



PERGAMON

Computers & Education 41 (2003) 249–270

---

---

**COMPUTERS &  
EDUCATION**

---

---

www.elsevier.com/locate/compedu

# Multimedia learning system and its effect on self-efficacy in database modeling and design: an exploratory study

Waiman Cheung<sup>a</sup>, Eldon Y. Li<sup>b,\*</sup>, Lester W. Yee<sup>c</sup>

<sup>a</sup>*The Chinese University of Hong Kong, Shatin, N.T., Hong Kong*

<sup>b</sup>*California Polytechnic State University, San Luis Obispo, CA 93407, USA*

<sup>c</sup>*Xcelon Corporation, 25 Mall Road, Burlington, MA 01803, USA*

Received 18 September 2002; accepted 22 April 2003

---

## Abstract

Metadatabase modeling and design integrate process modeling and data modeling methodologies. Both are core topics in the information technology (IT) curriculum. Learning these topics has been an important pedagogical issue to the core studies for management information systems (MIS) and computer science (CSc) students. Unfortunately, the learning curve for the associated metadatabase modeling methodologies and their corresponding computer aided software engineering (CASE) tools have made it difficult for students to grasp. Addressing this learning issue, this study developed a multimedia learning system (MLS) and examines the effect of this MLS on the self-efficacy of learning these topics. It confirms that the MLS has significant impact on the self-efficacy in learning and that the software usefulness and software ease-of-use indeed affect the learning self-efficacy of MIS students. Furthermore, longer usage of the MLS can improve the self-efficacy in learning, but cannot make the improvement faster. Finally, the MLS can help the MIS students improve their self-efficacy in learning more than helping the CSc students.

© 2003 Elsevier Ltd. All rights reserved.

*Keywords:* Multimedia learning system; Learning process; Self-efficacy; CASE tool; Software usage; Metadatabase; Database modeling and design; Information technology

---

## 1. Introduction

Databases are ubiquitous in modern information systems. A properly designed database underpins the success of an information system. The nature of designing a database involves much human judgment, particularly in the aspect of database and business-process modeling. Together they are

---

\* Corresponding author.

*E-mail addresses:* wcheung@baf.msmail.cuhk.edu.hk (W. Cheung), eli@calpoly.edu (E.Y. Li), lyee@exln.com, lester\_yee@usa.net (L.W. Yee).

called metadatabase modeling [24]. Conveying the understanding of metadatabase modeling and design poses great challenges for both the teacher and students [11]. For every given business case associated with the development of a database, there exists multiple metadatabase designs that are considered correct and suitable. This abstraction of multiple solutions in metadatabase modeling and design introduces a degree of cognitive dissonance for students, as many seek and expect a definitive answer to such a problem. The tendency by students to seek a convergence of definitive solutions to a technical problem tends to be the norm in many science and engineering courses. To alleviate some of these anxieties, students themselves often request additional supporting materials and examples from the teachers to supplement their class lectures. From the perspective of the teachers, such situations impose significant burden on the teaching of the course. A plausible action to release this burden is to use a multimedia learning system (MLS) to supplement the learning of the subject.

Multimedia learning systems (MLSs) have been prevalent in today's training programs. The literature is full of reports on the benefits of using such systems in students/employee training [5,16,17,21]. These benefits include savings in terms of money and time on the company side as well as self-pacing and easy accessibility [19] on the student/employee side. For instance, Janoff [25] found that a computer-based training program had given a supermarket the opportunity to train an employee in about 50% of the time it previously took. The MLS reported in Ref. [8] has been implemented by over 400 government agencies and over 100 private companies in 12 countries. The actual system demonstrated cost savings of 45–65% and marked improvement in retention times. An important feature of a MLS is the possibility for learners to individualize their learning experience, including the amount of practice and the time spent on task which both predict knowledge gain in the learning process [6]. Vichuda, et al. [38] found that interactive MLS significantly improve users' attitudes (content, format, user-control, feedback, ease of use, and motivation), and some dimensions of attitude translate into learning performance improvement.

The many benefits of MLS notwithstanding, none of the existing studies has explored the extent of MLS on the self-efficacy of learning metadatabase modeling and design. A common question is "Does an MLS improve the student's self-efficacy in metadatabase modeling and design?" A more specific inquiry would be "Does an MLS have different effects on self-efficacy of the students in metadatabase modeling and design who have different skill orientations, namely, one is technical oriented (e.g., computer science) and the other is organizational oriented (e.g., management information systems)?" The rationale behind this is that if the topic of learning is technical, the MLS is less effective for technical-oriented IT (information technology) professionals and more effective for organizational-oriented IT professionals. To date, no study has been reported on this research inquiry. The purpose of our study is investigate this issue and explore the effect of MLS on student's self-efficacy in a non-trivial technical topic such as metadatabase modeling and design. Furthermore, it is to verify that the MLS helps organizational-oriented MIS (management information systems) students more than technical-oriented CSc (computer science) students in improving self-efficacy of such a technical topic.

## **2. The learning topic: metadatabase modeling and design**

Metadatabase modeling and design is a non-trivial technical task. Learning to use a CASE tool for such a task is equally complex [4]. Traditionally, database design has been a by-product of

information systems development through modeling methodologies of Data Flow Diagrams (DFD) and Entity/Relationship (E/R) Diagrams. The DFD and E/R modeling methodologies themselves were conceived independently to address issues of business process modeling and data modeling, respectively. What was lacking was a well-defined integration between these two popular methodologies that are usually used together. To fill this void, Hsu [22] introduced the metadatabase model. A metadatabase model goes beyond the conventional wisdom of data dictionary or repository and includes the organization's business rules. It contains not only data models but also contextual knowledge pertaining to the enterprise. A common methodology for metadatabase modeling and design is the two-stage entity–relationship (TSER) methodology [22,24].

### 2.1. The two-stage entity–relationship methodology

The TSER methodology approaches the aforementioned dichotomy of modeling methods with a two-stage modeling process whereby an enterprise information model can be specified in its entirety from the semantic level to the structural level in a synergistic way. At the semantic/functional modeling level, there are two constructs, Subject and Context, which can be referred to as the semantic notion of “entity” and “relationship”, respectively. The output of this level is a Semantic Entity–Relationship (SER) model. The SER model can have many levels of elaboration (decomposition), ranging from the enterprise-level overview used for top-level communications (similar to the Context Diagram in DFD) all the way to the level of detailed objects used for the ensuing Operational Entity–Relationship (OER) model. The OER model is the output of the structural/operational level of data modeling wherein the knowledge in the form of business/operating rules is declared. Four constructs are used in the OER model. The constructs *Operational Entity* and *Plural Relationship* correspond to the classical data-oriented notion of entities and relationships with the requirement that the model is in the third normal form. The other two constructs *Functional Relationship* and *Mandatory Relationship* define the referential integrity constraints in the OER model. Since the OER focuses on the data-structure level, an enterprise-wide (or global) OER model can be created to represent entirely the structure of the information utilized within the organization. The TSER methodology provides not only the means for defining the two models but also a well-defined mechanism (algorithms) of mapping the functional SER model into the structural OER model.

### 2.2. The CASE tool

Using computer-aided software engineering (CASE) tools during the analysis and design phases of the system development process is well receptive today [34,43]. To facilitate the use of the TSER methodology during the metadatabase modeling and design process, we also adopted a CASE tool, called the *Information-Based Modeling System (IBMS)*, developed by a research team at the Rensselaer Polytechnic Institute [23,24]. The latest version of this tool runs on the MS-Windows platform and utilizes the GUI technology. Fig. 1 exhibits the function tree of this tool.

Targeted at database modelers and designers of all levels of expertise, the tool employs an SER diagram modeler (see Fig. 2) for specifying functional objects (e.g., instructor, course, and classroom),

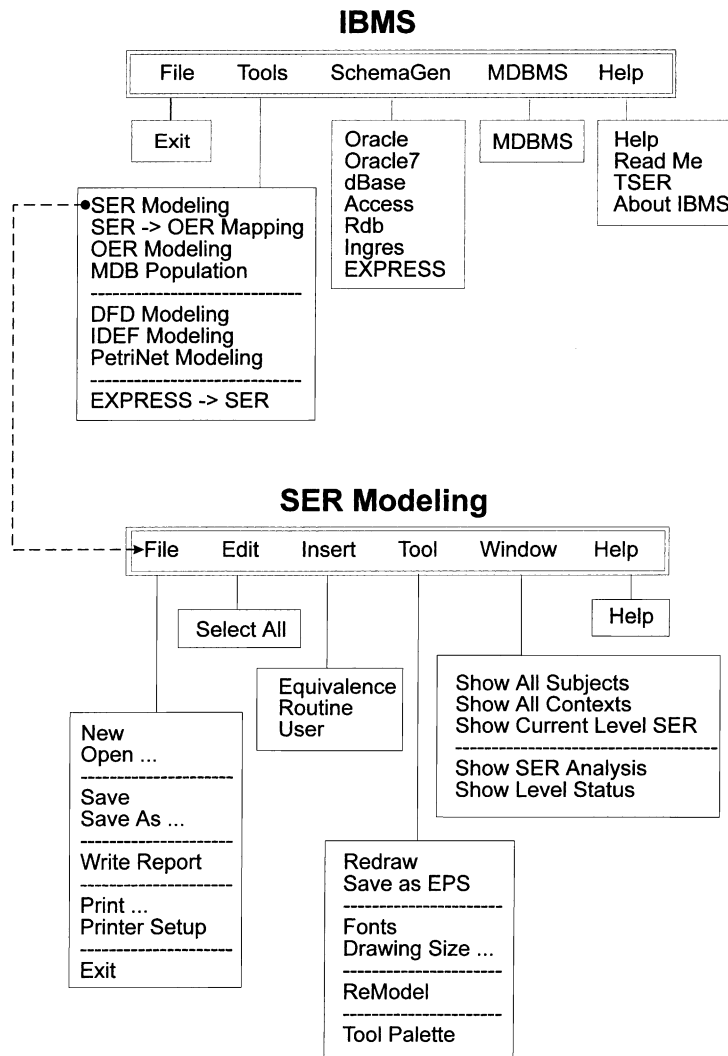


Fig. 1. Function tree diagram of IBMS software. The Two-Stage Entity–Relationship (TSER) Methodology and the Information-Based Modeling System (IBMS) are the conception of Professor Cheng Hsu of Rensselaer Polytechnic Institute, Troy, New York. TSER and IBMS have been taught in Rensselaer classrooms from in 1987, and at universities in US and Hong Kong from the early 1990s. They now have a wider acceptance internationally. The methodology itself has been well-documented in a number of papers and thesis and the IBMS CASE tool is freely available on the Internet as educational freeware (<http://viu.eng.rpi.edu>).

their relevant data fields, and their inter-relationships. The above determination and specification of modeling details are formalized in the TSER methodology with which one can create a proper and well-designed database. IBMS is implemented with formalized mapping algorithms to directly create usable database schema in Oracle SQL, dBase IV, and MS-Access from an SER model. Fig. 3 shows a sample of Oracle SQL schema created by the IBMS. The key to a good

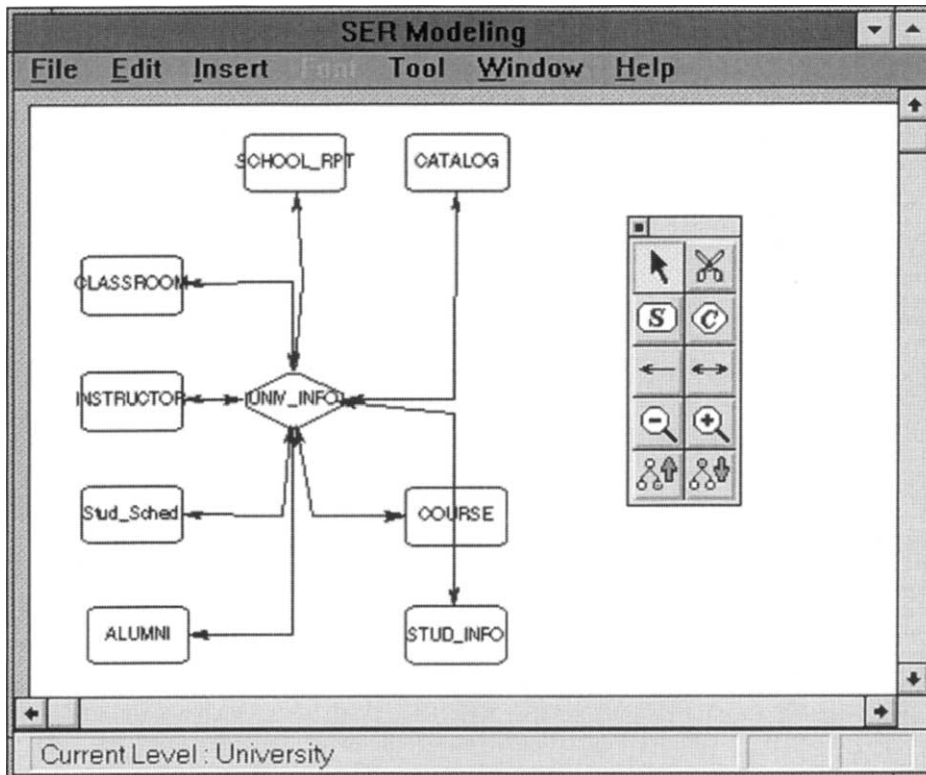


Fig. 2. Example of TSER database design model for a university.

database design using TSER, however, is achieving a proper specification of the functional SER model. This is a process of primarily human intelligence and IBMS was not designed to automate this process. This is where an MLS will come in useful. In fact, an MLS for learning metadatabase modeling and design must be designed with the underlying goal of enabling students to achieve the proper specification of a functional SER model.

### 3. The multimedia learning system

One of the major obstacles to institutionalize CASE tools is the long learning curve [31,36]. This may be the reason why the CASE tool usage has been much lower than would be expected based on the popular literature [18,34]. In order to minimize the learning-curve effect of the CASE tool on the outcome of learning, an MLS has been developed in this study.

Based on an understanding of existing work on MLS [1,10,14,28,29,32,35,42–44], two modules were developed for the system. The first module deals with the concepts portion associated with metadatabase modeling. The second module is a software replica of IBMS that provides context-sensitive help of software functions as well as matching tutorials of software applications [27].

```

Notepad - UNIV.SQL
File Edit Search Help
CREATE TABLE COURSE
(COURSE_NO CHAR(10) NOT NULL,
PREREQ CHAR(20) NOT NULL,
SEMESTER CHAR(20) NOT NULL,
STUD_NO CHAR(9) NOT NULL,
DENDSEM CHAR(12),
DEGREE SOUGHT CHAR(3),
STUD_NAME CHAR(40),
DSTRTSEM CHAR(12));

CREATE UNIQUE INDEX COURSEIDX ON COURSE
(COURSE_NO, PREREQ, SEMESTER, STUD_NO);

CREATE TABLE CLASSROOM
(COURSE_NO CHAR(10) NOT NULL,
SEMESTER CHAR(20) NOT NULL,
DENDSEM CHAR(12),
DSTRTSEM CHAR(12),
CAMPUS CHAR(20),
COURSE_TITLE CHAR(40),
DAY_TIME CHAR(20),
LOCATION CHAR(20),);

```

Fig. 3. Resulting SQL database schema output from IBMS Software.

Fig. 4 exhibits the functionality of the replica and Fig. 5 shows the welcoming screen of the MLS. The characteristics of the two modules are briefly described below.

### 3.1. Module 1—the modeling concepts

The concepts module provides tutorials for the topics associated with database and process modeling, general Entity–Relationship model, and the TSER methodology. It was able to host voice (audio) support as a secondary channel of guidance, in addition to the interactive graphics. Several examples were used to demonstrate the concepts.

### 3.2. Module 2—the software replica

A software replica looks and feels like the original software. In this IBMS replica, 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 complexities in using the software (e.g., knowledge modeling and semantic equivalence—in database terminology). Fig. 6 shows a sample screen of the mail order case: an invoice and its corresponding data items and functional dependences. Also, this module employs multimedia including graphical animations to walk the users through the mail-order case analysis (see Fig. 7), database modeling (see Fig. 8), and several design activities.

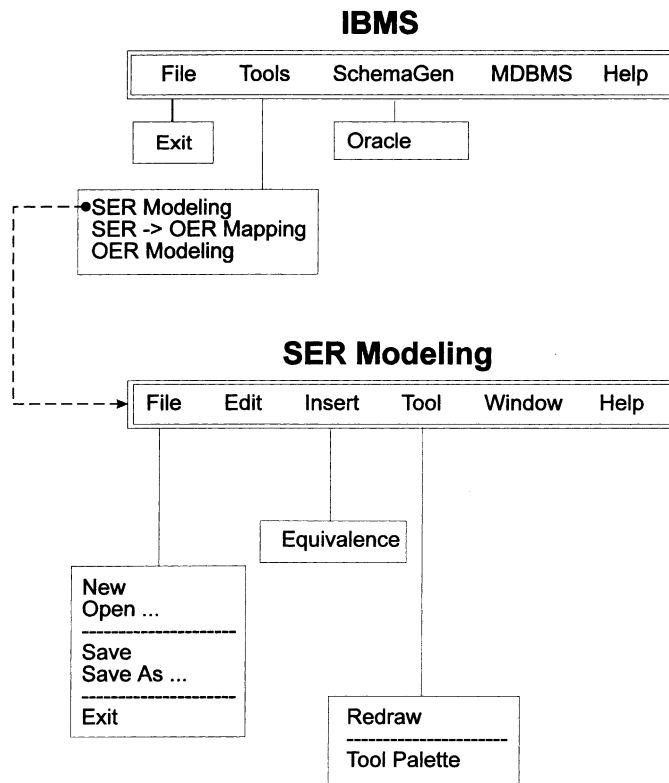


Fig. 4. Functionality of IBMS replica.

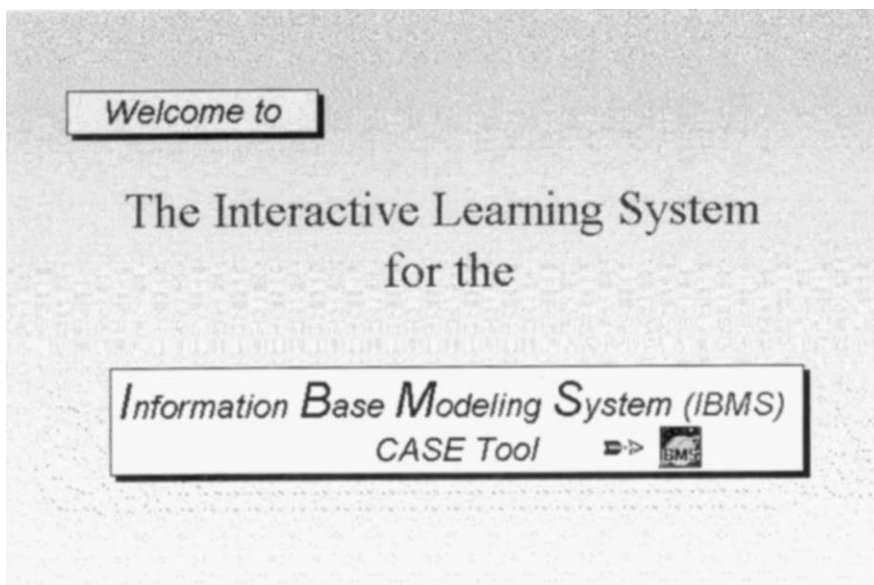


Fig. 5. Title screen of multimedia learning system.

**Business Case Analysis**

**Order Invoice Document**

Invoice No.: 1888      Date: 30/10/96  
 Customer ID: Y126      Credit Status: A  
 Customer Name: ABC Limited

Product ID	Description	Quantity	Price	Extended Price
SKU9991	Hammer	1	19.00	95.00
SKU1234	Wrench	1	4.00	4.00
SKU0011	Drill	2	99.00	198.00
...	...	...	...	...

Total \$ 297.00

**1 Define all data items/attributes:**

INVOICE_NO	CUST_ID	CUST_NAME	DATE	CREDIT_STATUS	PROD_ID
PART_DESC	QTY	RETAIL_PRICE	EXT_PRICE	TOTAL_PRICE	

**2 Define FDs:**

INVOICE_NO	--->	CUST_ID	DATE	TOTAL_PRICE
CUST_ID	--->	CUST_NAME	CREDIT_STATUS	

Other FDs will be shown, please click Continue button

Continue

Fig. 6. The mail-order business case.

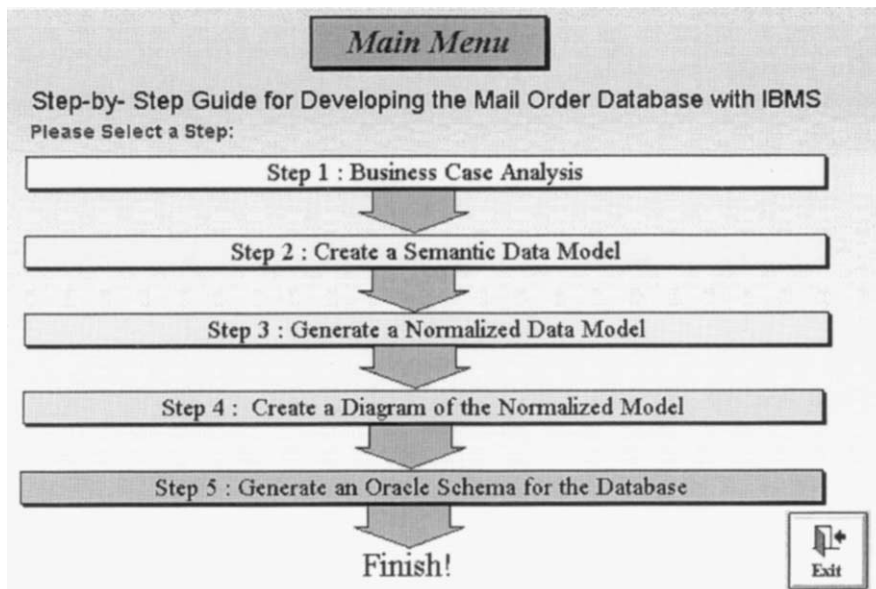


Fig. 7. Main menu of modules in the learning system.

### 3.3. The development platform

Some of the basic criteria of designing the MLS for this study include incorporating graphical user interface (GUI) and multimedia [15,20,26] and introducing interactivity where students can involve themselves in the process of metadata modeling and design [13,30]. Further, a tutorial



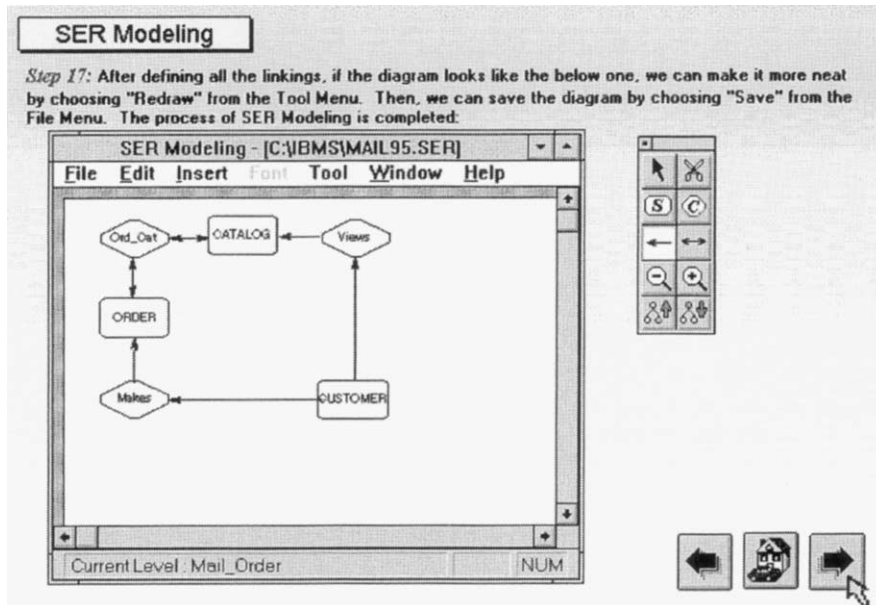


Fig. 8. Sample screen of modeling in the learning system.

should not be too lengthy to become boring, and that a limit of 30 min should be adopted for a single sitting—representing a reasonable attention span [1].

Based on these criteria, we evaluated several multimedia authoring tools available for the actual development of the modules. These tools include Microsoft Visual Basic, Asymetrix Toolbook CBT, and Macromedia Director. After some trials and evaluations, Macromedia Director was chosen as the most appropriate development tool. A key feature of Macromedia Director was its ability to develop stand-alone and distributable multimedia applications. This is another reason for its adoption, as students can be given copies to take home to use on their own PC's as well as being downloadable from a Web site.

#### 4. The learning effect: self efficacy

In this research project we want to evaluate the learning effect of the MLS. A review of the literature on this aspect has led to the identification of a scale factor [7,33,37,39,41] appropriate for research on learning effect. Specifically, the concept of self-efficacy:

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 [3].

Self-efficacy, in the context of this study, refers to judgment of one's capability to use computer software for a particular task. The purpose of the self-efficacy instrument is to obtain the information

of the subjects' confidence level in handling database modeling and design. A particular test instrument adapted from Compeau and Higgins [9] will be repeated in three stages of the evaluation process, which is detailed later.

Since the evaluation process includes the actual use of the MLS software, there exist potential side effects associated with the software itself. Specifically, the learnability of the software affects the breadth and depth of students' exercises of learning subject [4]. That is, the design, the features, and the user-friendliness of MLS would have a great impact on the student's use of the database methodology. In view of this potential side effect, two additional instruments were used to evaluate the quality of the MLS software. These two instruments address the usefulness and ease-of-use scale factors of software quality. They were developed by Davis [12] and have been thoroughly tested in terms of construct validity for their measurement scales. On one hand, perceived usefulness refers to the degree to which a person believes that using a particular system would enhance his or her performance and increase personal benefits such as bonuses, extra time, less stress, etc. On the other hand, perceived ease-of-use refers to the degree to which a person believes that using a particular system would be free of effort. The general idea here is that if a particular system (software) is easy to use, it is likely to be acceptable to the users. This study adopted these two instruments to identify the effect of the MLS quality on student's learning TSER methodology.

## 5. Research hypotheses

Based on the research purpose of identifying the effect of MLS on student's self-efficacy, the following three hypotheses could be postulated.

**Hypothesis 1.** The MLS helps a student improve self-efficacy in database modeling and design. Because the MLS used in this study is a replica of the IBMS and contains interactive tutorials on database modeling and design, it is expected that the self-efficacy of the student could be improved if he/she uses the MLS to learn the subject without interacting with other persons.

**Hypothesis 2.** The longer a student uses the MLS, the higher his/her self-efficacy in database modeling and design.

**Hypothesis 3.** The increment of improvement in a student's self-efficacy from using of the MLS diminishes with time.

Considering the training program for MIS students is less technical than that of CSc students, the assistance offered by the MLS should be more appreciated by the MIS students. Moreover, the perceived usefulness and ease-of-use should influence the self-efficacy of MIS students more than that of the CSc students. Therefore, the following four hypotheses could be further formulated.

**Hypothesis 4.** The self-efficacy gained from using the MLS is different between the organizational-oriented (MIS) students and the technical-oriented (CSc) students.

**Hypothesis 5.** The organizational-oriented (MIS) students have higher self-efficacy gained from using the MLS than the technical-oriented (CSc) students do.

**Hypothesis 6.** The perceived usefulness and ease-of-use of the MLS tool significantly affect the self-efficacy gained by the MIS student.

**Hypothesis 7.** The perceived usefulness and ease-of-use of the MLS tool do not affect the self-efficacy gained by the CSc students.

## 6. Methodology

### 6.1. Subjects

The subjects of this study were selected from two groups of students in their beginning senior year. One group consists of Management Information Systems (MIS) students from a business college and the other consists of Computer Science (CSc) students from a engineering college. To qualify for participation in this study, the student must not have taken any course in Database Modeling and Design. The CSc students had more exposure to computers and programming compared to the MIS students who had taken Introduction to MIS, Microsoft Office Software, and System Analysis and Design courses. Both groups of students had never worked on any database analysis or design project before. In order to reduce sampling error, the sample size was made equal between the two groups. It was determined by the minimum of the number of qualified students. Although the CSc group had more qualified students, the sample size was set to 23, the number of qualified MIS students. The experiment was conducted twice in a computer laboratory, one for each group. A total of 46 data points were collected.

### 6.2. Questionnaire

There are three instruments in the questionnaire used for this study. The first instrument of self-efficacy was adapted Compeau and Higgins [9]. It contains 10 questions as shown in [Appendix A](#). The other two instruments were adapted from Davis [12]. One measures the usefulness of software as shown in [Appendix B](#), the other measures the ease-of-use of software as shown in [Appendix C](#). The primary reason for choosing these instruments for this study lies on their proven psychometric quality such as reliability, content validity, and construct validity. While the self-efficacy instrument used a 10-point scale (1 = Not at all confident to 10 = Totally confident), the usefulness and ease-of-use instruments used a seven-point scale (1 = Extremely unlikely to 7 = Extremely likely).

### 6.3. Procedure

A systematic stepwise survey was used to test the subjects' self-efficacy in database modeling and design. [Fig. 9](#) shows that the survey was divided into three stages using five instruments (i.e., three self-efficacy surveys, one software usefulness test, and one software ease-of-use test).

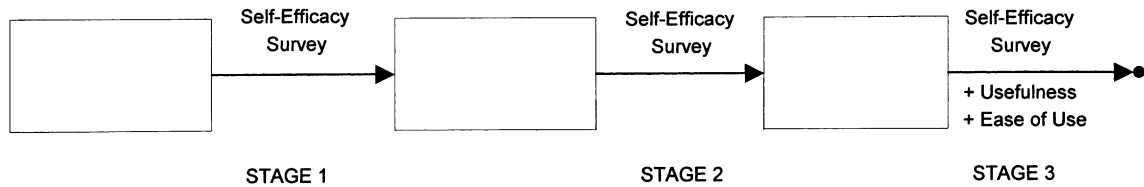


Fig. 9. The stepwise survey process.

Before we began the experiment, we must make sure that both CSc and MIS students have equal self-efficacy when they start using the MLS software to learn database modeling and design. For this purpose, a 2 h structured lecture using electronic slides on data modeling and design and including two short exercises was conducted in a large classroom, allowing both groups of students to attend. The students were not exposed to the MLS and the IBMS software during the lecture. The use of videotaped lecture helped us optimize the structure of the lecture. After the lecture, the students filled out the first-stage self-efficacy instrument and were reminded not to study the lecture materials or discuss the lecture topic with anyone.

The next day, the MIS students were regrouped in the computer laboratory to practice the MLS for database modeling and design. A simple business case was provided to the students for the practice. The practice lasted for 3 h and contained six tutorials. The students were given a short quiz whenever they completed a tutorial. They also took a 30-min break for a quick lunch after completing three tutorials. At the end of the practice, the students were asked to complete the second-stage self-efficacy test, followed by a longer break. At 2.00 p.m., they were regrouped and given a different and more comprehensive business case to complete in 3 h. This skill test allowed them to have direct hands-on experience with the metadatabase modeling and design concepts learned along with the IBMS-lookalike MLS software. The students were told to finish the assignment in time regardless of having the correct model and design or not. At the end of the skill test, the solution was displayed online for the students to compare with their models and designs. Finally, the concluding stage capped off the evaluation process with the self-efficacy instrument for the third time, plus the two instruments (i.e., a usefulness test and a ease-of-use test) for the students to specify their perceived usefulness and ease-of-use of the MLS. The same procedure was repeated one more time for the CSc students.

## 7. Results and discussion

A design feature of our survey methodology is that the self-efficacy (SE) test is given to each student three times: before using the MLS tutorial (SE1), after using the MLS tutorial (SE2), and after doing a data modeling project using MLS (SE3). Fig. 10 shows the results of the three self-efficacy tests. While  $Q_i$  represents a student's response on a 10-point scale to the  $i$ th question of a SE test, the SE score is  $\sum_{i=1}^{10} Q_i$ . Table 1 shows the SE scores of the MIS group and the CSc group. It reveals that the two groups of students have similar self-efficacy scores before using the tutorial. This is evidenced by that the average SE1 scores are very close between the two groups (Wilcoxon's test [40] of the 10-scale items is insignificant at  $P=0.721$ ). This

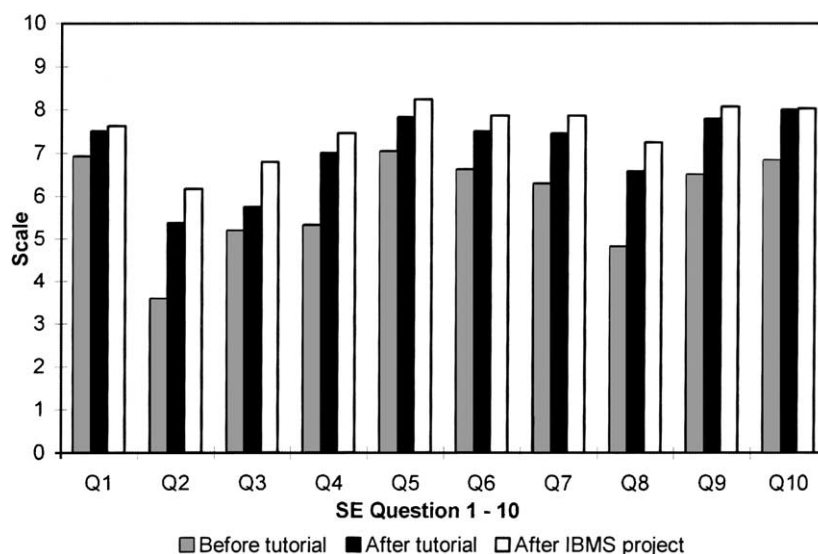


Fig. 10. Overall self-efficacy test results.

finding suggests that the background of the two groups of students regarding their knowledge on database modeling and design is homogeneous. This gives us the signal to continue our analyses.

According to Table 2, the students had perceived more usefulness (5.29) but less ease-of-use (4.41) about the MLS tool. They expressed improving self-efficacy evaluation along the learning process. The average SE1 score versus average SE2 score and the average SE2 score versus average SE3 score were subjected to the same test. The results showed that the average SE2 score is significantly higher than the average SE1 score ( $P=0.005$  based on Wilcoxon's signed rank test). Furthermore, the average SE3 score is significantly higher than the average SE2 score ( $P=0.012$ ). These two findings together support Hypotheses 1 and 2. However, the increment of improvement was larger after their initial use of the MLS tutorial (SE2 minus SE1) than after finishing the database-modeling project using the MLS (SE3 minus SE2). The former difference is significantly higher than the latter at  $P=0.005$ , supporting Hypothesis 3.

The interesting part is that the MIS students apparently had shown more improvement on self-efficacy than the CSc students in performing the task after the first use of the MLS ( $P=0.005$ ). The same is also true after they have finished the comprehensive business case ( $P=0.005$ ). Both findings support Hypotheses 4 and 5.

One explanation for potential differences in improvement on the scores of self-efficacy is that the scores could be affected by the ease-of-use and the usefulness of the MLS software itself. Thus, two other instruments were administered for these two situational factors and the results support the explanation that although the MLS tool is useful, it is not exactly easy-to-use. Although scores of usefulness in Fig. 11 are higher than those of ease-of-use, there is no significant difference between these two sets of scores assigned by the two groups of students. The Wilcoxon's signed rank tests are insignificant at  $P=0.598$  and  $P=0.461$ , respectively.

Table 1  
Self-efficacy survey data

	MIS students	CSc students	Overall
<b>SE1</b>			
Q1	6.91	6.57	6.74
Q2	3.57	3.65	3.61
Q3	5.04	4.78	4.91
Q4	5.26	5.65	5.46
Q5	6.96	6.83	6.90
Q6	6.50	6.60	6.55
Q7	6.20	6.80	6.50
Q8	4.90	5.00	4.95
Q9	6.40	6.70	6.55
Q10	6.91	6.57	6.74
<i>Average SE1 score</i>	<i>58.65</i>	<i>59.17</i>	<i>58.91</i>
<b>SE2</b>			
Qi	7.52	6.91	7.22
Q2	5.39	4.57	4.98
Q3	5.74	5.17	5.46
Q4	7.04	6.35	6.70
Q5	7.70	7.40	7.55
Q6	7.40	7.00	7.20
Q7	7.40	7.30	7.35
Q8	6.50	6.10	6.30
Q9	7.80	7.30	7.55
Q10	8.10	7.00	7.55
<i>Average SE2 score</i>	<i>70.65</i>	<i>65.13</i>	<i>67.89</i>
<b>SE3</b>			
Q1	7.70	6.90	7.30
Q2	6.20	5.60	5.90
Q3	6.80	5.90	6.35
Q4	7.50	7.00	7.25
Q5	8.30	7.20	7.75
Q6	7.90	6.80	7.35
Q7	7.90	7.10	7.50
Q8	7.30	6.20	6.75
Q9	8.00	7.20	7.60
Q10	8.00	6.90	7.45
<i>Average SE3 score</i>	<i>75.61</i>	<i>66.61</i>	<i>71.11</i>

### 7.1. Correlation analysis

In order to test [Hypotheses 6 and 7](#), the Pearson's and the Spearman's correlations of usefulness and ease-of-use scores against the SE scores are examined as shown in [Table 3](#). According to Pearson's correlations, the SE3 score from the MIS group relates significantly and positively with usefulness ( $r=0.422$ ;  $P=0.045$ ) and ease-of-use ( $r=0.505$ ;  $P=0.014$ ) scores, while no significant correlation was found in the CSc group. These findings support both Hypothesis 6 and 7, respectively.

Table 2  
Usefulness and ease-of-use survey data

	MIS students	CSc students	Overall
<i>Perceived usefulness</i>			
Q1	5.04	5.43	5.24
Q2	5.39	5.48	5.43
Q3	5.26	5.09	5.17
Q4	5.22	5.13	5.17
Q5	5.39	5.48	5.43
Q6	5.57	5.48	5.52
Average usefulness score	5.26	5.33	5.29
<i>Ease of use</i>			
Q1	4.48	4.78	4.63
Q2	4.00	4.35	4.17
Q3	4.39	4.17	4.28
Q4	4.26	4.48	4.37
Q5	4.78	4.43	4.61
Q6	4.22	4.48	4.35
Average ease-of-use score	4.38	4.44	4.41

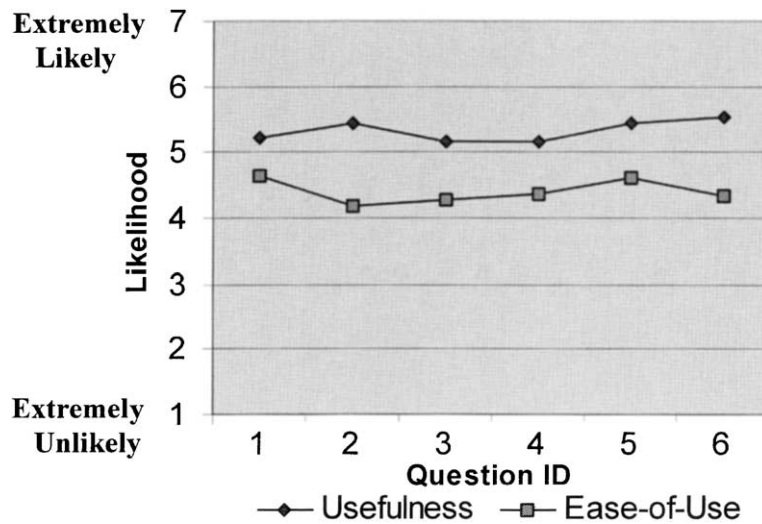


Fig. 11. Scores of usefulness and ease-of-use.

7.2. Effectiveness of TSER

As the best MLS would not be effective if the TSER method is inherently poor, one must assure the effectiveness of the TSER. The TSER model was developed to integrate major tasks of system analysis with database design in complex enterprises and was later expanded to include knowledge

Table 3  
Correlations of self-efficacy and situational factors

Student type	Situational factor	Correlation	SE1	SE2	SE3
All students	Usefulness	Pearson's	0.179	0.043	<b>0.302</b>
		<i>Sig. (2-tailed)</i>	0.234	0.778	0.041*
		Spearman's	0.221	0.118	0.212
	Ease-of-Use	<i>Sig. (2-tailed)</i>	0.141	0.436	0.158
		Pearson's	0.165	0.248	<b>0.414</b>
		<i>Sig. (2-tailed)</i>	0.274	0.097	0.004**
MIS students	Usefulness	Spearman's	0.104	0.226	<b>0.323</b>
		<i>Sig. (2-tailed)</i>	0.490	0.131	0.029*
		Pearson's	0.004	-0.025	<b>0.422</b>
	Ease-of-Use	<i>Sig. (2-tailed)</i>	0.985	0.909	0.045*
		Spearman's	0.272	0.028	0.314
		<i>Sig. (2-tailed)</i>	0.209	0.899	0.144
CSc students	Usefulness	Pearson's	-0.024	0.016	<b>0.505</b>
		<i>Sig. (2-tailed)</i>	0.914	0.942	0.014*
		Spearman's	0.008	0.164	0.405
	Ease-of-Use	<i>Sig. (2-tailed)</i>	0.971	0.455	0.055
		Pearson's	0.397	0.128	0.215
		<i>Sig. (2-tailed)</i>	0.060	0.562	0.324
CSc students	Usefulness	Spearman's	0.208	0.152	0.000
		<i>Sig. (2-tailed)</i>	0.340	0.488	0.999
		Pearson's	0.297	0.396	0.406
	Ease-of-Use	<i>Sig. (2-tailed)</i>	0.168	0.061	0.054
		Spearman's	0.201	0.388	0.342
		<i>Sig. (2-tailed)</i>	0.358	0.068	0.110

\* Correlation is significant at the 0.05 level (2-tailed).

\*\* Correlation is significant at the 0.01 level (2-tailed).

representation. It entails two levels of modeling constructs which allows for top-down analysis as well as bottom-up design (i.e., reverse engineering of existing application into TSER constructs). There are rigorous TSER algorithms which map from semantic models to structural models and the resulting structures are in normalized forms (the third normal form or higher). The integrity constraints built into the TSER constructs can be used to facilitate the management of the metadatabase [23]. Furthermore, the effectiveness of the TSER methodology can be evidenced by the fact that major corporation like Samsung Electronic has decided to adopt it for its enterprise integration and re-engineering projects and the US Army is in the process of sponsoring further development and deployment of the methodology for its manufacturing and logistic systems. Finally, the TSER is compatible with common modeling methods such as DFD and IDEF0 (Integration Definition for Function Modeling [2]) for functional modeling using Subject and Context constructs; with ER models, semantic data models, and object-oriented models for data modeling using ER diagrams or Subject constructs; and with process and flow models and rule-base models for knowledge modeling using Context constructs. Therefore, the observations



reported in this paper can be generalized for the MLS tools tailored to the other compatible modeling methods.

## **8. Conclusions and recommendations**

Multimedia learning systems are becoming a popular pedagogy in educational programs. The effect of using MLS in the learning of metadatabase modeling and design has never been investigated. This paper fills this void and reports an experiment involving the implementation of an MLS and the evaluation of its effect on a student's self-efficacy. The system aims to help users/students to learn metadatabase modeling and design using the TSER modeling methodology and the IBMS CASE tool. Seven hypotheses were postulated and tested in this study using three self-efficacy tests, a usefulness test, and an easy-to-use test. All of the hypotheses have been supported.

Specifically, the results of the self-efficacy tests have indicated that both the MIS and CSc students have confidence in understanding TSER after using an MLS. Furthermore, MIS students who have more business training but less computation and programming exposure can benefit more from the MLS in our study. Longer usage of the MLS does help the MIS students gain higher self-efficacy in metadatabase modeling and design. Yet, it does not lend itself to speeding up the improvement of self-efficacy in the learning process. The study also reveals that MLS is indeed a useful tool for metadatabase modeling and design, although it is not as easy to use as it should be, probably due to the complexity of the IBMS tool. This tells us that developers of MLS or CASE tools should make the tools easy to use and useful to the users because these features affect significantly the self-efficacy in a subject area during the training programs. Based on the findings in this study, we highly recommend that an MLS be used as a pedagogical tool to improve self-efficacy in a technical topic during the learning process.

Collecting experimental data of this kind of research is an extremely time-consuming, if not impossible, task. Small number of data points has been the common limitation of many published experiments. This is also the major limitation of our experiment. In order to generalize our conclusions, more experiments should be conducted to collect larger number of data points. Nevertheless, we had employed the nonparametric statistical test appropriate for small sample size. Therefore, the findings from the current study are statistically correct and provide us with the first look into the dynamics of self-efficacy in a technical topic during the learning process.

### **Appendix A. Computer self-efficacy measure**

The following questions ask you to indicate whether you could use an IBMS-lookalike multimedia learning system (MLS) to complete a metadatabase modeling and design job 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 MLS. 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". Please skip the 10-point scale if your answer is "NO".

Example:

*I could complete a metadatabase modeling and design job using an MLS software ...*

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

*I could complete a metadatabase modeling and design job using an MLS software ...*

		NOT AT ALL CONFIDENT			MODERATELY CONFIDENT			TOTALLY CONFIDENT				
		---	1	2	3	4	5	6	7	8	9	10
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 about the IBMS-lookalike multimedia learning system (MLS) you used and circle the one that best *describes* you if data modeling and database design were your job.

---



---

Example:

Using the MLS would improve data modeling and design performance.

7	6	5	4	3	2	1
Extremely Likely	Quite Likely	Slightly Likely	Neither	Slightly Unlikely	Quite Unlikely	Extremely Unlikely

- 
- 
- Using the MLS in my job would enable me to accomplish metadatabase modeling and design more quickly.

7	6	5	4	3	2	1
Extremely Likely	Quite Likely	Slightly Likely	Neither	Slightly Unlikely	Quite Unlikely	Extremely Unlikely

- Using the MLS would improve metadatabase modeling and design performance.

7	6	5	4	3	2	1
Extremely Likely	Quite Likely	Slightly Likely	Neither	Slightly Unlikely	Quite Unlikely	Extremely Unlikely

- Using the MLS in my job would increase my productivity.

7	6	5	4	3	2	1
Extremely Likely	Quite Likely	Slightly Likely	Neither	Slightly Unlikely	Quite Unlikely	Extremely Unlikely

- Using the MLS would enhance my effectiveness on metadatabase modeling and design.

7	6	5	4	3	2	1
Extremely Likely	Quite Likely	Slightly Likely	Neither	Slightly Unlikely	Quite Unlikely	Extremely Unlikely

- Using the MLS would make it easier to do metadatabase modeling and design.

7	6	5	4	3	2	1
Extremely Likely	Quite Likely	Slightly Likely	Neither	Slightly Unlikely	Quite Unlikely	Extremely Unlikely

- I would find the MLS useful in metadatabase modeling and design.

7	6	5	4	3	2	1
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 about the IBMS-lookalike multimedia learning system (MLS) you used and circle the one that best *describes* you if data modeling and database design were your job.

---

---

Example:

I would find it easy to get the MLS tool to do what I want it to do.

7	6	5	4	3	2	1
Extremely	Quite	Slightly	Neither	Slightly	Quite	Extremely
Likely	Likely	Likely		Unlikely	Unlikely	Unlikely

---

---

1. Learning to operate the MLS would be easy for me.

7	6	5	4	3	2	1
Extremely	Quite	Slightly	Neither	Slightly	Quite	Extremely
Likely	Likely	Likely		Unlikely	Unlikely	Unlikely

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

7	6	5	4	3	2	1
Extremely	Quite	Slightly	Neither	Slightly	Quite	Extremely
Likely	Likely	Likely		Unlikely	Unlikely	Unlikely

3. My interaction with the MLS would be clear and understandable.

7	6	5	4	3	2	1
Extremely	Quite	Slightly	Neither	Slightly	Quite	Extremely
Likely	Likely	Likely		Unlikely	Unlikely	Unlikely

4. I would find the MLS to be flexible to interact with.

7	6	5	4	3	2	1
Extremely	Quite	Slightly	Neither	Slightly	Quite	Extremely
Likely	Likely	Likely		Unlikely	Unlikely	Unlikely

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

7	6	5	4	3	2	1
Extremely	Quite	Slightly	Neither	Slightly	Quite	Extremely
Likely	Likely	Likely		Unlikely	Unlikely	Unlikely

6. I would find the MLS easy to use.

7	6	5	4	3	2	1
Extremely	Quite	Slightly	Neither	Slightly	Quite	Extremely
Likely	Likely	Likely		Unlikely	Unlikely	Unlikely

## References

- Akpinar, Y., & Hartley, J. R. (1996). Designing interactive learning environments. *Journal of Computer-Assisted Learning*, 12(1), 33–46.
- Anonymous. (1993). *Integration definition for function modeling (IDEF0)*. Gaithersburg, MD: Federal Information Processing Standards Publications (FIPS PUBS) 183, National Institute of Standards and Technology (NIST), 21 December.
- Bandura, A. (1996). *Social Foundations of Thought and Action*. Englewood Cliff, NJ: Prentice Hall.
- Boloix, G., & Robillard, P. N. (1998). CASE tool learnability in a software engineering course. *IEEE Transactions on Education*, 41(3), 185–193.
- Brookshaw, C. & Seoane, D. (1996). Training effectiveness. *InfoWorld*, 18(42), 14 October. 76,77,80.
- Brown, K. G. (2001). Using computers to deliver training: which employees learn and why? *Personnel Psychology*, 54(2), 271–296.
- Busch, T. (1995). Gender differences in self-efficacy and attitudes towards computers. *Journal of Educational Computing Research*, 12(2), 147–158.
- Callahan, E. R. Jr., Shim, J. P., & Oakley, G. W. (2000). Learning, information, and performance support (LIPS): a multimedia-aided approach. *Interfaces*, 30(2), 29–40.
- Compeau, D. R., & Higgins, C. A. (1995). Computer self-efficacy: development of a measure and initial test. *MIS Quarterly*, 19(2), 189–211.
- Courtway, P. (1995). Hospital saves thousands using multimedia tutorial. *Health Management Technology*, 16(12), 30–32.
- Dadashzadeh, M., & Khosrowpour, M. (1991–1992). Semantic integrity considerations for effective data management: important issues for the database course. *J. Educational Technology Systems*, 20(1), 19–30.
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340.
- Durbridge, N. (1996). The interactive world of art explorer. *Innovations in Education and Training International*, 33(1), 30–40.
- Edelson, D. C. (1996). Learning from cases and questions: the socratic case-based teaching architecture. *The Journal of the Learning Sciences*, 5(4), 357–410.
- Ellis, J. A., Whitehill, B., & Irick, C. (1996). The effects of explanations and pictures on learning, retention, and transfer of a procedural assembly task. *Contemporary Educational Psychology*, 21(2), 129–148.
- Fitsel, T. (1999). The new net gains. *New Zealand Management*, 46(1), 57–62.
- Gordon, J. (1996). Multimedia training in the fortune 1000. *Training*, 33(9), 53–58.
- Guinan, P. J., Coopridge, J. G., & Sawyer, S. (1997). The effective use of automated application development tools. *IBM Systems Journal*, 36(1), 124–139.
- Hannas, C. (2001). Shopping for E-learning. *The Journal of Corporate Accounting & Finance*, 12(5), 19–22.
- Hays, T. A. (1996). Spatial abilities and the effects of computer animation on short-term and long-term comprehension. *Journal of Educational Computing Research*, 14(2), 139–155.
- Hoffman, T. (1996) Multimedia drives training at marine corps. *Computerworld*, 30(45), 77 & 82.
- Hsu, C. (1985). Structured databases systems analysis and design through two-stage entity-relationship approach. *Proceedings 4th International Conference on Entity Relationship Approach*, 56–63.
- Hsu, C. (1996). *Enterprise integration and modeling: the metadatabase approach*. Boston, MA: Kluwer Academic Publishers.
- Hsu, C., Babin, G., Bouziane, M., Cheung, W., Rattner, L., & Yee, L. (1992). Metadatabase modeling for enterprise information integration. *Journal of Systems Integration*, 2(1), 5–37.
- Janoff, B. (1999). User-friendly. *Progress Grocer*, 78(3), 65–70.
- Large, A., Beheshti, J., Breuleux, A., & Renaud, A. (1996). Effect of animation in enhancing descriptive and procedural texts in a multimedia learning environment. *Journal of the American Society for Information Science*, 47(6), 437–448.
- Leigh, W., & Paz, N. (1993). The development of educational replicas of software application systems. *Journal of Educational Technology Systems*, 21(1), 71–84.
- Livergood, N. D. (1993). A study of the effectiveness of a multimedia intelligent tutoring system. *Journal of Educational Technology System*, 22(4), 337–344.

- McDonough, D., Strivens, J., & Rada, R. (1994). University courseware development: comparative views of computer-based teaching by users and non-users. *Computers Education*, 23(5), 211–220.
- Milhem, W. D. (1996). Interactivity and computer-based instruction. *Journal of Educational Technology*, 24(3), 225–233.
- Nelson, A. C., & Rottman, J. (1996). Before and after CASE adoption, Dec 15. *Information & Management*, 31(4), 193–202.
- Oram, I. (1996). Computer support of learning from cases in management education. *Innovations in Education and Training International*, 33(1), 70–73.
- Plowman, L. (1996). Narrative, linearity and interactivity: making sense of interactive multimedia. *British Journal of Education Technology*, 27(2), 92–105.
- Post, G. V., Kagan, A., & Keim, R. T. (1999). A structural equation evaluation of CASE tools attributes. *Journal of Management Information Systems*, 15(4), 215–234.
- Ramani, K. V., & Rao, T. P. R. (1994). A graphics based computer-aided learning package for integer programming: the branch and bound algorithm. *Computers Education*, 23(4), 261–268.
- Sumner, M., & Ryan, T. (1994). The impact of CASE: can it achieve critical success factors? *Journal of Systems Management*, 45(6), 16–21.
- Taylor, J. (1996). Moving into multimedia: issues for teaching and learning. *Innovations in Education and Training International*, 33(1), 22–29.
- Vichuda, K., Ramamurthy, K., & Haseman, W. D. (2001). User attitude as a mediator of learning performance improvement in an interactive multimedia environment: an empirical investigation of the degree of interactivity and learning styles. *International Journal of Human-Computer Studies*, 54(4), 541–583.
- Weller, H. G. (1996). Assessing the impact of computer-based learning in science. *Journal of Research in Education*, 28(4), 461–485.
- Wilcoxon, F. (1945). Individual comparisons by ranking methods. *Biometrics*, 1, 80–83.
- Wild, M. (1996). Mental models and computer modelling. *Journal of Computer-Assisted Learning*, 12(1), 10–21.
- Woolf, B. P. (1996). Intelligent multimedia tutoring systems. *Communications of the ACM*, 39(4), 30–31.
- Wu, L., Miller, L., & Nilakanta, S. (2001). Design of data warehouses using metadata. *Information and Software Technology*, 43(2), 109–119.
- Yang, C. S., & Moore, D. (1996). Designing hypermedia systems for instruction. *Journal of Educational Technology Systems*, 24(1), 3–30.

**Waiman Cheung** holds an MBA and a PhD in Decision Sciences and Engineering Systems from Rensselaer Polytechnic Institute. He is currently a Professor of the Business Faculty, The Chinese University of Hong Kong where he teaches both graduate and undergraduate level MIS courses. Prior to that he had operated his own MIS consulting company and worked as a Technical Staff for Oracle Systems in the US. His research interests include Information Systems Integration, Database Modeling, Electronic Commerce, and Data Mining.

**Eldon Y. Li** is Professor and a former Coordinator of MIS area at the College of Business, California Polytechnic State University, San Luis Obispo, California, USA He holds a bachelor degree from National Chengchi University in Taiwan and MS and PhD degrees from Texas Tech University. He has provided consulting services to many firms for a variety of software projects and served as a management consultant to the clientele of the US Small Business Administration. He was a software quality specialist at Bechtel Corporation's Information Services Division and a visiting software scientist at IBM Corporation. He is a Certified Data Educator (CDE) and is Certified in Production and Inventory Management (CPIM). His research interest lies in human factors in information technology (IT), strategic IT planning, software engineering, quality assurance, and information and systems management. He is currently the Editor-in-Chief of *International Journal of Electronic Business* and *International Journal of Internet and Enterprise Management*.

**Lester W. Yee** holds an MBA and a PhD in Decision Sciences and Engineering Systems from Rensselaer Polytechnic Institute. He is currently a Principal Architect at eXcelon Corporation in Massachusetts. Prior to that, he was an Assistant Professor at Babson College (1999) and at The University of Hong Kong (1994–1999). His research interests include artificial intelligence, systems integration, metadatabase, bio-informatics and information visualization. Dr. Yee has contributed articles to *IEEE Transactions on Software Engineering*, *Journal of Systems Integration*, *Computer and Industrial Engineering*, and *Journal of Intelligent Manufacturing*.