightly Likely	• Neither	• Slightly Unlikely	• Quite Unlikely	• Extremely Unlikely

3. Using IBMS in my job would increase my productivity.

• Extremely Likely	• Quite Likely	• Slightly Likely	• Neither	• Slightly Unlikely	• Quite Unlikely	• Extremely Unlikely

4. Using IBMS would enhance my effectiveness on data modeling and design.

• Extremely Likely	• Quite Likely	• Slightly Likely	• Neither	• Slightly Unlikely	• Quite Unlikely	• Extremely Unlikely

5. Using IBMS would make it easier to do data modeling and design.

• Extremely Likely	• Quite Likely	• Slightly Likely	• Neither	• Slightly Unlikely	• Quite Unlikely	• Extremely Unlikely

6. I would find IBMS useful in data modeling and design.

• Extremely Likely	• Quite Likely	• Slightly Likely	• Neither	• Slightly Unlikely	• Quite Unlikely	• Extremely Unlikely

Appendix C

Perceived Ease of Use

Evaluate each of the 6 statements and *circle* the one that best *describes* you if data modeling and database design was your job.

Example:

I would find it easy to get IBMS to do what I want it to do.

• Extremely Likely	• Quite Likely	• Slightly Likely	• Neither	• Slightly Unlikely	• Quite Unlikely	• Extremely Unlikely

---

1. Learning to operate IBMS would be easy for me.

• Extremely Likely	• Quite Likely	• Slightly Likely	• Neither	• Slightly Unlikely	• Quite Unlikely	• Extremely Unlikely

2. I would find it easy to get IBMS to do what I want it to do.

• Extremely Likely	• Quite Likely	• Slightly Likely	• Neither	• Slightly Unlikely	• Quite Unlikely	• Extremely Unlikely

3. My interaction with IBMS would be clear and understandable.

• Extremely Likely	• Quite Likely	• Slightly Likely	• Neither	• Slightly Unlikely	• Quite Unlikely	• Extremely Unlikely

4. I would find IBMS to be flexible to interact with.

• Extremely Likely	• Quite Likely	• Slightly Likely	• Neither	• Slightly Unlikely	• Quite Unlikely	• Extremely Unlikely

5. It would be easy for me to become skillful at using IBMS.

• Extremely Likely	• Quite Likely	• Slightly Likely	• Neither	• Slightly Unlikely	• Quite Unlikely	• Extremely Unlikely

6. I would find IBMS easy to use.

• Definitely No	• Very Unlikely	• Somewhat Unlikely	• Neutral	• Somewhat Likely	• Very Likely	• Definitely Yes