DEVELOPMENT OF LEARNING MODELS TO PROMOTE UNDERGRADUATE STUDENTS' UNDERSTANDING ON DATABASE

HONGSIRI PIYAYODILOKCHAI

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Thesis
entitled

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Hongsiri Piyayodilokchai
Miss Hongsiri Piyayodilokchai
Candidate

Patcharin P.
Lect. Patcharin Panjaburee, Ph.D.
Major advisor

Watcharee K.
Lect. Watcharee Ketpichainarong, Ph.D.
Co-advisor

S. Luealamai
Lect. Sutha Luealamai, Ph.D.
Co-advisor

B. Mahaisavariya
Prof. Banchong Mahaisavariya,
M.D., Dip Thai Board of Orthopedics
Dean
Faculty of Graduate Studies
Mahidol University

S. Luealamai
Lect. Sutha Luealamai, Ph.D.
Program Director
Doctor of Philosophy Program in
Science and Technology Education
Institute for Innovative Learning
Mahidol University

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on
May 18, 2011

Hongsiri....Piyayodilokchai
Miss Hongsiri Piyayodilokchai
Candidate

Pisarn Soydhurum
.....
Mr. Pisarn Soydhurum, Ph.D.
Chair

Patcharin P.
.....
Lect. Patcharin Panjaburee, Ph.D.
Member

S. Luealamai
.....
Lect. Sutha Luealamai, Ph.D.
Member

Watcharee K
.....
Lect. Watcharee Ketpichainarong, Ph.D.
Member

B. Mahaisavariya
.....
Prof. Banchong Mahaisavariya,
M.D., Dip Thai Board of Orthopedics
Dean
Faculty of Graduate Studies
Mahidol University

.....
Assoc. Prof. Wannapong Triampo, Ph.D.
Director
Institute for Innovative Learning
Mahidol University

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Hongsiri Piyayodilokchai

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HONGSIRI PIYAYODILOKCHAI 5037075 ILSE/D

Ph.D. (SCIENCE AND TECHNOLOGY EDUCATION)

THESIS ADVISORY COMMITTEE: PATCHARIN PANJABUREE, Ph.D., WATCHAREE KETPICHAINARONG, Ph.D., SUTHA LUEALAMAI, Ph.D.

ABSTRACT

The overall aim of this research was to develop two SQL learning models to promote students' performance on a database. The concept of the three-phase learning cycle model was applied to develop the first learning unit. The effectiveness of this learning unit on the second year undergraduate students was compared to that of the traditional learning unit. The analysis of the data showed that the developed learning unit could help students improve their understanding of the SQL in the database. Additionally, the results showed that the students were happy, enthusiastic, and thinkable.

The second learning unit utilises the multimedia to supplement students' learning, based on the concept of the five-phase learning cycle model. This learning activity was implemented on second year undergraduate students to enhance their understanding of the database. The effectiveness of this learning unit on the students' understanding of SQL and on their perceptions and preferences in the learning environment were examined. The results showed that the students who participated in this learning unit had better a understanding of SQL in the database. Additionally, the students who participated in this learning unit were enjoyable, enthusiastic, and no more stressed.

KEY WORDS: LEARNING CYCLE / LEARNING UNIT / MULTIMEDIA / SQL

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DEVELOPMENT OF LEARNING MODELS TO PROMOTE UNDERGRADUATE STUDENTS' UNDERSTANDING ON DATABASE

หงษ์ศิริ ภิยโยดิลกชัย 5037075 ILSE/D

ปร.ด. (วิทยาศาสตร์และเทคโนโลยีศึกษา)

คณะกรรมการที่ปรึกษาวิทยานิพนธ์: พัชรินทร์ ปัญจบุรี, Ph.D., วัชรี เกษพิชัยณรงค์, Ph.D., สุธา เหลือลมัย, Ph.D.

บทคัดย่อ

จุดมุ่งหมายของงานวิจัยนี้คือพัฒนารูปแบบการเรียนรู้เรื่อง ภาษาสอบถามเชิงโครงสร้าง จำนวน 2 ชุดการเรียนรู้ เพื่อส่งเสริมความเข้าใจเรื่องฐานข้อมูลของนักศึกษา สำหรับหน่วยการเรียนรู้แรกได้พัฒนาขึ้นโดยอาศัยแนวคิดแบบวัฏจักรการเรียนรู้ 3 ขั้น ในการศึกษานี้ได้ประเมินประสิทธิภาพของหน่วยการเรียนรู้กับนักศึกษาปริญญาตรี ชั้นปีที่ 2 โดยเปรียบเทียบกับหน่วยการเรียนรู้จากวิธีปกติ จากการวิเคราะห์ข้อมูลพบว่าหน่วยการเรียนรู้ที่พัฒนาขึ้นนี้ มีส่วนช่วยในการพัฒนาความเข้าใจทางด้านฐานข้อมูลในเรื่องภาษาสอบถามเชิงโครงสร้างให้แก่นักศึกษาและผลแสดงให้เห็นว่านักศึกษามีความสุข กระตือรือร้นและได้คิด

สำหรับหน่วยการเรียนรู้ที่สองนั้นนักศึกษาได้เรียนเสริมโดยใช้สื่อประสม ซึ่งหน่วยการเรียนรู้นี้มีพื้นฐานแนวคิดแบบวัฏจักรการเรียนรู้ 5 ขั้น กิจกรรมการเรียนรู้นี้จัดขึ้นเพื่อส่งเสริมให้นักศึกษาปริญญาตรี ชั้นปีที่ 2 มีความเข้าใจในการเรียนทางด้านฐานข้อมูล ในการศึกษานี้ได้ประเมินประสิทธิภาพของหน่วยการเรียนรู้ต่อการเรียนรู้ของนักศึกษาทั้งในด้านความเข้าใจในเนื้อหาและทัศนคติต่อการเรียน ผลการวิเคราะห์ข้อมูลแสดงให้เห็นว่านักศึกษามีความรู้ความเข้าใจทางด้านฐานข้อมูลในเรื่อง ภาษาสอบถามเชิงโครงสร้างได้เป็นอย่างดี และผลแสดงให้เห็นว่านักศึกษามีความสนุกสนาน กระตือรือร้นและการเรียนรู้ที่ไม่เคร่งเครียด

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LIST OF ABBREVIATIONS

DBMS	DataBase Management System
DDL	Data Definition Language
DML	Data Manipulation Language
e.g.	Exempli gratia (Latin), for example
et al.	Et alli (Latin), and other
i.e.	Id est (Latin), that is
SQL	Structured Query Language

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CHAPTER I
INTRODUCTION

This chapter introduces the significance of the research study on the development of two instructional units based on the learning cycle on SQL for undergraduate students. The rationale of the study is also discussed. Furthermore, in the following sections, research questions and research objectives are given to explain the scope of this study. Finally, this chapter also includes an outlines of this thesis as well as a chapter summary.

1.1 Significance of the study

SQL (Structured Query Language) is a nonprocedural language (Rob & Coronel, 2007) for querying data from a database system. This language can be applied to solve problems, manipulate data, and extract meaningful information (Myers & Douglas, 2007). Students can learn several concepts of a database course, e.g., security management and referential integrity, via SQL (Balwin, 1990; Dean & Milani, 1995). Consequently, SQL is the most important topic in helping students gain more knowledge from a database course (Lenox & Woratschek, 2005).

Most textbooks about SQL only describe each command, followed by an example (Mannino, 2007; Rob & Coronel, 2007; Wilton & Colby, 2005). Although the referential integrity concept is present in SQL, most textbooks only represent the result from each command (Mannino, 2007; Rob & Coronel, 2007), resulting in students' difficulties in understanding the concept. Shneiderman's (1978) study showed that although the students could produce queries equally well in natural language and in SEQUEL (an earlier acronym of SQL), they produced several SEQUEL errors before achieving a correct artificial query. Smelcer II (1989) found that the most common error was the omission of the "join statement", which combines multiple tables. Common problems that students had difficulty understanding were

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grouping, joining, and aggregate and scalar functions (Abu Naser, 2006). The students would benefit more if the teacher could demonstrate the referential integrity concept present in a database and allow the students to practice by themselves.

In recent years, there are a number of learning approaches that support students' learning with understanding. Among the learning approaches, the learning cycle approach is most widely used to promote students' understanding. For undergraduates, this approach has been implemented in areas such as physics (Ates, 2005; Zollman, 1990), life science, agricultural science, and health science (Jittam et al., 2009). Moreover, this approach has also been applied to chemical education at the postgraduate level (Tsoi, Goh, & Chia, 2005). To the best of our knowledge, there is no report of the study that applies the idea of the learning cycle approach to develop a learning unit on SQL in a database course. It, therefore, is a challenge to develop an innovative SQL learning unit to promote undergraduate students' understanding. To measure the success of the developed learning unit, this study investigated the students' learning achievement after the learning. Moreover, the students' attitude toward the proposed learning unit was investigated.

Although there are several "E" models (e.g. 3E, 4E, 5E, and other modifications) the basic concept is that have an experience with the phenomena in the learning of the concept. Among "E" models, 3E model and 5E model is most widely used to promote students' understanding in several areas such as in life science course, biological education, and technological education (Dibley & Parish, 2007; Gerdprasert, Pruksacheva, Panijpan, & Ruenwongsa, 2010a, in press, 2010b; Kaveevivitchai et al., 2009; Kaynar, Tekkaya, & Cakiroğlu, 2009; Liu, Peng, Wu, & Lin, 2009). To our knowledge, there has no report of the study that applied the idea of such two learning cycle models to develop learning unit on database course for SQL command topic. Moreover, the benefit of multimedia tool for enhancing students' learning and promote active learning process, as well as a 5E learning cycle model based on inquiry-based approach as improve more understanding concepts an effective hands-on, minds-on especially for enhancing understanding and with the ways in which students learn nature of the world. Therefore, it is challenge to develop the SQL command learning unit based on the 3E learning cycle model and the 5E learning cycle model supplemented with multimedia to promote the students to have an

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experience with phenomena in the learning of the topic in Thai undergraduate student context.

1.2 Rationale of the study

To overcome some problems above and enhanced conceptual understanding, the learning cycle approach is recognized as one of the alternative used to construct the two novel learning units on SQL for undergraduate students by using 3E learning cycle model and 5E learning cycle model, respectively. The students had the opportunity to learn by themselves from practicing in the classroom, and share experiences with classmates and teacher in the classroom. The teacher's role will be changed from lecturer to facilitator who provides resources for learning. These learning units are expected to enhance undergraduate students' conceptual understanding in SQL, improve students' skills, and raise attitude of learning environment, resulting in promote understanding in Database.

1.3 Research questions and research objectives

Six research questions help frame this developed learning unit on SQL based on the learning cycle approach.

1. To what extent can the innovative SQL learning unit based on 3E learning cycle model enhance students' learning achievement on SQL?

2. What is undergraduate students' attitude toward the innovative SQL learning unit based on 3E learning cycle model?

3. To what extent can the innovative SQL learning unit based on 5E learning cycle model enhance students' learning achievement on SQL?

4. What is undergraduate students' attitude toward the innovative SQL learning unit based on 5E learning cycle model?

5. To what extent can the proposed learning unit based on 5E learning cycle model supplemented with multimedia promote undergraduate students' learning achievement on SQL?

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6. What is undergraduate students' attitude toward the innovative SQL learning unit based on 5E learning cycle model supplemented with multimedia?

To optimize the learning cycle-based learning unit, the objectives of this study are following:

1. To develop a learning unit on SQL based on 3E learning cycle model.
2. To investigate the students' learning achievement on SQL after receiving the developed learning unit based on 3E learning cycle model.
3. To investigate the students' learning attitude after receiving the developed learning unit based on 3E learning cycle model.
4. To develop a learning unit on SQL based on 5E learning cycle model.
5. To investigate the students' learning achievement on SQL after receiving the developed learning unit based on 5E learning cycle model.
6. To investigate the students' learning attitude after receiving the developed learning unit based on 5E learning cycle model.
7. To develop a learning unit on SQL based on 5E learning cycle model supplemented with multimedia.
8. To investigate the students' learning achievement on SQL after receiving the developed learning unit based on 5E learning cycle model supplemented with multimedia.
9. To investigate the students' learning attitude after receiving the developed learning unit based on 5E learning cycle model supplemented multimedia.

1.4 Organization of the dissertation

The thesis is presented in five chapters.

The first chapter provides the significance of the study. Rationale is discussed, and states the research questions which informs the study and specifies the objectives of the study. Finally, it gives an outline of the study and summary of the chapter.

Chapter 2 provides a literature review relevant to the topic of this study and consists of four major parts. The first part describes the philosophy of constructivism. The second part discusses about the inquiry-based learning. The third

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part is the theory of learning cycle which reviews about two approaches: 3E learning cycle approach and 5E learning cycle approach. Finally, the fourth part presents multimedia learning.

Chapter 3 presents the first study that described the detail of development of the SQL learning unit based on the 3E learning cycle model, and the experimental design of this study. The description of the second study that provided the detail of development of the SQL learning unit based on the 5E learning cycle model. Moreover, the experimental design of the second study is included in this chapter.

Chapter 4 describes the results on implementation of the 3E learning cycle model-based learning unit and the 5E learning cycle model-based learning unit on SQL to undergraduate students. The discussion of the findings of these two studies is offered.

Finally, chapter 5 describes conclusion of this study. Limitations of these studies and suggestions for further study are included in this chapter.

1.5 Summary of the chapter

This chapter outlines the details of the significance of this study and rationale for investigation. The research questions, the aims of the research study, and the organization of the dissertation are also presented.

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CHAPTER II
LITERATURE REVIEW

This chapter presents are review of relevant literature for this research database and SQL query language. Enforcing integrity constraints were reviewed. For educational aspect, the constructivism was reviewed. The learning cycle approach was also presented. The learning cycle model, especially 3E learning cycle model and 5E learning cycle model, and multimedia have been utilized for promoting students' learning achievement. Both learning cycle models were reviewed. Moreover, multimedia learning which has been widely applied by researchers for instructional tool was discussed. The multimedia learning that relevant information system education was also discussed.

At the end of this chapter, the summary of the literature review is also provided.

2.1 Database

The term database has been used to refer to anything from a collection of names and addresses to a complex system of data retrieval and storage that based on user interfaces and a client computers network and servers. There are as many definitions for the word database as there are books about them. Despite the lack of an absolute meaning, most sources agree that a database is a collection of data organized in a structured format defining by metadata that describes that structure. Metadata is as data about the data being stored; it defines how the data is stored within the database (Sheldon, 2003).

A data model is a collection of high-level data description constructs that hide many low-level storage details (Ramakrishnan & Gehrke, 2003). Most database management systems (DBMS) today are based on the relational data model. The

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central data description construct in relational model is a relation, which can be thought of as a set of records.

A description of data in terms of a data model is called a schema. In the relational model, the schema for a relation specifies its name, the name of each field (or attribute or column), and the type of each field. As an example, customer information in an order database may be stored in a relation with the following schema:

Customers(CustID: string, Name: string,
Age: integer, Province: string)

The preceding schema says that each record in the Customers relation has four fields, with field names and types as indicated. An example instance of the Customers relation appears in figure 2.1.

CustID	Name	Age	Province
48011	Somchai	35	Bangkok
48102	Chuleeporn	39	Chanthaburi
48211	Polasit	32	Ayuthaya
48320	Pachrapong	45	Khonkaen
48334	Porntiwa	50	Chiangmai

Figure 2.1 An instance of the customers relation

A set of fields that uniquely identifies a tuple according to a key constraint is called a candidate key for the relation; this term often abbreviates to just key (Ramakrishnan & Gehrke, 2003). In the case of the Customers relation, the (set of fields containing just the) CustID field is a candidate key. There are two parts to the key definition:

1. Two distinct tuples in a legal instance cannot have identical values in all the fields of a key.

2. No subset of the set of fields in a key is a unique identifier for a tuple.

A tuple can be referred to from elsewhere in the database by storing the values of its primary key fields.

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Sometimes the information stored in a relation is linked to the information stored in another relation. If one of the relations is modified, the other must be checked, and perhaps modified, to keep the data consistent.

Suppose that, in addition to Customers, there is a second relation:

LoanDetail(PropertyNo: string, LoanAmount: integer,
LoanRate: real, LoanPeriod: real,
LoanRemark: string, CustomerID: string)

Any value that appears in the CustomerID field of an instance of the LoanDetail relation should also appear in the CustomerID field of some tuple in the Customers relation. The CustomerID field of LoanDetail is called a foreign key and refers to Customers. The foreign key in the referencing relation (LoanDetail; in example) must match the primary key of the referenced relation (Customers); that is, it must have the same number of columns and compatible data types, although the column names can be different.

Foreign key

PropertyNo	LoanAmount	LoanRate	LoanPeriod	LoanRemark	CustomerID
C002	1,215,000	4.25	15	A	48011
S001	1,440,000	4	20	B	48102
B001	3,040,000	3.75	30	D	48320
U001	3,360,000	3.75	30	D	48334

LoanDetail (Referencing relation)

Primary key

CustID	Name	Age	Province
48011	Somchai	35	Bangkok
48102	Chuleeporn	39	Chanthaburi
48211	Polasit	32	Ayuthaya
48320	Pachrapong	45	Khonkaen
48334	Pornthiwa	50	Chiangmai

Customers (Referenced relation)

Figure 2.2 Referential integrity

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2.2 The SQL query language

Database query languages provide access to important corporate information. Such queries may be composed via menus or command languages or direct manipulation, but at last appear as Structured Query Language (SQL) queries (Smelcer, 1995).

SQL is today the standard language for relational and object-relational databases (Brass & Goldberg, 2006). SQL supports the creation and maintenance of the relational database and the management of data within that database (Sheldon, 2003).

A relational database of SQL consists of data organized into tables. Each table consists of columns and rows. The columns are labeled with column names (e.g., ID, NAME, ADDRESS) and each row contains a set of values, one for each column. See Appendix A for an example of several tables in a SQL database.

Retrieving data from a database is the most common SQL operation. A database retrieval is called a query. Most SQL queries are composed of three clauses: SELECT, FROM, and WHERE. The SELECT clause specifies which columns to print (e.g., SELECT Name, Province). The FROM clause specifies the tables in which those columns are found (e.g., FROM Customer, Property). The WHERE clause specifies constraints on which items in the columns are to be printed (e.g., WHERE Price > 50000). If a query requires data from multiple tables, then a join condition is added to the WHERE clause (e.g., AND ID = CustomerID).

For example, suppose one needs to find out the CustomerID of all customers (CustomerID), and the propertytype (PropertyType) they get loan that have price (PropertyPrice) greater than 1,500,000 baht. Further, suppose CustomerID is stored in one table (LoanDetail) and PropertyType and PropertyPrice are stored in another table (Property). If the LoanDetail and Property tables share a common column, PropertyNo (by “share” it mean that both tables have a column name “PropertyNo”), then the correct query is

```
SELECT CustomerID, PropertyType
FROM LoanDetail, Property
WHERE PropertyPrice > 1500000
AND LoanDetail.PropertyNo = PropertyType.PropertyNo;
```

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Although SQL is considered a sublanguage because of its nonprocedural nature, it is nonetheless a complete language in that it allows one to create and maintain database objects, secure those objects, and manipulates the data within the objects (Sheldon, 2003). One common method used to categorize SQL statements is to divide them according to the performing functions. Based on this method, SQL can be separated into three types of statements: there are data definition language, data control language and data manipulation language.

2.2.1 Data Definition Language (DDL)

DDL statements are used to create, modify, or delete database objects such as tables, views, schema, domains, triggers, and stored procedures. The SQL keywords most often associated with DDL statements are CREATE, ALTER, and DROP. For example, we would use the CREATE TABLE statement to create a table, the ALTER TABLE statement to modify the table's properties, and the DROP TABLE statement to delete the table definition from the database.

2.2.2 Data Control Language (DCL)

DCL statements allow us to control who has access to specific objects in database. With the DCL statements, you can grant or restrict access by using the GRANT or REVOKE statements, the two primary DCL commands. The DCL statements also allow us to control the type of access each user has to database objects. For example, we can determine which users can view a specific set of data and which users can manipulate that data.

2.2.3 Data Manipulation Language (DML)

DML statements are used to view, add, modify, or delete data stored in database objects. The primary keywords associated with DML statements are SELECT, INSERT, UPDATE, and DELETE, all of which represent the types of statements that using the most. For example, a SELECT statement used to retrieve data from a table and an INSERT statement to add data to a table.

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In this study, we are concerned with the DDL and DML, since these two types of statements were the basis of learning database concept. DDL statements are used to define database objects which the learners can learn their database concept from applying the DDL. For DML statements are used to manipulate the data stored in database objects which the learners can apply database concept for example referential integrity for manipulating and utilizing the beneficial information.

2.3 Enforcing integrity constraints

A database is only as good as the information stored in it, and a DataBase Management System (DBMS) must therefore help prevent the entry of incorrect information. An integrity constraint is a condition specified on a database schema and restricts the data that can be stored in an instance of the database. If a database instance satisfies all the integrity constraints specified on the database schema, it is a legal instance. A DBMS enforces integrity constraints, in that it permits only legal instances to be stored in the database.

Integrity constraints are specified when a relation is created and enforced when a relation is modified. The impact of domain, primary key and unique constraints is straightforward: If an insert, delete, or update command causes a violation, it is rejected.

The impact of foreign key constraints is more complex because SQL sometimes tries to rectify a foreign key constraint violation instead of simply rejecting the change. The discussion of the referential integrity enforcement steps were taken by the database management system (DBMS) in terms of LaonDetail and Customers tables, with the foreign key constraint that LoanDetail.CustomerID is a reference to (the primary key of) Customers.

In addition to the instance C1 (44444, Rattana, 46, Saraburi) of Customers, consider the instance of LoanDetail shown in figure 2.2. Deletions of LoanDetail tuples do not violate referential integrity, but insertions of LoanDetail tuples could. The following insertion is illegal because there is no Customers tuple with CustomerID 41111:

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```
INSERT
INTO LoanDetail(PropertyNo, LoanAmount, LoanRate,
        LoanPeriod, LoanRemark, CustomerID)
VALUES ('A111', 2500000, 3.00, 15, 'D', '41111');
```

On the other hand, insertions of Customers tuples do not violate referential integrity, and deletions of Customers tuples could cause violations. Further, updates on either LoanDetail or Customers that change the CustomerID (respectively, CustID) value could potentially violate referential integrity.

SQL provides several alternative ways to handle foreign key violations. There are three basic questions for consideration:

1. What should we do if a LoanDetail row is inserted, with a CustomerID column value that does not appear in any row of the Customers table?

In this case, the INSERT command is simply rejected.

2. What should we do if a Customers row is deleted?

The options are:

- Delete all LoanDetail rows that refer to the deleted Customers row.
- Disallow the deletion of the Customers row if a LoanDetail row refers to it.
- Set the CustomerID column to the CustID of some (existing) 'default' customer; for every LoanDetail row that refers to the deleted Customers row.
- For every LoanDetail row that refers to it, set the CustID column to null. For proposed example, we are limited to the first two options in our study because we will demonstrate via Microsoft Access which supports only two options.

3. What should we do if the primary key value of a Customers row is updated? The options here are similar to the previous case (Ramakrishnan & Gehrke, 2003).

Such that the learners should learn the enforcing integrity constraints for designing the data stored in database with consistent in order to retrieve creditably information.

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2.4 Constructivism

Constructivism is a theory of knowledge on the basis of philosophy, psychology, and cybernetics. It asserts two main principles: knowledge is not passively received but actively construct by the cognizing subject, the function of cognition is adaptive and serves the organization of experienced in the world, not the discovery of ontological reality (Von Glasersfeld, 1989). Von Glasersfeld (1989) states that knowledge is independent of observers and reflects "objective representation" of the world and notes that Piaget's view of knowledge can be considered as an "adaptive function" instead of an "objective representation". Kamii, Manning and Manning (1991) added that, "*individuals do not acquire knowledge by internalizing it directly from the outside but by constructing it from the inside, in interaction with the environment*" (p. 18). Constructivism has been extremely influential in mathematics and science education (Cheung & Toh, 1990; Steffe & Gale, 1995). There is a literature on the psychology of programming (Mayer, 1988), and many of these researchers clearly hold constructivist views. It can be adapt to information technology education with slight modifications.

As the understanding of learning and teaching has grown, the development of constructivism has transitioned from a Piagetian individual development paradigm to the recognition of cognitive development within a social setting. Shymansky and co-workers (1997) have refined this social contextual learning in terms of interactive constructive teaching. They describe this refinement as "*a classroom in which teachers orchestrate experience and discourse opportunities and social context to produce cognitive conflict in students who progressively resolve these problems by integrating new knowledge into prior knowledge structures*" (p. 572).

Piaget's cognitive constructivist perspectives emphasize the importance of knowledge connectedness in building new learning on an individual's previous understanding and personal experiences (Harris & Graham, 1994). The new knowledge scheme comes into being through an individual's adaptation to new experiences and modification of current schemes (Cobb, 1994). Piagetian stresses that individuals' current knowledge scheme and personal experiences are idiosyncratically different from one another. For example, two adults reading the same article often have different interpretations of the article's message because each of them brings his

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or her knowledge system to analyze, understand, and evaluate the article. An individual's prior knowledge and life experiences affect what is to be learned and how it is learned. These would contribute to each learner's unique understanding of the world (Burry-Stock & Oxford, 1994; Poplin, 1988).

Vygotsky's sociocultural constructivism in particular places the interplay between the process of an individual's active construction of knowledge and the reciprocal influence of social environments (Harris & Graham, 1994; Prawat & Floden, 1994). From the social constructivist perspective, learning is a socially connected and placed activity that is increased in contextualized and realistic environments. Thus, social interaction in a provided culture-shared social setting, to some level, forms individuals' knowledge construction systems (Cobb, 1994; Driver, Asoko, Leach, Mortimer, & Scott, 1994).

Constructivist perspective, learning emphasize learning processes in which active participants construct new knowledge in interaction with rich and authentic learning environments (Otting & Zwaal, 2007), self-regulated construction of knowledge (Cobb, 1994), assimilators of information from others (Cobb, 1994; Von Glasersfeld, 1989), or "alternative frameworks" (Ben-Ari, 2001). These alternative frameworks "naturally occur as part of the transfer and linking process" (Clancy, 2004). The process of *coming to know* is the result of interaction of the new knowledge with the experienced learner of the world (Matthews, 1993). Constructivist view emphasizes on knowledge construction, not knowledge duplication (Collins, 1991). Following constructivist theory, the teacher will become a facilitator of learning instead of a conveyor of knowledge. At times this facilitation is helped by lecturing, and at times it is not (Wankat & Oreovicz, 1993). In conclusion, constructivists believe that an individual learner gains knowledge by constructing reality through their experience with facilitating from teachers.

2.5 Inquiry-based learning

Inquiry is activity key part of constructivist theory that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already know in

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light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations (National Research Council, 2000). Moreover, inquiry is an "act or an instance of seeking for truth, information, or knowledge; investigation; research; or a question or query", while the root word inquire means "to ask for information about, to make an investigation or search, to seek information or questioning" (Webster's Third International Dictionary ,1986 cited in Barrow, 2006). In other words, inquiry is an educational or learning process that is based on the constructivist theory of how people learn.

Inquiry-based learning is an approach which promises to improve science teaching by engaging students in authentic investigations, thereby achieving a more realistic conception of scientific endeavour as well as providing a more student-centered and motivating environment (Kubicek, 2005). Inquiry learning has its origins in the practices of scientific inquiry and places a heavy emphasis on posing questions, gathering and analyzing data, and constructing evidence-based arguments (Krajcik & Blumenfeld, 2006; Kuhn, Black, Keselman, & Kaplan, 2000). There is an extensive body of research on scaffolding learning in inquiry-based environments (Davis & Linn, 2000; Reiser, 2004; Toth, Suthers, & Lesgold, 2002). Inquiry-based learning is also an interactive method of learning by which students learn from asking their own questions and generating solutions (Koch & Appleton, 2007). However, the meaning of inquiry in science education is inconsistency (Barrow, 2006; Martin-Hauser, 2002; Schwartz, Lederman, & Crawford, 2004).

In conclusion, the inquiry-based learning is a teaching and learning process that teacher as a facilitator who provides the opportunity for students to observing, examining books and other sources of information using tools to gather, analyze, and interpret data which students learn from their explanation, predictions, and communicating the results.

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2.6 Learning cycle approach

The learning cycle is one of the learning and teaching approach based on the concept of inquiry (Renner & Lawson, 1973). This approach has been presented to students and teachers should do when the activities occurred in the class (Colburn & Clough, 1997: Lawson, 1986; Renner & Lawson, 1973). In this approach, opportunities for students to reveal their prior science idea exist in two ways: (1) students make predictions before exploring, and (2) students generate hypotheses to explain new phenomena (Blank, 2000). Many Science educators (e.g. Abraham, 1998) proposed the learning cycle approach as a strategy for teaching and learning in science.

As an instructional approach, the origin of the learning cycle is generally attributed to the Science Curriculum Improvement Study (SCIS) materials of the 1970s. Many versions of the learning cycle use in science curricula (e.g. 3E, 4E, 5E, 11E, and other modifications). Among version of the learning cycle models, 3E model and 5E model is most widely appeared in promoting the students' understanding in the idea of biological education, physics education, life science course, technological education (Allard & Barman, 1994; Ates, 2005; Dibley & Parish, 2007; Kaynar, et al., 2009; Liu, et al., 2009).

2.6.1 The 3E learning cycle model

The 3E learning cycle model is an inquiry-based teaching model which can be useful to teachers in designing the instruction in science classrooms (Lawson, Abraham, & Renner, 1989). Based on Piaget's intellectual development theory, the learning cycle approach is intended to help student progress from concrete to abstract thinking about content. A key aspect of 3E learning cycle model is that it attempts to engage students in meaningful inquiries with the aim of improving their skills to inquire and helping them construct meaningful concepts (Lawson, 2000).

The 3E learning cycle model consists of three phases: exploration, term introduction, and concept application (Eakin & Karplus, 1976; Lawson, et al., 1989; Musheno & Lawson, 1999). The exploration phase coming first implies that the information exposed by the hands-on activities in which students explore new objects, new material, events or situations with minimal guidance or expectation of

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accomplishments. Following the exploration is the term introduction in which the instructors gather information from the students about their exploration experience and use it to introduce the main concepts of the lesson and any vocabulary related to the concepts. The term introduction is then followed by an instructional phase called the concept application in which students are given opportunities to deepen their understanding of new concepts by trying to apply them in new contexts (Allard & Barman, 1994; Karplus, 1977, 1980; Lawson, 2000; Wankat & Oreovicz, 1993).

The 3E learning cycle model has been used successfully to teach a wide variety of areas such as physics education, life science, agricultural science, and health science to students from first grade to undergraduate level (Allard & Barman, 1994; Ates, 2005; McComas III, 1991; Musheno & Lawson, 1999; Renner, Abraham, & Birnie, 1985; Zollman, 1990). The previous studies which applied the 3E learning cycle model found that this model could be used to encourage students to think creatively and critically, as well as led to the better understanding of science concepts, improved attitude toward science and science learning, improved reasoning ability, and developed science process skills (Lawson et al., 1989).

2.6.2 The 5E learning cycle model

Colburn and Clough (1997) asserted that the learning cycle can help students enjoy science, understand class content, and apply scientific processes and concepts to authentic situations. Originating in an elementary science program called Science Curriculum Improvement Study (SCIS) by Myron Atkin and Robert Karplus, learning cycle generally consists of three phases: exploration, term introduction, and concept application at Biological Sciences Curriculum Study (BSCS). They have extended the three phases into five, known as the 5E learning cycle model: engagement, exploration, explanation, elaboration and evaluation (Bybee et al., 2006; Eisenkraft, 2003).

The 5E learning cycle model is seen as an effective hands-on, minds-on, inquiry-based scientific pedagogy, especially for enhancing understanding (Bybee et al., 2006; Stamp & O'Brien, 2005) and with the ways in which students learn nature of the world (Bybee et at., 2006). This learning unit has five instructional stages in the

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model, including engagement, exploration, explanation, elaboration and evaluation (Bybee, 2002; Bybee et al., 2006).

2.6.2.1 Engagement phase (E1): The teacher or curriculum task accesses students' prior knowledge and help them become engaged in new concept through the use of short activities that generate enthusiasm and access prior knowledge. The activities should make connections between what students know and can do, expose prior conceptions, and organize students' thinking toward the learning outcomes of current activities.

2.6.2.2 Exploration phase (E2): Exploration experiences provide students with a common set of experiences within which present concepts (i.e., misconceptions), processes, and skills are reflected and conceptual change is facilitated. Students have the opportunity to compare ideas that identify inadequacies of current concepts. Learners are not just passive receptors; they also have the chances to inquire knowledge actively. They may complete manipulate materials that guide them use existing knowledge their student possess to generate new ideas, explore questions and possibilities, and execute a preliminary investigation.

2.6.2.3 Explanation phase (E3): In this phase, there is more interaction between teacher and students. The explanation phase focuses students' attention on a specific aspect of their engagement and exploration experiences and provides opportunities for students to demonstrate their conceptual understanding, process skills, or behaviors. This phase also provides opportunities for teachers to directly use instruction. Learners explain their understanding of the concept. An explanation from the teacher or the curriculum may guide them to modify and enhance their concepts.

2.6.2.4 Elaboration phase (E4): Teachers challenge and extend students' conceptual understanding and skills. Through new experiences, the students learn to develop broader and deeper understanding, more information, and adequate skills. Students apply their understanding of the concept by conducting additional activities.

2.6.2.5 Evaluation phase (E5): The evaluation phase encourages students to assess their understanding and abilities and provides

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opportunities for teachers to evaluate student progress toward achieving the learning goals (Bybee, 2002, 2006; Bybee et al., 2006).

The 5E learning cycle model is a realistic, constructivist method of leading students through a learning sequence in which they become engaged in a topic, explore that topic, are given an explanation for their experiences, elaborate on what they have learned and are then evaluated (Wilder & Shuttleworth, 2005).

The idea of the 5E learning cycle model has been applied to promote students' understanding in several areas. For example, in 2007, Dibley and Parish used video games based on the 5E learning cycle model as the exploratory experience in a life science curriculum. In biological education, Kaynar and co-workers (2009) studied the effectiveness of the 5E learning cycle model on students' achievement of cell concepts, and scientific epistemological beliefs. For technological education, Liu and co-workers (2009) presented designed mobile learning activities based on the 5E learning cycle model. Van Hook and Huziak-Clark (2007) developed a lesson on the conceptual model of magnetism using the 5E learning cycle model which students could adopt and use the model to describe how the magnets and paperclips interacted.

For example, in their study of an eighth-grade genetics class, Balci, Cakiroglu, and Tekkaya (2006) compared the effectiveness of the 5E learning cycle model with the effectiveness of expository instruction. According to the authors' conclusions, the activities for students in the 5E learning cycle model helped them to activate their prior knowledge and to overcome struggling with their misconceptions. In addition to the knowledge gains, these students had the opportunity to explain, to argue, and to debate their ideas, practices that helped the students further extend the conceptual understanding.

Another study applied the 5E learning cycle model to a teacher-development program in a food-safety curriculum (Beffa-Negrini, Cohen, Laus, & McLandsborough, 2007). Seventy-one secondary teachers registered for the program, which designed online food-safety training activities rooted in the American National Science Education Standards and the Biological Sciences Curriculum Study. The participants used through 3 modules, each with 15 hours of web-based instruction, interactive discussion, and tools for conducting experiments or for critically evaluating projects. After analyzing 38 pre-test and port-test evaluations, they found that the

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teachers were satisfied with the program and that most of them felt more able to critically evaluate food-safety information on the Internet. By experiencing the 5E instruction strategy to food safety topic, and by using an inquiry-based approach, these teachers could continue to effectively instruct on this topic.

Krall, Straley, Shafer and Osborn (2009) evaluated a unique series of physical science course through a distance learning medium, inquiry-based professional development for middle school teachers in rural region. The lesson followed the 5E learning cycle model and incorporated key tenets from conceptual change research. Instruction through hands-on inquiry investigations distinguishes this program from other distance learning programs. From the preliminary pilot study, the result reported that the 43 teachers' content knowledge were higher for six of nine temperature and heat concepts. The teachers' view toward the distance learning medium and the course in general were positive.

Gerdprasert and colleague (2010b) showed that supplementation with learning unit made learning significantly more effective than the traditional lecture and students responded positive attitude toward this learning unit. This study, the web-based learning unit was developed based on integrating principles of the mechanism of labour with the 5E inquiry cycle model.

From above point of view, in our study, we are concerned with the application of 3E and 5E learning cycle models to develop the innovative SQL learning units in which students have ownership of their learning.

2.7 Multimedia learning

One of main points of our study is to develop the learning unit supplemented with multimedia. There are many reasons described as follows. Multimedia learning is proposed as an active, student-centered approach in which learners can select relevant words and images, organizing them into coherent verbal and visual models, and integrating them into whole conceptual structures (Mayer, 2005). Such an approach can enhance students' learning when appropriate principles are taken into account (Mayer & Moreno, 2003; Moreno & Mayer, 2000). Animations and virtual simulation that require technological supports provide the most recent and

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sophisticated implementations of multimedia learning. Therefore, nowadays multimedia learning is obtained by suggesting that teachers should use computers.

2.7.1 Multimedia tools

Multimedia teaching-learning tools are changing the way students from all levels are taught in the education arena. Alternatively, multimedia can be used in the construction industry (Shelbourn, Aouad, & Hoxley, 2001). Multimedia is a means by which we can begin to reduce educational costs without lessening quality (Yaverbaum & Nadarajan, 1996). Multimedia is the presentation of material using both words (printed or spoken text) and pictures (illustrations, photos, animation, or video) (Mayer, 2005). Mayer has published a series of principles for how to design multimedia instruction with static visual media (Mayer, 2005). One of these principles was relevant as a frame of reference for this study: The multimedia principle: students learn better from words and pictures than from words alone. Multimedia is just another instructional tool that helps the learners increase interesting, effective and efficient. However, new technologies can help students learn at the first, the instructional designer and the teaching quality are important (Chang & Chen, 1995).

2.7.2 Overview of the cognitive theory of multimedia learning

Mayer and Moreno (2002) present a cognitive theory of multimedia learning to help guide the design of instructional multimedia materials. The cognitive theory of multimedia learning is based on three cognitive science principles: human processing information; limited capacity assumption; active processing assumptions (Mayer & Moreno, 2003). When novice learner receives new information, it reaches the short-term memory. Learner must possess prior knowledge in long term to use in assimilation the new information and he/she actively use the prior knowledge to connect the new material.

Multimedia learning tools have also been successfully adopt in related area as in, for instance, data communications and networks (Asif, 2003; Elkateeb & Awad, 1999; Yaverbaum & Nadarajan, 1996), operating system concepts (Rias & Zaman, 2008, 2010), multimedia learning (Lahwal, Amaimin, & Al-Ajlan, 2009; Teoh & Neo, 2006), computer algorithms and design patterns (Byrne, Catrambone, & Stasko, 1999;

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Dukovich & Janzen, 2009), or even merging skills for learning English in to semiconductor technology courseware (Tsai, 2009). Nevertheless, it is not easy to find studies which demonstrate their effectiveness for SQL learning.

Database system learning with multimedia has been widely used and proved to be a successful educational tool to communicate the objectives and involved the student as an active participant in the learning process. The use of database courseware displayed in the animations as a supplement in a classroom indicated that student learned better when they were initially presented to one of the program of the sub-module in class and then being asked to review the other at home (Guimaraes, 2005). In surveys, they showed positively rate on the value of animated database courseware in students and faculty. This courseware could help students find pathways through which increased understanding and got high levels of learning (Murry & Guimaraes, 2008). In addition, the evaluations from faculty and student reported that the application of lessons-constructor-analyzer paradigm and incorporation of this courseware had been effective (Guimaraes & Murry, 2009).

Valdés, Tarrio, Moure, Mandado, and Salaverria (2000) proposed the interactive multimedia to their students as alternative study tools for supporting in electronic technology education. The concerning students' reaction was the use of resources made concepts much easier to understand and the results showed that this resource could increase students' motivation in the subject. In the implementation of Xu and Duan (2007) used developed CAI tool to facilitate both classroom teaching and students' home practicing of the theory of relation normalization. Their tool provided demonstration relation normalization associated algorithms step by step easily to understand, and presentation of the main theory for tutoring.

Moreover, Efendioğlu and Yelken (2010) developed a computer-based SQL teaching courseware. They found that students in programmed instruction group which learned via SQL courseware had better academic achievement than those in meaningful learning group. Therefore, it might be better if we apply the concept of multimedia as a supplementary of the SQL learning unit.

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2.8 Summary of the chapter

To sum up the literature review, in developing a 3E learning cycle model unit for encouraging students to think creatively and critically and getting more understanding of science concepts, improving attitude toward science and science learning, increasing reasoning ability, and developing scientific-process skills. Moreover, the benefit of multimedia tool for enhancing students' learning and promote active learning process, and the 5E learning cycle model based on inquiry-based approach as improve more understanding concepts an effective hands-on, minds-on especially for enhancing understanding and with the ways in which students learn nature of the world.

However, there is no report of the study that applies the idea of the 3E learning cycle model and the 5E learning cycle model with multimedia to develop a learning unit on SQL in a database course. Consequently, it becomes an interesting and challenging issue to construct a learning unit based on 3E learning cycle model and 5E learning cycle model with multimedia. Therefore, in the next chapter, we will show the overall activities of applying the 3E learning cycle model and the 5E learning cycle model supplemented with multimedia for applying to information system learning especially in SQL topic.

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CHAPTER III
METHODOLOGY

This chapter presents methodology employed in this study. It begins with the first study which is the development of SQL learning unit based on the 3E learning cycle model and experimental design of this study. Furthermore, the second study is the development of SQL learning unit based on the 5E learning cycle model and experimental design of this study is described.

3.1 The first study: The development of the SQL learning unit based on the 3E learning cycle model

Two lessons of the SQL instructional unit were developed:

- Lesson I: SQL for defining and manipulating data, and the rules related to keys in a relational database. This part focused on SQL's data definition language (DDL), which relates to creating tables, and the part of the data manipulation language (DML) that relates to inserting, updating, and deleting data, and integrity rules.
- Lesson II: SQL for retrieving data. This part focused on DML statements related to data retrieval.

These lesson plans were designed based on Lawson's (2001) 3E learning cycle model— exploration, term introduction, and concept application. Each lesson was divided into two parts: a two-hour computer laboratory and a one-hour lecture. These instructional plans provided students with experience in the computer laboratory before attending the lecture. The overall activities of each lesson were presented in table 3.1.

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Table 3.1 Two lessons of the SQL learning unit based on the 3E learning cycle model

Phases	Objectives	Student Activities
Lesson I: SQL for defining and manipulating data, and the rules related to keys in a relational database		
Exploration I	1. To be exposed to SQL commands and syntax: creating tables, inserting data, updating data, deleting data, integrity rules, primary keys, and foreign keys 2. To predict the output of SQL commands 3. To practice writing the SQL commands to generate the output	The DDL and DML commands were used to engage students with the SQL syntax. Upon showing each SQL statement, students explored its output and objectives. Then students generated the output of the proposed SQL statement by writing the SQL command and also observed SQL syntax errors using the Microsoft Office Access program in a computer laboratory.
Term Introduction I	1. To investigate the cause(s) of the SQL syntax error(s) 2. To summarize the objectives of DDL commands, and relate DML commands (in particular insert, update, and delete) to integrity rules	Students shared the output from Exploration I and discussed with classmates at the end of the two-hour computer laboratory. Then students discussed the cause(s) of the SQL syntax error(s) that they faced, and also summarized the objectives of DDL commands and related DML commands to integrity rules. They were introduced to the concepts of SQL in the categories of DDL and DML (in particular inserting,

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Table 3.1 Two lessons of the SQL learning unit based on the 3E learning cycle model (cont.)

Phases	Objectives	Student Activities
		updating, and deleting data) and taught in-depth concepts related to SQL syntax in the lecture.
Concept Application I	1. To apply knowledge they have learned in new situations	The students applied DDL and DML commands to a worksheet.
Lesson II: SQL for retrieving data		
Exploration II	1. To experience data retrieval 2. To predict the output of SQL commands 3. To practice writing the SQL commands to retrieve data	Similar to those in Exploration I: DML data-retrieval commands were used to introduce students to the SQL syntax. Upon showing each SQL statement, students predicted its output and objectives. Then students generated the output of retrieved data by writing SQL commands and also observed syntax errors using the Microsoft Office Access program in computer laboratory.
Term Introduction II	1. To investigate the cause(s) of the SQL syntax error(s) 2. To summarize the objectives of DML data-retrieval commands	From the data gathered from Exploration II, students shared the output and discussed with classmates at the end of the two-hour computer laboratory. Then students discussed the cause(s) of the SQL syntax error(s) that they faced and also summarized the

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Table 3.1 Two lessons of the SQL learning unit based on the 3E learning cycle model (cont.)

Phases	Objectives	Student Activities
		objectives of the DML data-retrieval commands. They were introduced to the term "DML (in particular retrieving data)" and taught in-depth concepts related to SQL syntax in the lecture.
Concept Application II	1. To apply knowledge they have learned in new situations	The students applied knowledge for writing DML data-retrieval commands in a worksheet.

The development of the SQL learning unit started from planning the instruction, consulting with the curriculum expert, conducting the pilot study, and revising the draft. The next step is implementation and data collection. Finally, the SQL learning unit was evaluated from all the data.

3.1.1 Experimental design of the first study

3.1.1.1 Participants

Thirty-four second-year undergraduate students (eighteen males, sixteen females), aged 18–20, were recruited to participate in this study. They were taught by the same teacher. After learning fundamental database concepts in the database course, all students took pre-test. Then the students were randomly divided into a control group (thirteen students) and an experimental group (twenty-one students). The students in the control group (CG) received the traditional lecture while those in the experimental group (E) were given the developed learning unit. All participants were assessed by a post-test, a small project, a questionnaire, and an interview. The complete procedures for designing the first experimental study are shown in figure 3.1.

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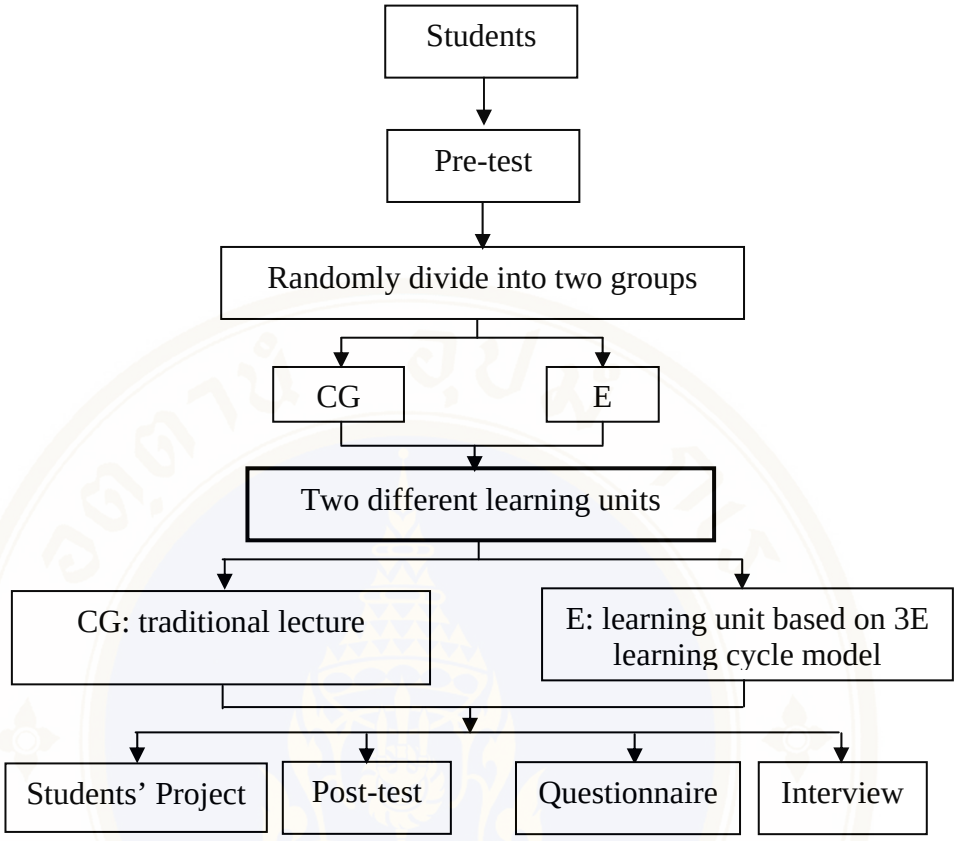

Figure 3.1 Work flow of experimental design of the first study

3.1.1.2 Data collection and data analysis

To evaluate the performance of the proposed learning unit, an experiment was conducted on a database course for second-year undergraduate students. The research instruments consisted of a conceptual test, students' projects, a questionnaire, and a semi-structured interview.

A. SQL-command conceptual understanding test

A pre- and a post-test on SQL commands were used to investigate students' conceptual understanding of SQL. The SQL conceptual test consisted of ten open-ended questions on two categories: the basic knowledge of SQL and the ability to apply SQL. The two categories comprised three and seven items respectively. The test was administered to the students before and after the implementation of the teaching process.

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B. Students' projects

The students' small projects were used to investigate students' ability to apply SQL-related database concepts after the implementation of the innovative learning unit. These projects were analyzed by using the rubric score, where 0–1.5 represents "beginning", 1.51–2.50 represents "developing", 2.51–3.50 represents "accomplished", and 3.51–4.00 represents "exemplary", according to five criteria: 1) database design; 2) framework of database system; 3) user interface design; 4) data preparation; and 5) applying SQL. The scoring rubric for analyzing students' projects is shown in table 3.2.

Table 3.2 Scoring rubric for analyzing students' projects

Criterion	Description			
	4 (Exemplary)	**3 (Accomplished)**	**2 (Developing)**	**1 (Beginning)**
1. Database design	Designed database cover 5 conditions: 1. Remove data redundancy 2. Setting primary key 3. Setting foreign key 4. Setting relationship 5. Determine appropriate attribute in each table	Designed database defined cover 4 conditions from all 5 conditions	Designed database defined cover 3 conditions from all 5 conditions	Designed database defined cover 2 conditions from all 5 conditions
2. Scope of application system	Scope of designed application cover 4 conditions: 1. Completely scope 2. Simulate the real system 3. Complexity of system 4. Useful system	Scope of designed application defined cover 3 conditions from all 4 conditions	Scope of designed application defined cover 2 conditions from all 4 conditions	Scope of designed application defined cover only one condition
3. User interface	Designed user interface cover 5 conditions: 1. User friendly 2. Appropriate to use 3. Well fineness designed page 4. Designed data	Designed user interface defined cover 4 conditions from all 5 conditions	Designed user interface defined cover 3 conditions from all 5 conditions	Designed user interface defined cover 2 conditions from all 5 conditions

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Table 3.2 Scoring rubric for analyzing students' projects (cont.)

Criterion	Description			
	4 (Exemplary)	**3 (Accomplished)**	**2 (Developing)**	**1 (Beginning)**
	access system 5. Accuracy of data displaying in interface			
4. Data preparation for system testing	Data preparation cover 4 conditions: 1. Fundamental data 2. Operational data 3. Completely data 4. Reasonable data	Data preparation defined cover 3 conditions from all 4 conditions	Data preparation defined cover 2 conditions from all 4 conditions	Data preparation defined cover only one condition
5. Applying SQL command in application	Applying SQL command cover 4 conditions: 1. Updating data 2. Querying from one table 3. Querying from more than one table 4. Querying by condition	Applying SQL command defined cover 3 conditions from all 4 conditions	Applying SQL command defined cover 2 conditions from all 4 conditions	Applying SQL command defined cover only one condition

C. Questionnaire

The questionnaire was administered to the students in the experimental group after finishing the instructional process. The questionnaire was employed to investigate students' satisfaction after receiving the proposed learning unit using a 5-point Likert scale, where 1 represents "strongly disagree", 2 represents "disagree", 3 represents "uncertain", 4 represents "agree", and 5 represents "strongly agree".

D. Semi-structured interview

The semi-structured interview was used to provide the in-depth data after the implementation of the innovative learning unit. The interview aimed at investigating the students' perspectives on the learning environment, the students' feelings, and the student-teacher interaction in the classroom. All dialogs in the interviewing process were audio recorded.

The quantitative data, collected from the pre- and post-test and the questionnaire, were analyzed by using t statistics. In terms of qualitative data, the

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interviews were tape-recorded and later transcribed and analyzed. All data were employed to find and develop meanings, patterns, or ideas that described the teaching and learning situation, students' views on teaching and learning, and the effectiveness of the purposed learning unit.

3.2 The second study: The development of the SQL learning unit based on the 5E learning cycle model and one based on the 5E learning cycle model supplemented with multimedia

Two lessons of the SQL instructional unit were developed:

- Lesson I: SQL for defining and manipulating data, and the rules related to keys in a relational database. This part focused on SQL's data definition language (DDL), which relates to creating tables, and the part of the data manipulation language (DML) that relates to inserting, updating, and deleting data, and integrity rules.
- Lesson II: SQL for retrieving data. This part focused on DML statements related to data retrieval.

These lesson plans were designed based on Bybee and co-workers' (2006) 5E learning cycle approach— engagement, exploration, explanation, elaboration, and evaluation. Each lesson was divided into two parts: a two-hour computer laboratory and a one-hour lecture. These instructional plans provided students with experience in the computer laboratory before attending the lecture. The overall activities of each lesson were shown in table 3.3.

Table 3.3 Teaching sequence of the 5E learning-based learning unit

Phases/Description	Objectives	Student Activities
Lesson I: SQL for defining, manipulating data and the rules related to the keys in relational database		
Engagement I	1. To introduce students learned in SQL commands	Students were engaged into the learning unit by answering

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Table 3.3 Teaching sequence of the 5E learning-based learning unit (cont.)

Phases/Description	Objectives	Student Activities
	learned in SQL commands	questions that teacher proposed about database concepts related to SQL commands (DDL and DML except querying language).
Exploration I	1. To be exposed to SQL commands and syntax: defining tables, manipulating data, integrity rules 2. To predict the output of SQL commands 3. To practice writing the SQL commands to generate the output 4. To investigate the cause(s) of the SQL syntax error(s)	The SQL commands (DDL and DML) were used to expose to students. By showing each SQL statement, students explored its output and objectives. Then students generated the output of the proposed SQL statement by writing the SQL commands and also observed SQL syntax errors using the Microsoft Office Access program in a computer laboratory.
Explanation I	1. To summarize the objectives of DDL commands, and relate DML commands (manipulating data in database) to integrity rules	Students shared the output from Exploration I and discussed with classmates. Then teacher encouraged students to share and discuss with class on the cause(s) of the SQL syntax error(s) that they faced, and summarized the objectives of DDL commands, DML commands

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Table 3.3 Teaching sequence of the 5E learning-based learning unit (cont.)

Phases/Description	Objectives	Student Activities
		(except query commands), and related DML commands to integrity rules. And also students were encouraged to construct the whole findings SQL command concepts. Teacher taught in-depth concepts related to SQL syntax.
Elaboration I	1. To elaborate students by applying knowledge in new situations	Students practiced and applied DDL and DML commands to a worksheet. They shared and corrected results with peers. Teacher provided results and additional information on practicing SQL commands.
Evaluation I	1. To evaluate their understanding and perceptions	Encourage students to evaluate their understanding, findings, explanation, and elaboration.
Lesson II: SQL for querying data		
Engagement II	1. To introduce students learned in SQL commands	Students were encouraged into the learning unit by answering questions that teacher proposed database concepts related to data querying commands
Exploration II	1. To experience data query 2. To predict the output of	Similar to those in Exploration I: DML data querying

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Table 3.3 Teaching sequence of the 5E learning-based learning unit (cont.)

Phases/Description	Objectives	Student Activities
	SQL commands 3. To practice writing the SQL commands to generate the output 4. To investigate the cause(s) of the SQL syntax error(s)	commands were used to introduce students to the SQL syntax. Upon showing each SQL statement, students predicted its output and objectives. Then students generated the output of query data by writing SQL commands and also observed syntax errors using the Microsoft Office Access program in a computer laboratory.
Explanation II	1. To summarize the objectives of DML (query commands)	Students shared the output from Exploration II and discussed with classmates. Then teacher encouraged students to share and discuss with class on the cause(s) of the SQL syntax error(s) that they faced, and summarized the objectives of the DML commands (query commands). And also students were encouraged to construct the whole findings SQL command concepts. Teacher taught in-depth concepts related to SQL syntax.

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Table 3.3 Teaching sequence of the 5E learning-based learning unit (cont.)

Phases/Description	Objectives	Student Activities
Elaboration II	1. To elaborate students by applying knowledge in new situations	Students practiced and applied DML commands (query commands) to a worksheet. They shared and corrected results with peers. Teacher provided results and additional information on practicing SQL commands.
Evaluation II	1. To evaluate their understanding and perceptions	Encourage students to evaluate their understanding, findings, explanation, and elaboration.

Moreover, we developed the multimedia served as the supplementary during the undergraduate students participate in the 5E learning cycle model-based activities. The overall activities of each lesson were shown in table 3.4

Table 3.4 Teaching sequence of the 5E learning unit-based activities supplemented with multimedia

Phases/Description	Objectives	Student Activities
Lesson I: SQL for defining, manipulating data and the rules related to the keys in relational database		
Engagement I	1. To introduce students learned in SQL commands	Students were engaged into the learning unit by using designed multimedia animation.
Exploration I	1. To be exposed to SQL commands and syntax: defining tables, manipulating data,	Game investigation: Provided students to predict SQL statements in DDL (create table, alter table, drop table)

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Table 3.4 Teaching sequence of the 5E learning unit-based activities supplemented with multimedia (cont.)

Phases/Description	Objectives	Student Activities
	integrity rules 2. To predict the output of SQL commands 3. To practice writing the SQL commands to generate the output 4. To investigate the cause(s) of the SQL syntax error(s)	and DML(insert, update, delete data from database) Content investigation: Students tried to write SQL syntax on designed multimedia animation by using SQL manual, used the Microsoft Office Access program in a computer laboratory for observing SQL syntax errors, communicated their results with peers and discussed the results of game and content investigation to the class.
Explanation I	1. To summarize the objectives of DDL commands, and relate DML commands (manipulating data in database) to integrity rules	Teacher encouraged students to share and discuss with class on the cause(s) of the SQL syntax error(s) that faced, and summarized the objectives of DDL commands, DML commands (except query commands), and related DML commands to integrity rules. And also students were encouraged to construct the whole findings SQL command concepts. Teacher taught in-

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Table 3.4 Teaching sequence of the 5E learning unit-based activities supplemented with multimedia (cont.)

Phases/Description	Objectives	Student Activities
		depth concepts related to SQL syntax.
Elaboration I	1. To elaborate students by applying knowledge in new situations	Students practiced and applied DDL and DML commands by using multimedia animation and used Microsoft Office Access program to learn error from error message responses. Teacher provided results and additional information on practicing SQL commands.
Evaluation I	1. To evaluate their understanding and perceptions	Encourage students to evaluate their understanding, findings, explanation, and elaboration.
Lesson II: SQL for querying data		
Engagement II	1. To introduce students learned in SQL commands	Students were engaged into the learning unit by using designed multimedia animation.
Exploration II	1. To experience data query 2. To predict the output of SQL commands 3. To practice writing the SQL commands to generate the output 4. To investigate the cause(s) of the SQL syntax error(s)	Game investigation: Provided students to predict SQL statements in DML (query commands) Content investigation: Students tried to write SQL syntax on designed multimedia animation by

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Table 3.4 Teaching sequence of the 5E learning unit-based activities supplemented with multimedia (cont.)

Phases/Description	Objectives	Student Activities
		using SQL manual, used the Microsoft Office Access program in a computer laboratory for observing SQL syntax errors, communicated their results with peers, and discussed the results of game and investigation to the class.
Explanation II	1. To summarize the objectives of DML (query commands)	Teacher encouraged students to share and discuss with class on the cause(s) of the SQL syntax error(s) that faced, and summarized the objectives of DML (query commands). And also students were encouraged to construct the whole findings SQL command concepts
Elaboration II	1. To elaborate students by applying knowledge in new situations	Students practiced and applied DML commands (query commands) by using multimedia animation and used Microsoft Office Access program to learn from error message responses. They shared and collected results with peers. Teacher provided results and additional information on practicing SQL

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Table 3.4 Teaching sequence of the 5E learning unit-based activities supplemented with multimedia (cont.)

Phases/Description	Objectives	Student Activities
		commands.
Evaluation II	1. To evaluate their understanding and perceptions	Encourage students to evaluate their understanding, findings, explanation, and elaboration.

The development of the SQL learning unit started from planning the instruction, consulting with the curriculum expert, conducting the pilot study, and revising the draft. The next step is implementation and data collection. Finally, the SQL learning unit was evaluated from all the data.

3.2.1 Experimental design of the second study

3.2.1.1 Participants

Ninety-five second-year undergraduate students (fifty-two males, forty-three females), aged 18–20, were recruited to participate in this study. They were taught by the same teacher. After learning fundamental database concepts in the database course, all students took pre-test. Then the students were randomly divided into a control group (thirty-three students), an experimental group 1 (thirty students), and an experimental group 2 (thirty-two students). The students in the control group (CG) received the traditional lecture; those in the experimental group 1 (E1) were given the developed the 5E learning cycle model-based learning units, while those in the experimental group 2 (E2) were given the developed the 5E learning cycle model-based learning unit supplemented with multimedia. All participants were assessed by a post-test, a small project, a questionnaire, and an interview. The complete procedures for designing the second experimental study are shown in figure 3.2.

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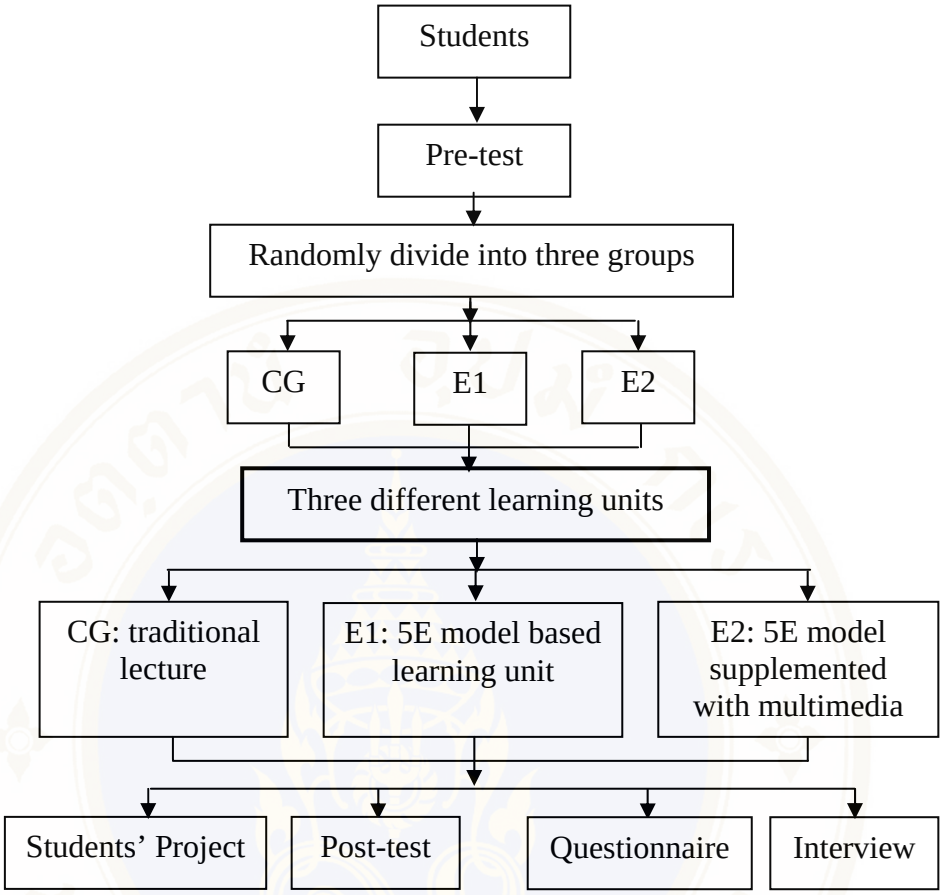

Figure 3.2 Work flow of experimental design of the second study

3.2.1.2 Data collection and data analysis

To evaluate the performance of the proposed learning unit, an experiment was conducted on a database course for second-year undergraduate students. The research instruments consisted of a conceptual test, students' projects, a questionnaire, and a semi-structured interview.

A. SQL-command conceptual understanding test

A pre- and a post-test on SQL commands were used to investigate students' conceptual understanding of SQL. The SQL conceptual test consisted of ten open-ended questions on two categories: the basic knowledge of SQL and the ability to apply SQL. The two categories comprised three and seven items respectively. The test was administered to the students before and after the implementation of the teaching process.

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B. Students' projects

The students' small projects were used to investigate students' ability to apply SQL-related database concepts after the implementation of the innovative learning unit. These projects were analyzed by using the rubric score, where 0–1.5 represents "beginning", 1.51–2.50 represents "developing", 2.51–3.50 represents "accomplished", and 3.51–4.00 represents "exemplary", according to five criteria: 1) database design; 2) framework of database system; 3) user interface design; 4) data preparation; and 5) applying SQL. The scoring rubric for analyzing students' projects is the same criterion as in the study one. The scoring rubric for analyzing students' projects is shown in table 3.5.

Table 3.5 Scoring rubric for analyzing students' projects

Criterion	Description			
	4 (Exemplary)	**3 (Accomplished)**	**2 (Developing)**	**1 (Beginning)**
1. Database design	Designed database cover 5 conditions: 1. Remove data redundancy 2. Setting primary key 3. Setting foreign key 4. Setting relationship 5. Determine appropriate attribute in each table	Designed database defined cover 4 conditions from all 5 conditions	Designed database defined cover 3 conditions from all 5 conditions	Designed database defined cover 2 conditions from all 5 conditions
2. Scope of application system	Scope of designed application cover 4 conditions: 1. Completely scope 2. Simulate the real system 3. Complexity of system 4. Useful system	Scope of designed application defined cover 3 conditions from all 4 conditions	Scope of designed application defined cover 2 conditions from all 4 conditions	Scope of designed application defined cover only one condition
3. User interface	Designed user interface cover 5 conditions: 1. User friendly 2. Appropriate to use 3. Well fineness designed page	Designed user interface defined cover 4 conditions from all 5 conditions	Designed user interface defined cover 3 conditions from all 5 conditions	Designed user interface defined cover 2 conditions from all 5 conditions

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Table 3.5 Scoring rubric for analyzing students' projects (cont.)

Criterion	Description			
	4 (Exemplary)	**3 (Accomplished)**	**2 (Developing)**	**1 (Beginning)**
	4. Designed data access system 5. Accuracy of data displaying in interface			
4. Data preparation for system testing	Data preparation cover 4 conditions: 1. Fundamental data 2. Operational data 3. Completely data 4. Reasonable data	Data preparation defined cover 3 conditions from all 4 conditions	Data preparation defined cover 2 conditions from all 4 conditions	Data preparation defined cover only one condition
5. Applying SQL command in application	Applying SQL command cover 4 conditions: 1. Updating data 2. Querying from one table 3. Querying from more than one table 4. Querying by condition	Applying SQL command defined cover 3 conditions from all 4 conditions	Applying SQL command defined cover 2 conditions from all 4 conditions	Applying SQL command defined cover only one condition

C. Questionnaire

The questionnaire was administered to the students in both two experimental groups and the traditional group after finishing the instructional process. The questionnaire was employed to investigate students' satisfaction after receiving the proposed learning unit using a 5-point Likert scale, where 1 represents "strongly disagree", 2 represents "disagree", 3 represents "uncertain", 4 represents "agree", and 5 represents "strongly agree".

D. Semi-structured interview

The semi-structured interview was used to provide the in-depth data after the implementation of the innovative learning unit. The interview aimed at investigating the students' perspectives on the learning environment, the students' feelings, and the student-teacher interaction in the classroom. All dialogs in the interviewing process were audio recorded.

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The quantitative data, collected from the pre- and post-test and the questionnaire, were analyzed by using t statistics. In terms of qualitative data, the interviews were tape-recorded and later transcribed and analyzed. All data were employed to find and develop meanings, patterns, or ideas that described the teaching and learning situation, students' views on teaching and learning, and the effectiveness of the purposed learning unit.

3.3 Ethics

Ethics is important in research educations because it protects the participants from any harm both physical and mental harm. This research study was approved by Documentary Proof of The Committee for Research Ethics (Social Sciences) from Mahidol University. The consent forms were given to the principles of the university to ask for their permission to do research in university and in their classes. All data from personal data and student works were kept confidential. Pseudonyms for university name, and students were used to preserve anonymity and their privacy was protected. At the end of research process, all data was destroyed by researcher.

3.4 Summary of the chapter

To sum up, this chapter has described the process of developing of the instructional units on the topic of SQL. The instructional units were developed based on different learning model: the 3E learning cycle model for study one and the 5E learning cycle model supplemented with multimedia for study two. In addition, both studies were conducted to evaluate the effectiveness of each learning unit. The experimental results are depicted in the next chapter.

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CHAPTER IV
RESULTS AND DISCUSSION

In this chapter, the results from pre-test, post-test, project, questionnaire, and semi-structured interview are analyzed to find out if the innovative approach would be helpful in achieving learning achievement. Moreover, the experiment results are discussed. The contribution of the proposed approach in information system education area and guideline for applying the proposed approach into the classroom are presented in this chapter.

4.1 Results from learning unit based on the 3E learning cycle model

4.1.1 Students' achievement

A. Results of pre- and post-test

After the implementation the developed learning unit on a database management system course for second-year undergraduate students, the pre-test aimed to examine the prior knowledge of both the control and the experimental groups. While the post-test explored how the two groups were affected by the treatments in terms of students' basic and application knowledge of SQL.

To examine the students' improvement, the total mean scores on the pre- and post-test were analyzed for the control group and the experimental group. Figure 4.1 shows that the pre- and post-test mean scores were significantly different in both groups. The results implied that both our innovative learning unit and the traditional teaching method could help students to improve their knowledge of SQL.

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Table 4.1 Mean scores of pre- and post-test on SQL conceptual understanding between the control and experimental groups

Category		Pre-Test		Post-Test	
		Control Group (N = 13)	Experimental Group (N = 21)	Control Group (N = 13)	Experimental Group (N = 21)
Basic knowledge of SQL (Total Score: 10)	Mean	3.30	3.15	5.28	5.80
	SD	1.38	1.43	1.38	1.41
	t	0.290		1.063	
Ability to apply SQL (Total Score: 20)	Mean	3.08	4.09	7.54	10.15
	SD	1.29	1.94	1.77	2.88
	t	1.657		3.271*	
Overall (Total Score: 30)	Mean	6.75	7.47	12.89	15.99
	SD	2.18	2.63	2.12	3.43
	t	0.835		2.919*	

* Significant difference ($p < 0.05$)

As shown in table 4.1, the total mean score on the pre-test (6.75) of the control group was not significantly difference from that of the experimental group (7.47). The result suggested that both groups of the students had similar prior knowledge regarding SQL.

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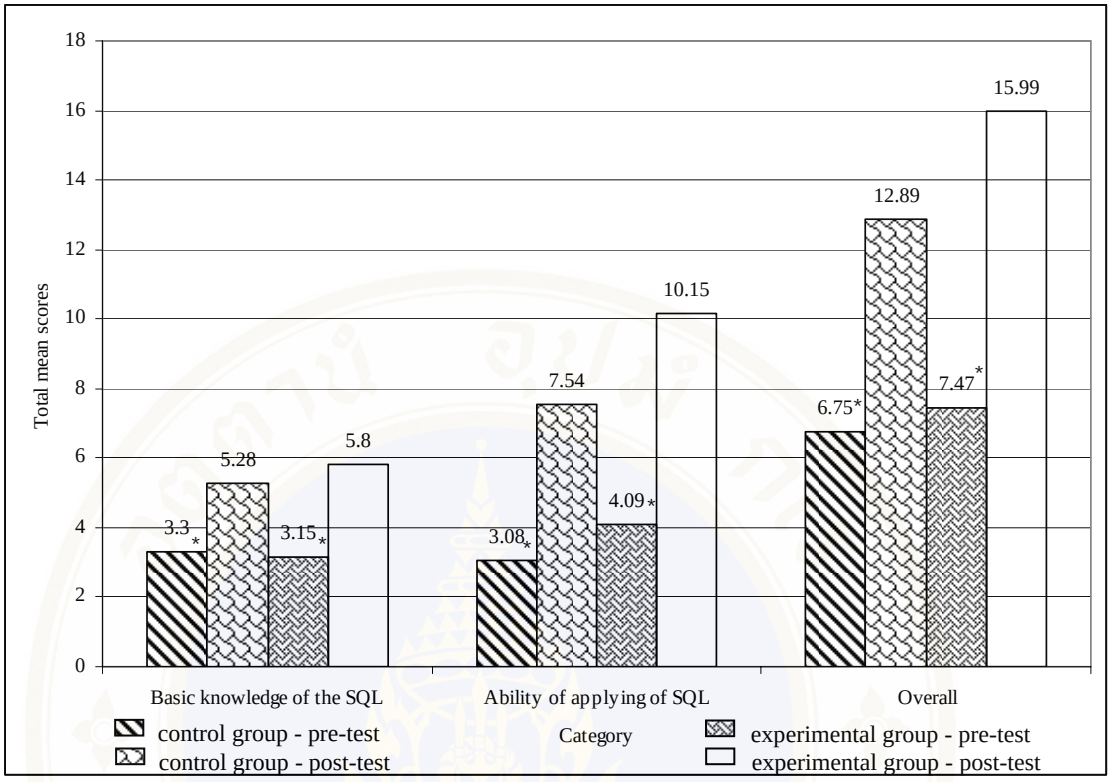

* Significant difference ($p<0.05$)

Figure 4.1 Students' mean scores of the control group and the experimental group

To evaluate the developed learning unit, another analysis was made to compare the students' achievements between the control group and the experimental group. As shown in table 4.1, the post-test mean score on SQL basic knowledge of the control group (5.28) was not significantly different from that of the experimental group (5.80). It might be the periods of learning activities are short for the students to taking the learning objects in class. But the post-test mean score on SQL basic knowledge of experimental group was higher than control group. The post-test mean score on SQL application knowledge of the experimental group (10.15), however, was significantly higher than that of the control group (7.54). The total mean score on post-test of the experimental group (15.99) was also significantly higher than that of the control group (12.89). Obviously, the students in the experimental group enhanced their achievement in applying SQL significantly more than those in the control group after using our innovative learning unit.

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B. Results of students' small project

Table 4.2 shows the overall student-project results. Students' projects in the experimental group regarding the framework of database system, which included completely developing the database system and its usefulness in the real-life situation, were exemplary. Moreover, they were exemplary in applying SQL commands to update and query data from multiple tables, and querying data by using correct conditions. As a comparison, students' projects in the control group were just accomplished in those areas. These results confirmed that our innovative learning unit was able to promote students' understanding of SQL, particularly applying SQL to develop small projects.

Table 4.2 The overall rubric scores of students' projects

Criteria (Total score: 20)	Results of students' project representation	
	Control group	Experimental group
Database design (4)	Accomplished	Accomplished
Framework of database system (4)	Accomplished	Exemplary
User interface design (4)	Accomplished	Accomplished
Data preparation (4)	Accomplished	Accomplished
Applying SQL (4)	Accomplished	Exemplary

4.1.2 Students' attitude

A. Results of the questionnaire

The questionnaire was employed to investigate students' satisfaction after receiving the developed learning unit. As shown in table 4.3, the maximum scores were 5. Most of the students who followed the proposed learning unit based on the 3E learning cycle model were satisfied with the learning unit. Moreover, numerous students felt that they had the opportunities to participate in the classroom during the proposed learning activities. Furthermore, most students agreed that they could learn better and with more understanding of SQL from the developed

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learning activity. Thus, most of them realized that SQL is an important topic and felt that the developed learning activities could encourage them to learn.

Table 4.3 Students' responses to the questionnaire

Item	Mean	SD
I was satisfied with the proposed learning unit	3.59	0.59
I participated in class	3.52	0.68
This learning unit could enhance my understanding of SQL	3.83	0.40
I know SQL syntax better	3.86	0.57
I realize the importance of SQL	4.00	0.71
Learning activities could encourage me in learning	3.57	0.68
N = 21		

B. Results of the interview

We interviewed five students who received the proposed learning unit to acquire more detailed feedback.

- Students' comments toward the proposed learning unit.

''I am happy to have this opportunity to experience the learning activities. This is an innovative way to learn. I learn much about SQL. Moreover, I can share knowledge with my friends during the learning activities. When completing the learning activities, I felt very happy to apply SQL to my project. I really prefer the learning activities to other courses."

"Well, this method can cause students to think before, and make students eager to study more. It is self practicing, and we can know where it is wrong and can correct it. If an instructor says this is wrong then I can remember and correct the next time. If I do it wrong myself, I will remember."

"Allows us to think and imagine before how it comes out. When we write it completely, run and see the result. It may be not what we think. So we can remember much more. From our error, try to write. If we write it out, we will understand more. Then it is as a self training."

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- Students' suggestions to future improvements of the learning unit.

"It seems that the periods of learning activities are too short to some students owing to the large number of learning objects taken into account at the same time. It would be better to extend the learning time."

"To control their own learning progresses during the proposed learning activities, it would be better to integrate the proposed learning activities on a computer-based environment, so that the entire learning activities can be conducted in a more-efficient way."

These comments are valuable and will be taken into account when developing the next SQL learning unit based on the learning cycle on a computer-based environment.

To sum up, this study was conducted to investigate the effectiveness of two methods of learning SQL (the 3E learning cycle model and traditional) for undergraduate students. The results of this study indicated that the 3E learning-cycle-model-treatment group significantly outperformed the traditional-treatment group in understanding key aspects and concepts involved in SQL.

Possible reasons for this observed difference might include the value associated with alternative ways of acquiring knowledge in science, particularly inquiry, and confirmation value of hands-on activities. During the 3E learning cycle model, students learned through their own actions and reactions by being involved in hands-on activities. They explored SQL and the responses from running the exemplary statements encouraged them to modify the commands to find the correct answers. Students' explorations involved trying out and learning from errors. Students in the 3E learning-cycle model group were also involved in hands-on activities that helped them to examine the adequacy of their prior conceptions and encouraged them to discuss about those conceptions. This led to disequilibrium when predictions based on their prior beliefs were contradicted and provided the opportunity to construct more appropriate concepts. The 3E learning-cycle model required a teaching strategy in which students had enough time to identify and express their preconceptions and

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examine their usefulness, before the new concept or a group of related concepts was verbally introduced and explicated. Meanwhile, students in the traditional group mainly focused on concepts related to the subject, the process that required less conceptual restructuring.

The finding of this study regarding better performance of students in the 3E learning-cycle-model group was consistent with the view claiming that correct use of the 3E learning cycle model accomplished both effective learning of concepts and development of skills in the reasoning patterns used in concept construction (Ates, 2005; Musheno & Lawson, 1999; Zollman, 1990).

Ates (2005) indicated that an instructional method consisting of hands-on activities resulted in better understanding of science concepts and involvement than did an instructional method consisting only of traditional strategies in teaching and learning science. Analyses of questionnaire responses in the present study suggested that the students in the 3E learning-cycle model group were encouraged by and satisfied with the learning unit, and participated in the learning activities. The students also reported that their understanding of SQL was enhanced.

The result regarding more valuable experience and better performance in SQL topics was consistent with the prior studies that employed the team approach and a learning tool (Abu Naser, 2006; Lenox & Woratschek, 2005).

Lenox and Woratschek (2005) discussed that database project problems had provided students with a valuable experience by using the team approach on one of the most popular database topic; SQL. Abu Naser (2006) presented an intelligent tutoring system (DB-ITS) as a guided learning environment to support problem solving. The results indicated that this tool was more advantageous than the traditional approach; furthermore the students performed better in the exam. In the interpretation of findings from this study, it was also suggested that information technology educators who taught SQL using the 3E learning-cycle model should be aware of their students' level of prior experience and knowledge of SQL. The 3E learning-cycle model may be of particular value to the science teacher.

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However, there is no report of the study that applies the 3E learning cycle model to develop a learning unit on SQL topic. So this research study may provide a useful guideline to further the development of a learning unit based on the 3E learning cycle model. From the results of students' interview, there are some valuable comments for integrating a computer-based environment in SQL learning unit thus such that the second study will be taken a computer-based environment in SQL learning unit.

4.2 Results from learning unit based on the 5E learning cycle model and one based on the 5E learning cycle model supplemented with multimedia

4.2.1 Students' achievement

A. Results of pre- and post-test

After the implementation the developed 5E learning cycle instruction supplemented with multimedia on a database management system course for the second-year undergraduate students, the pre-test aimed to examine the prior knowledge of all the control and two experimental groups. While the post-test explored how the three groups were affected by the treatments in terms of students' basic and application knowledge of SQL.

Table 4.4 show that there is no significant difference in the pre-test score in the CG (2.70 ± 3.56), the E1 (3.42 ± 3.72) and the E2 (4.52 ± 1.98). The results suggested that three groups of the students had similar prior knowledge regarding SQL. However, in overall of the post-test scores, the scores in E2 (19.44 ± 6.04) were significantly higher than those both in the E1 (12.17 ± 8.27) and the CG (7.75 ± 4.58) as shown in table 4.7.

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Table 4.4 Means, standard deviations, and one-way analyses of variance (ANOVA) summary table for the pre-test results of the three groups

		Group	Number of students	Average score	Standard deviation	*F(2, 92)*
Overall	(a)	CG	33	2.70	3.56	2.697
(Total	(b)	E_1	30	3.42	3.72	
Score: 30)	(c)	E_2	32	4.52	1.98	

(a) Control group CG: traditional learning.
(b) Experimental group E_1: 5E learning cycle model.
(c) Experimental group E_2: 5E learning cycle model supplemented with multimedia.

Moreover, in table 4.5 and table 4.6 shown that, in basic knowledge of SQL, there was significant difference in post-test scores among the E2 and the E1, the E2 and the CG, and the E1 and the CG. Similar results were found in the ability to apply SQL. These results suggested that the SQL learning unit based on the 5E learning cycle model supplemented with multimedia is more helpful for students in learning SQL.

Table 4.5 Means, standard deviations, and one-way analyses of variance (ANOVA) summary table for the post-test results of the three groups in basic knowledge of SQL

Category		Group	Number of students	Average score	Standard deviation	*F(2, 92)*	Post hoc test (Scheffe)
Basic	(a)	CG	33	4.55	1.68	28.304	(c) > (a)*
knowledge of	(b)	E_1	30	5.64	1.97		(c) > (b)*
SQL (Total	(c)	E_2	32	7.69	1.45		(b) > (a)*
Score: 10)							

*$p < .05$
(a) Control group CG: traditional learning.
(b) Experimental group E_1: 5E learning cycle model.
(c) Experimental group E_2: 5E learning cycle model supplemented with multimedia.

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Table 4.6 Means, standard deviations, and one-way analyses of variance (ANOVA) summary table for the post-test results of the three groups in ability to apply SQL

Category		Group	Number of students	Average score	Standard deviation	*F(2, 92)*	Post hoc test (Scheffe)
Ability to apply SQL (Total Score: 20)	(a)	CG	33	3.21	3.58	21.576	(c) > (a)*
	(b)	E_1	30	6.53	6.71		(c) > (b)*
	(c)	E_2	32	11.75	5.21		(b) > (a)*

*$p < .05$
(a) Control group CG: traditional learning.
(b) Experimental group E_1: 5E learning cycle model.
(c) Experimental group E_2: 5E learning cycle model supplemented with multimedia.

Table 4.7 Means, standard deviations, and one-way analyses of variance (ANOVA) summary table for the post-test results of the three groups

Category		Group	Number of students	Average score	Standard deviation	*F(2, 92)*	Post hoc test (Scheffe)
Overall (Total Score: 30)	(a)	CG	33	7.75	4.58	27.394	(c) > (a)*
	(b)	E_1	30	12.17	8.27		(c) > (b)*
	(c)	E_2	32	19.44	6.04		(b) > (a)*

*$p < .05$
(a) Control group CG: traditional learning.
(b) Experimental group E_1: 5E learning cycle model.
(c) Experimental group E_2: 5E learning cycle model supplemented with multimedia.

B. Results of students' small project

Table 4.8 shows the overall student-project results. Students' projects in the experimental group 2 (E2) regarding the database design, framework of database system, user interface design and data preparation were exemplary. Moreover, they were exemplary in applying SQL commands to update and query data from multiple tables, and querying data by using correct conditions. The results in the experimental group 1 (E1) were exemplary in the framework of database system and applying SQL. As a comparison, students' projects in the control group were only exemplary in this framework area. These results confirmed that our innovative

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learning unit was able to promote students' understanding of SQL, particularly applying SQL to develop small projects.

Table 4.8 The overall rubric scores of students' projects

Criteria (Total scores: 20)	Results of students' project representation		
	Control group	Experimental group 1	Experimental group 2
Database design (4)	Accomplished	Accomplished	Exemplary
Framework of database system (4)	Exemplary	Exemplary	Exemplary
User interface design (4)	Accomplished	Accomplished	Exemplary
Data preparation for system testing (4)	Accomplished	Accomplished	Exemplary
Applying SQL (4)	Accomplished	Exemplary	Exemplary

4.2.2 Students' attitude

A. Results of the questionnaire

When the satisfaction of receiving the developed learning unit were evaluated using 16 items on 5E assessment scale, rating on 5-point Likert scale from poor to excellent. As shown in table 4.9, the maximum scores were 5. The students in the experimental group 2 (E2) who followed the proposed learning unit based on the 5E learning cycle instruction with SQL multimedia were satisfied with the engagement method. Moreover, the experimental 1 (E1) and 2 (E2) groups felt that they had the opportunities to explore the SQL commands and explain their knowledge in the classroom during the proposed learning activities. Furthermore, these two groups agreed that they had elaborated with their peer from the learning activities. Thus, the experimental group 2 (E2) realized that they had assess their knowledge according to the learning objectives.

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Table 4.9 Students' responses to the questionnaire

Intervention group	Category									
	Engagement		Exploration		Explanation		Elaboration		Evaluation	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
CG	3.85	0.66	3.69	0.73	3.68	0.73	3.74	0.67	4.03	0.71
E_1	4.06	0.51	4.02	0.61	3.91	0.52	3.90	0.52	4.01	0.60
E_2	4.15	0.51	4.03	0.61	4.01	0.71	3.94	0.63	4.29	0.64

(a) Control group CG: traditional learning.
(b) Experimental group E_1: 5E learning cycle model.
(c) Experimental group E_2: 5E learning cycle model supplemented with multimedia.

B. Results of the interview

We interviewed students in three groups to acquire more detailed feedback.

- Students' comments toward the 5E with SQL multimedia learning unit.

Engagement

Most students felt that the engaged media was easier to learn and more enjoy:

"The engaged activities are well and I prefer the SQL multimedia module as it is much easier to understanding in which one can learn at one's own pace like trial and error. I enjoy doing the SQL multimedia as I learn the concept from it."

"Game in SQL module is much easier to understanding and learning. I can play by answering the questions. I feel it is well."

"I am more interested in learning because you engage using learning application like cartoons, it is much easier to understanding, and I enjoy trying the test."

"Game increases enjoy in learning."

Two students felt that the engaged activities were not stressed:

"I am not stressed when you engage the introduction using SQL multimedia because database concept is quite complicated one."

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"I feel it is a new learning situation and more interesting by using a game for training which I can learn and enjoy so the learning activities are not boring or more serious."

The student responses the SQL multimedia more interesting:

"The SQL multimedia is more interesting and colorful."

Exploration

"I can learn from practicing the SQL commands by own using the SQL multimedia."

"I learn by writing SQL commands after you engage with SQL multimedia"

"The learning activities can help my learning because I can try to write the commands and run for testing where the error found so I can understand how to coding the SQL format and correcting the error."

Explanation

"I can share and explain my knowledge so I can understand by myself."

Elaboration

"When I have some problems or do not understand in the SQL commands, I can consult my peer or teacher. I can apply some commands in my small project."

"I can ask some problems for enhance my understanding and some error. Moreover, I can share with my friends."

"I can apply this concept with programming language to developing my group project."

"I can share SQL concept with my colleague for adapting SQL commands in project."

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"This learning activity is held my understanding in SQL syntax and database structure for applying in my project when I share our knowledge to classmates and teacher. Thus, I can get the solution."

Evaluation

"For doing pre-test and post-test, I can assess my knowledge and understanding. The SQL module provide the exercises for evaluate my knowledge and understanding."

"I am more enthusiasm in learning when I get pre-test and post-test."

"The classroom evaluation is provided the worksheet to the students for sharing their answers in class and pre-test and post-test. The evaluation is the good method because I can receive how understanding I get."

"Teacher often asks the questions in class for assessing students understanding."

Overall

"Well, it is easier to understand by trying to play the SQL game."

"The teaching steps are well."

"These activities enhance understanding."

"The learning activities are informal because students can learn from game. Thus, the class environment is not stressed."

"I feel that the learning methods are good setting, due to promoting students learning and assisting very well for developing the project."

"Very well, it is not bored and all activities are enthusiastic and held attention in learning."

"I prefer especially game because I am not yet found learning media as game so it is interesting and useful for self studying."

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"I am enjoyable because it is not only provided content but also offered the game so I learn more in SQL. It is not bored and I am eager to learn."

- Students' suggestions to future improvements of the learning unit

"The periods of learning activities are too short to some students. It would be better to extend the learning time."

- Students' comments toward the 5E learning unit.

Engagement

"Engagement is related to SQ commands."

"I would like to learn when you engage the concept that related to SQL as reviewing database concept."

"I know what SQL apply to."

Exploration

"I think it's good though I practice for correcting error. Students can share their answer in this step."

"Well, I will learn by own that teaching is a good method instead of getting passive learning which is boring."

"This step assist learning owing to I have to think and try to correct error before."

"I learn more the concept and how to practice by trying to correct SQL statement after that I learn that SQL syntax. I get more understanding and it is easier to apply to other statement."

Explanation

"I share the concept in class and with my peer. You always request questions and ask us. It is good to encourage students to pay more attention."

"In the first, I can not share my knowledge because I just learn this concept. However teacher may be asked questions. Later, I get more understanding therefore I can share my knowledge to classmates and teacher."

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Elaboration

"When I have problem, I ask my friends."

"When I find error or incorrect statement, I can share with my classmates. This step made me understanding how to correct SQL statement."

"I can apply the concept in my project and to other programming language that related to database system."

"Well, I can review by own practicing and apply in group project. Thus the errors are found, I share with my friends and teacher."

"You provide another database case study that I can apply to my work and other conditions which I can enhance to complete in my project."

"I do the worksheet which I can apply SQL commands for other scenario."

Evaluation

"In class, you always ask students about the concept or may be get the problems to solving, these are assessing us the knowledge. These steps can encourage me to held attention."

"I do pre- and post-test for evaluating my understanding."

Overall

"Well, this learning model can encourage my intention."

"Very good, I can apply SQL to database concept and increase my knowledge and understanding in database system."

- Students' suggestions to future improvements of the learning unit

"The learning periods are short. Learning time should be extended for learning other in-dept SQL concepts."

- Students' comments toward the traditional learning.

Engagement

"You review the database concept which relate to SQL concept that made me increase understanding."

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Exploration

"I do not practice because you lecture all SQL syntax in class."

Explanation

"I do not have a chance to explain by own."

Elaboration

"I can ask the problems with my friends for correcting the error."

"I can share the idea with classmates and teacher. In this activity I can get more understanding."

"I can ask the teacher about problems when I don't understand."

Evaluation

"Pre- and post-test are provided for evaluating how students gain after learning."

"You always ask students for assessing their knowledge and understanding that encourage students learning. It's well."

"You may be walk around the class for assessing students understanding when doing worksheet. When you evaluate me, I can ask about my problem."

Overall

"Well, this learning model assists me easier understanding. While you teach, I can ask the problem and do the worksheet for applying in the other database in which increase my understanding"

- Students' suggestions to future improvements of the traditional learning unit

"It should be practicing along with teaching SQL concept."

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To sum up, this study was conducted to investigate the effectiveness of three methods of learning SQL (5E learning cycle model instruction supplemented with multimedia, 5E leaning cycle instruction and traditional instruction) for undergraduate students. The results of this study indicated that the 5E learning cycle model instruction supplemented with multimedia-treatment group significantly outperformed the 5E learning cycle model instruction-treatment group and the traditional-treatment group in understanding key aspects and concepts involved in SQL.

Possible reasons for this observed difference might include the value associated with alternative ways of acquiring knowledge in science, particularly inquiry, and confirmation value of hands-on activities. During the 5E learning cycle instruction, students learned through their own actions and reactions by being involved in hands-on activities. They were engaged by SQL game and the responses from dragging, dropping and clicking the exemplary statements encouraged them to modify and mark parts of the commands to find the correct answers. They explored SQL and the responses from running the exemplary statements encouraged them to modify the commands to find the correct answers. Students' explorations involved trying out and learning from errors. Students in the 5E learning cycle instruction group were also involved in hands-on activities that helped them to examine the adequacy of their prior conceptions and encouraged them to discuss about those conceptions. This led to disequilibrium when predictions based on their prior beliefs were contradicted and provided the opportunity to construct more appropriate concepts. The 5E learning cycle instruction supplemented with SQL multimedia required a teaching strategy in which students had enough time to identify and express their preconceptions and examine their usefulness, before the new concept of a group of related concepts was verbally introduced and explicated. Students elaborated by applying and extending new knowledge they have constructed to other new database case study and their small projects. The evaluation in 5E learning cycle instruction required the students had evaluated what they have done. The students in the 5E learning cycle instruction required the same as teaching strategy with 5E learning cycle instruction with SQL multimedia in exception of engagement stage which these students were engaged by reviewing the database concept related to SQL commands. Meanwhile, students in the

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traditional group mainly focus on concepts related to the subject, the process that required less conceptual restructuring.

The finding of this study regarding better performance of students in the 5E learning cycle instruction supplemented with SQL multimedia group was consistent with the view claiming that correct use of the 5E learning cycle instruction accomplished both effective learning concepts and ability to apply concepts.

The positive effect of 5E learning cycle instruction on students' achievement was supported by previous studies in the literature (Gerdprasert et al., 2010a, in press, 2010b; Kaveevivitchai et al., 2009; Kaynar et al., 2009; Liu et al., 2009). For example, Kaynar and co-workers (2009) revealed effectiveness of five E learning cycle model over traditional learning on students' cell concepts achievement. Studying with the third-year university nursing and midwifery, Gerdprasert and co-workers (2010b) showed that supplementation with learning unit made learning significantly more effective than the traditional lecture and students responded positive attitude toward this learning unit. This study, the web-based learning unit was developed based on integrating principles of the mechanism of labour with the 5E inquiry cycle model. Present study is also consistent with the results reported by earlier studies that indicate positive effect of 5E learning cycle instruction on students' application. For example, Van Hook and Huziak-Clark (2007) showed similar results with the present study. They used 5E learning cycle model that a learning model in which students using the understanding gained in the previous learning steps, to apply and include their ideas about how things work through collaborative hands-on inquiry with their peer and all those studies guided by a knowledgeable teacher. Students in the constructivist classroom were able to adopt their learning concept and used provided hands-on materials to describe how it worked with each other.

This study indicated the positive effect of integrating multimedia with learning approach on students' understanding and their motivation. The present study is also consistent with the study by Murray and Guimaraes (2008) found that the positive rate on the value of animated courseware in students and faculty. This learning tool could help students find pathway through which increase understanding and received high level of learning. In, another study, Valdés and co-workers (2000)

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provided the multimedia resources for students as alternative study tools. Their work showed that students found the learning tools easily understanding and were motivated to learn.

Overall results of the existing studies suggest that when students receive appropriate instruction which help them understand relevant ideas, sound understanding of SQL concepts can be achieved. The existing studies, thus, contributes the classroom practices in the teaching of database concepts in general, SQL in particular, and the development of suitable materials promoting students' achievement in different database concepts.

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CHAPTER V
CONCLUSION

This chapter summarizes the interpretation and discussion of research findings of the learning unit based on the 3E learning cycle model and the learning unit based on the 5E learning cycle model, and one integrated supplemented with multimedia on SQL topic. The effectiveness of the learning unit based on the 3E learning cycle model and based on the 5E learning cycle model and one integrated with multimedia and students outcome are described.

5.1 The effectiveness of the 3E learning cycle model-based learning unit on students' outcome

The findings in this study clearly demonstrated that the proposed learning unit based on the 3E learning cycle model promoted students' conceptual understanding of SQL. The students could construct their own knowledge through the learning activities as judged by the posttest scores on SQL conceptual understanding. The innovative SQL learning unit based on the learning cycle also helped the students to develop the ability to apply SQL to small database projects. They were able to apply their own knowledge as well as to manage the data in their database systems. The questionnaire results revealed that the students had positive perceptions of this learning unit. The students perceived this instructional unit as a constructivist learning environment.

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5.2 The effectiveness of the learning unit based on 5E learning cycle model and one supplemented with multimedia on students' outcome

The finding of the present study indicated that both the 5E learning cycle model integrated with multimedia and the 5E learning cycle model caused a significantly better acquisition of principles conceptions related to SQL commands than traditional instruction. However, the learning unit based on the 5E learning cycle model supplemented with multimedia is more helpful that one based on common 5E learning cycle model. In the experimental groups, the emphasis has given to students' own practicing from errors found. Students were involved in activities that helped them activate their prior knowledge and struggle with their own practicing. These activities also provide evidence that students' initial conceptions are insufficient understanding of the concepts. To deal with these errors found practicing, for instance, in the SQL syntax instruction, students became dissatisfied with their existing conceptions. This dissatisfaction let them accept better explanations to the situation that were introduced. In this way, students were allowed to think about their prior knowledge and reflect on it. The important part in the implementation of the SQL concepts instruction was the intensive teacher-student interaction. Similarly, the use of the 5E learning cycle model can clarify students' thought processes and correct their error found practicing. When students explore a new concept through an exploration, their new experiences cause them reevaluate their past experiences. This produces disequilibrium in the student, and s/he needs to accommodate the concept to reach equilibration. The students in the learning cycle group have the opportunity to explain, to argue, and to debate their ideas, which allows them to accommodate the concept. In the elaboration phase, students gain familiarity with the introduced concept and either assimilate or accommodate the new concept in their schemata. The persistence of inadequate cognitive structures is attacked by applying new concepts to a broad range of new examples.

The study presented here revealed that teacher-centered and textbook-oriented science instruction less to improve students' conceptual understanding and leave many errors found practicing unchanged.

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5.3 Limitations of the first study

Although most of the information system students in this study were satisfied in the 3E learning cycle model-based learning unit. However, some students had less participated in class. This may be partly due to the lack of attitude in academic discussion in class. Normally Thai students may be used to passive instruction and thus less favour participated discussion. Another limitation is that this learning unit has been tried only on one group of 21 students.

5.4 Limitations of the second study

Although most of the information system students in this study favored the idea of integration the 5E learning cycle model with multimedia. However, some students had less participated in class by explaining for discussing and/or expressing ideas. This may be partly due to the lack of ideas sharing as well as attitude in academic discussion in the class. Normally Thai information system students may be familiar with traditional lecture and may be have less opportunity to sharing their ideas in class. The high score of the experimental groups may not be attributed to only the exposure to our learning unit. Students' own pursuit knowledge in the textbooks and other web-based sources might also contribute to better achievements. Another limitation is that this 5E learning cycle model-based learning unit supplemented with multimedia has been tried only on 32 students. Additionally, the interview results came from only 6 volunteer students relevant to 5E learning cycle model-based learning unit supplemented with multimedia. The students in these groups may prefer 5E learning cycle model instruction that contribute the positive results of the interview.

5.5 Recommendations of the first study

The recommendations for the first study are divided into two parts: recommendations for further study, and for further development.

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5.5.1 Recommendations for further study

The 3E learning cycle model-based learning unit should be tried out with other groups of students from other university in the faculty of business administration with similar problems as ours. Higher numbers of students should give rise to a more conclusive result. It should as well be tried out on a large number of students with different backgrounds before being adopted for wider use. Additionally, the interview results came from only 5 volunteer students. The students in this group may prefer this learning style that contributes the positive results of the interview. Moreover, some students suggested that the learning unit should be developed based on a computer-based environment.

5.5.2 Recommendations for further development

The results from students with no significant difference in achievement on SQL basic knowledge suggested for further improvement of the learning unit. From some students suggested that the learning unit should be developed based on a computer-based environment. Additionally, some students commented that the periods of learning activities are too short to some students performing the proposed of learning objects in class. From the students' suggestion, the learning unit should be redesign to be suitable for the periods of learning. Thus a developing computer-based environment should be supported to be suitable for the periods of learning and appropriate to the learning activities. This innovative SQL learning unit had been shown to improve students' achievement and computer-science process skills. It can be used as a guide to further the development of the learning cycle unit.

5.6 Recommendations of the second study

The recommendations for this study are divided into two parts: recommendations for further study, and for further development.

5.6.1 Recommendations for further study

For generalizability, the researcher needed to analyze the context of the learning process and students' background in more details. The 5E learning cycle

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model-based learning unit should be performed on students from other information system students. Additionally, the interview results should come from more volunteer students. Higher numbers of students should give rise to a more results of the conclusive result.

5.6.2 Recommendations for further development

To promote meaningful learning, it is necessary to overcome error found practicing with the help of different instructional methods rather than the traditional one. The results of this study suggested that the use of the 5E learning cycle model supplemented with multimedia as and alternative method to traditional instruction. However, successful implementation of such strategies requires that teachers are aware of students' prior knowledge and direct the classroom activities accordingly.

From the lesson learned, the learning unit should be redesign to be suitable for the periods of learning activities. The next developing SQL learning unit based on the 5E learning cycle model-based supplemented with multimedia should be focus on in-dept concept according to learning periods.

Based on the research findings, it could be suggested that the Thai information system curriculum for undergraduate students should be revised by placing move multimedia computer-based environment in the subject with abstract topic. Concerning the students' learning achievement, teachers should provide the various assessment tools to assess them because information system curriculum aims to improve applying abilities for students.

Moreover, the strategy of the learning process in this study enables students to learn based on their own exploration and explanation. Teachers should design the assessments that corroborate the learning activity. Formative assessment to follow students' progress during the learning process should be considered as important as the final examination.

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APPENDICES

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APPENDIX A

Pre-test on topic “SQL”

Defining the structure of 6 tables in DentalTreatmentDB as following:

1. Dentist

Field	DataType	Additional
DentistID	text(5)	Primary Key
DentistTitle	text(10)	
DentistName	text(30)	
DentistTelephone	text(15)	
DentalSpecialist	text(35)	

2. Customer

Field	DataType	Additional
CustomerID	text(5)	Primary Key
CustomerTitle	text(5)	
CustomerName	text(30)	
CustomerProvince	text(15)	
CustomerTelephone	text(15)	

3. Treatment

Field	DataType	Additional
TreatmentID	text(3)	Primary Key
TreatmentDate	date	

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DentistID	text(3)
CustomerID	text(5)

4. TreatmentDetail

Field	DataType	Additional
TreatmentID	text(3)	Primary Key
TreatmentType	text(2)	Primary Key
Quantity	single	

5. TreatmentType

Field	DataType	Additional
TreatmentType	text(2)	Primary Key
Treatment	text(60)	
Unit	text(10)	
Price	integer	

6. DivisionTreatment

Field	DataType	Additional
Division	text(2)	Primary Key
DivisionTreatment	text(30)	

Relationship between table as follow:

Customer to Treatment	CustomerID to CustomerID (1-M)
Dentist to Treatment	DentistID to DentistID (1-M)
Treatment to TreatmentDetail	TreatmentID to TreatmentID (1-M)
TreatmentType to TreatmentDetail	TreatmentType to TreatmentType (1-M)

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Dentist

DentistID	DentistTitle	DentistName	DentistTelephone	DentalSpecialist
101	Dr.	Surin Kuanxxxx	08-6334-xxxx	General
102	Dr.	Chaisurate Taxxxx	08-1813-xxxx	General
103	Dr.	Chutima Kositxxxx	08-9206-xxxx	General
104	Dr.	Jinda Namkaxxxx	08-9229-xxxx	General
201	Dr.	Nida Wiwatxxxx	08-9987-xxxx	Orthodontics
202	Dr.	Pornsak Tuntaxxxx	08-1899-xxxx	Orthodontics
301	Dr.	Chatchai Kunaxxxx	08-9202-xxxx	Implant dentistry
401	Assoc.Prof.Dr.	Supojn Thanaxxxx	08-9433-xxxx	Prosthodontics
501	Dr.	Wachira Chertxxxx	08-1913-xxxx	Periodontics
601	Dr.	Poomesak Laoxxxx	08-1781-xxxx	Endodontics
701	Dr.	Amornpong Waxxxx	08-9938-xxxx	Oral surgery
702	Dr.	Narisorn Suwatxxxx	08-9832- xxxx	Oral surgery

Customer

CustomerID	Customer Title	CustomerName	CustomerProvince	CustomerTelephone
48011	Mr.	Apicharte Poolxxxx	Nonthaburi	0-2984-xxxx
48064	Mr.	Surachai Jamxxxx	Bangkok	08-1566-xxxx
48078	Mr.	Utai Phuxxxx	Bangkok	08-1776-xxxx
49005	Mr.	Aekapongs Singxxxx	Bangkok	08-1827-xxxx
49077	Miss	Sompan Sujeexxxx	Pathumthani	0-2524-xxxx
49088	Miss	Punnapa Tubxxxx	Samutsakhon	0-3441-xxxx
50024	Mr.	Wittaya Saixxxx	Bangkok	0-2251-xxxx
50055	Mr.	Somporn Panxxxx	Bangkok	0-2461-xxxx
50144	Mr.	Somsak Lersxxxx	Bangkok	08-4621-xxxx
51007	Mr.	Somchai Khaxxxx	Bangkok	0-2714-xxxx
51098	Mrs.	Radawan Singxxxx	Nonthaburi	08-1939-xxxx
51105	Mrs.	Sasiprapa Phuxxxx	Bangkok	0-2931-xxxx
51135	Mr.	Jampa Rongxxxx	Bangkok	08-1830-xxxx

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CustomerID	Customer Title	CustomerName	CustomerProvince	CustomerTelephone
52024	Mr.	Suchart Suphaxxxx	Samutsongkhram	0-3471-xxxx
52044	Mrs.	Nittaya Taexxxx	Samutprakan	0-2312-xxxx
52052	Miss	Chitchanok Chaxxxx	Bangkok	08-6541-xxxx

Treatment

TreatmentID	TreatmentDate	DentistID	CustomerID
602	1/6/2009	101	48011
603	1/6/2009	102	49005
604	1/6/2009	301	52024
605	1/6/2009	401	52052
606	1/6/2009	501	50024
607	1/6/2009	601	51135
608	2/6/2009	102	48078
609	2/6/2009	102	49077
610	2/6/2009	201	49088
611	2/6/2009	102	48064
612	3/6/2009	103	51098
613	3/6/2009	103	52044
614	3/6/2009	202	50144
615	3/6/2009	401	51105

TreatmentDetail

TreatmentID	TreatmentType	Quantity
602	11	1
603	62	2
604	31	1
605	41	1
606	11	1

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TreatmentID	TreatmentType	Quantity
607	62	1
608	11	1
609	11	1
610	21	1
610	23	2
611	13	2
612	11	1
613	11	1
614	21	1
614	24	1
615	62	1

TreatmentType

TreatmentType	Treatment	Unit	Price
11	Scaling and polishing	person	800
12	Root planing	tooth	300
13	Composite resin filling	surface	800
21	Metal braces	person	55000
22	Ceramic braces	person	65000
23	Retainer	each	2500
24	Active plate	each	4500
31	Titanium framework	tooth	55000
41	Diastema/space closing	tooth	2500
61	Anterior teeth	tooth	5000
62	Premolar teeth	tooth	7500
71	Extraction	tooth	1000

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Name-Surname …… Class …… No. ……

Using SQL statement to perform the following:

1. To build table “TreatmentDetail” with the following format:

TreatmentDetail

Field	DataType	Additional
TreatmentID	text(3)	Primary Key
TreatmentType	text(2)	Primary Key
Quantity	single	

By setting Primary Key (PK), Foreign Key (FK) according to the relationship between tables provided before (4 points)

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……...

2.1 If you want to update data “TreatmentID” in a table “Treatment” from 615 to 555, Can you update it of not, and why? (1 point)

……...
……...

2.2 For updating data “TreatmentID” from 615 to 555 in a table “Treatment”, How do you perform? (1 point)

……...
……...
……...

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2.3 Use SQL to update TreatmentID of the TreatmentID “615” from “615” to “555” (1.5 points)

……...

……...

……...

3.1 If you want to add a new record following below table into a table “TreatmentDetail”, Can you perform it or not, why? (1 point)

TreatmentID	**TreatmentType**	**Quantity**
699	12	1

……...

……...

3.2 For adding 1 record following the detail in item 3.1, How do you perform? (1 point)

……...

……...

……...

3.3 Use SQL to add 1 record in the table “TreatmentDetail” according to the details: TreatmentID to “699” TreatmentType to “12” Quantity to “1” (2 points)

……...

……...

……...

4. List only DentalSpecialist of all Dentists with no duplicated (1.5 points)

……...

……...

……...

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5. List all the information on the Dentist having name-surname beginning with character “C” (2 points)

……...
……...
……...
……...

6. List “TreatmentID”, “CustomerID”, “Treatment”, “Price” where Price is less than 10000 baht. Order the results by decreasing Price. (4 points)

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……...

7. List the Max_Pr for highest Price and NumRecs for the number of Treatment (3 points)

……...
……...
……...

8. List DentalSpecialist and Special_Num for the number of Dentists who are belong to that DentalSpecialist (2.5 points)

……...
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9. List “name-surname” “DentalSpecialist” of Dentists who are not been in treatment any customer (5 points) (Using Sub-Query)

……...
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10. List “TreatmentType” “Treatment” Payment which belong to the 603 TreatmentID (Payment of each item is Price x Quantity) (4 points)

……...
……...
……...
……...
……...
……...

****

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APPENDIX B

Post-test on topic “SQL”

Defining the structure of 6 tables in DentalTreatmentDB as following:

1. Dentist

Field	DataType	Additional
DentistID	text(5)	Primary Key
DentistTitle	text(10)	
DentistName	text(30)	
DentistTelephone	text(15)	
DentalSpecialist	text(35)	

2. Customer

Field	DataType	Additional
CustomerID	text(5)	Primary Key
CustomerTitle	text(5)	
CustomerName	text(30)	
CustomerProvince	text(15)	
CustomerTelephone	text(15)	

3. Treatment

Field	DataType	Additional
TreatmentID	text(3)	Primary Key

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TreatmentDate	date
DentistID	text(3)
CustomerID	text(5)

4. TreatmentDetail

Field	DataType	Additional
TreatmentID	text(3)	Primary Key
TreatmentType	text(2)	Primary Key
Quantity	single	

5. TreatmentType

Field	DataType	Additional
TreatmentType	text(2)	Primary Key
Treatment	text(60)	
Unit	text(10)	
Price	integer	

6. DivisionTreatment

Field	DataType	Additional
Division	text(2)	Primary Key
DivisionTreatment	text(30)	

Relationship between table as follow:

Customer to Treatment	CustomerID to CustomerID (1-M)
Dentist to Treatment	DentistID to DentistID (1-M)
Treatment to TreatmentDetail	TreatmentID to TreatmentID (1-M)
TreatmentType to TreatmentDetail	TreatmentType to TreatmentType (1-M)

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Dentist

DentistID	DentistTitle	DentistName	DentistTelephone	DentalSpecialist
101	Dr.	Surin Kuanxxxx	08-6334-xxxx	General
102	Dr.	Chaisurate Taxxxx	08-1813-xxxx	General
103	Dr.	Chutima Kositxxxx	08-9206-xxxx	General
104	Dr.	Jinda Namkaxxxx	08-9229-xxxx	General
201	Dr.	Nida Wiwatxxxx	08-9987-xxxx	Orthodontics
202	Dr.	Pornsak Tuntaxxxx	08-1899-xxxx	Orthodontics
301	Dr.	Chatchai Kunaxxxx	08-9202-xxxx	Implant dentistry
401	Assoc.Prof.Dr.	Supojn Thanaxxxx	08-9433-xxxx	Prosthodontics
501	Dr.	Wachira Chertxxxx	08-1913-xxxx	Periodontics
601	Dr.	Poomesak Laoxxxx	08-1781-xxxx	Endodontics
701	Dr.	Amornpong Waxxxx	08-9938-xxxx	Oral surgery
702	Dr.	Narisorn Suwatxxxx	08-9832- xxxx	Oral surgery

Customer

CustomerID	CustomerTitle	CustomerName	CustomerProvince	CustomerTelephone
48011	Mr.	Apicharte Poolxxxx	Nonthaburi	0-2984-xxxx
48064	Mr.	Surachai Jamxxxx	Bangkok	08-1566-xxxx
48078	Mr.	Utai Phuxxxx	Bangkok	08-1776-xxxx
49005	Mr.	Aekapongs Singxxxx	Bangkok	08-1827-xxxx
49077	Miss	Sompan Sujeexxxx	Pathumthani	0-2524-xxxx
49088	Miss	Punnapa Tubxxxx	Samutsakhon	0-3441-xxxx
50024	Mr.	Wittaya Saixxxx	Bangkok	0-2251-xxxx
50055	Mr.	Somporn Panxxxx	Bangkok	0-2461-xxxx
50144	Mr.	Somsak Lersxxxx	Bangkok	08-4621-xxxx
51007	Mr.	Somchai Khaxxxx	Bangkok	0-2714-xxxx
51098	Mrs.	Radawan Singxxxx	Nonthaburi	08-1939-xxxx
51105	Mrs.	Sasiprapa Phuxxxx	Bangkok	0-2931-xxxx

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CustomerID	CustomerTitle	CustomerName	CustomerProvince	CustomerTelephone
51135	Mr.	Jampa Rongxxxx	Bangkok	08-1830-xxxx
52024	Mr.	Suchart Suphaxxxx	Samutsongkhram	0-3471-xxxx
52044	Mrs.	Nittaya Taexxxx	Samutprakan	0-2312-xxxx
52052	Miss	Chitchanok Chaxxxx	Bangkok	08-6541-xxxx

Treatment

TreatmentID	TreatmentDate	DentistID	CustomerID
602	1/6/2009	101	48011
603	1/6/2009	102	49005
604	1/6/2009	301	52024
605	1/6/2009	401	52052
606	1/6/2009	501	50024
607	1/6/2009	601	51135
608	2/6/2009	102	48078
609	2/6/2009	102	49077
610	2/6/2009	201	49088
611	2/6/2009	102	48064
612	3/6/2009	103	51098
613	3/6/2009	103	52044
614	3/6/2009	202	50144
615	3/6/2009	401	51105

TreatmentDetail

TreatmentID	TreatmentType	Quantity
602	11	1
603	62	2
604	31	1
605	41	1

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TreatmentID	TreatmentType	Quantity
606	11	1
607	62	1
608	11	1
609	11	1
610	21	1
610	23	2
611	13	2
612	11	1
613	11	1
614	21	1
614	24	1
615	62	1

TreatmentType

TreatmentType	Treatment	Unit	Price
11	Scaling and polishing	person	800
12	Root planing	tooth	300
13	Composite resin filling	surface	800
21	Metal braces	person	55000
22	Ceramic braces	person	65000
23	Retainer	each	2500
24	Active plate	each	4500
31	Titanium framework	tooth	55000
41	Diastema/space closing	tooth	2500
61	Anterior teeth	tooth	5000
62	Premolar teeth	tooth	7500
71	Extraction	tooth	1000

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Name-Surname …… Class …… No. ……

Using SQL statement to perform the following:

1. To build table “TreatmentDetail” with the following format:

TreatmentDetail

Field	DataType	Additional
TreatmentID	text(3)	Primary Key
TreatmentType	text(2)	Primary Key
Quantity	single	

By setting Primary Key (PK), Foreign Key (FK) according to the relationship between tables provided before (4 points)

……...
……...
……...
……...
……...
……...
……...
……...

2.1 If you want to update data “TreatmentID” in a table “Treatment” from 614 to 444, Can you update it of not, and why? (1 point)

……...
……...

2.2 For updating data “TreatmentID” from 614 to 444 in a table “Treatment”, How do you perform? (1 point)

……...
……...
……...

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2.3 Use SQL to update province of the CustomerID “52052” from “Bangkok” to “Nakhonpathom” (1.5 points)

……...
……...
……...

3.1 If you want to add a new record following below table into a table “TreatmentDetail”, Can you perform it or not, why? (1 point)

TreatmentID	**TreatmentType**	**Quantity**
699	11	1

……...
……...

3.2 For adding 1 record following the detail in item 3.1, How do you perform? (1 point)

……...
……...
……...

3.3 Use SQL to add 1 record in the table “TreatmentDetail” according to the details: TreatmentID to “615” TreatmentType to “71” Quantity to “1” (2 points)

……...
……...
……...

4. List only province of all customers with no duplicated (1.5 points)

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5. List all the information on the customer having name-surname beginning with “Som” (2 points)

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6. List “TreatmentID”, “CustomerID”, “Treatment”, “Price” where Price is less than 3000 baht. Order the results by decreasing Price. (4 points)

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7. List the Min-Pr for lowest Price and NumRows for the number of Treatment (3 points)

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8. List DentalSpecialist and Special_Count for the number of Dentists who are belong to that DentalSpecialist (2.5 points)

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9. List “name-surname” “DentalSpecialist” of Dentists who are not been in treatment any customer (5 points) (Using Sub-Query)

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10. List “TreatmentType” “Treatment” Payment which belong to the 610 TreatmentID (Payment of each item is Price x Quantity) (4 points)

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APPENDIX C

Questionnaire for Students' Satisfaction about SQL Learning Unit (The first study)

Instruction: The objective of this questionnaire was employed to investigate students' satisfaction in the SQL learning unit. Your opinion will be used to developing learning method for undergraduate level. Please consider each statement.

Please use ✓ in the space of the table which the best describes your feelings. (strongly agree-5, agree-4, uncertain-3, disagree-2, strongly disagree-1)

Statements	Level of your opinion				
	5	4	3	2	1
1. I was satisfied with the proposed learning unit					
2. I participated in class					
3. This learning unit could enhance my understanding of SQL					
4. I learned better in SQL syntax					
5. I realized the importance of SQL					
6. Learning activities could encourage me in learning					

Suggestion or Comment

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APPENDIX D

Questionnaire for Students' Satisfaction about SQL Learning Unit (The second study)

This questionnaire composes of 3 parts:

1. Personal data
2. Evaluation details
3. Suggestions

Part 1 : Personal data

: Questions about personal data from students.

Please use ✓ in the or input texts relevant to your information.

1. Gender Male Female
2. Age …… year ……. month
3. Educational level 1st year 2nd year 3rd year 4th year
4. Accumulative Grade < 1.00 1.00-1.99 2.00-2.99 3.00-4.00

Part 2 : The questions for students' satisfaction about the learning-teaching activities in SQL topic

Instruction: Please answer the questions relevant to your personal view by using ✓ following the 5 criterion level:

Level 1 means strongly disagree

Level 2 means disagree

Level 3 means uncertain

Level 4 means agree

Level 5 means strongly agree

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There is no right or no wrong answers in these questions. They are about the opinion in the SQL topic learning-teaching activities. Thus, please consider to answer each question.

Statements	**Level of learner's opinion**				
	5	**4**	**3**	**2**	**1**
1. These learning-teaching activities can increase encouraging in learning					
2. These learning-teaching activities can help learners to relate prior knowledge to the current topics					
3. These learning-teaching activities can engage learners to the content					
4. I learn by manipulating via these learning-teaching activities					
5. There are many encouraging questions along the hands-on activities via these learning-teaching activities					
6. These learning-teaching activities help learners self performing					
7. These learning-teaching activities concern the learners' explanation and share learning concepts by self practicing					
8. There are many encouraging questions for evaluating the individual understanding via these learning-teaching activities					
9. I understand the additional concept from teacher explanation					
10. There are many exercises for learners practicing and learning via these learning-teaching activities					
11. I can learn from sharing, observing, and problem solving with my classmates					
12. I can learn from asking and suggesting from teacher					
13. I can link the learning concepts with real situation					
14. I have assessed my knowledge and understanding after learning this topic					
15. The learning evaluations are relevant to learning objectives					
16. The evaluations are clear, suitable and able to measure					

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Part 3: Other suggestions

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APPENDIX E

Semi-Structured Interview Questions
(The first study)

Interview questions

1. How did you feel when at first you saw SQL syntax and forecasted the results? How did you feel after own practicing and sharing discussion from the results?
2. How did you get more understanding after forecasting the results and then self practicing?
3. How did you get more understanding after self practicing with discussion from the error found?

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APPENDIX F

Semi-Structured Interview Questions
(The second study)

Objective: To obtain information regarding the student's preference and perception of the learning-teaching activities.

Your answers will be kept in secret. It does not have any effects on an individual. It will be used to interpret in table form and analyze in summary.

Interview questions

1. How did the activities help you to engage in learning topic?
2. How did the activities help you to self learning concepts by manipulating?
3. How did the activities give you a chance to explain or share knowledge and understanding?
4. How did the activities help you to apply new situation and share your thinking with friends or teacher?
5. To what extent do the activities assist you to assess your knowledge and understanding?
6. How did you feel about all activities after learning?

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APPENDIX G

Examples of Snap Shot of the Second Study

A view of learning menu in DDL and DML

A SQL game that the students drag and drop the answers into the appropriate box

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A SQL game that the students click on each parts of the SQL statement for answering

A view of learning by writing the SQL command section

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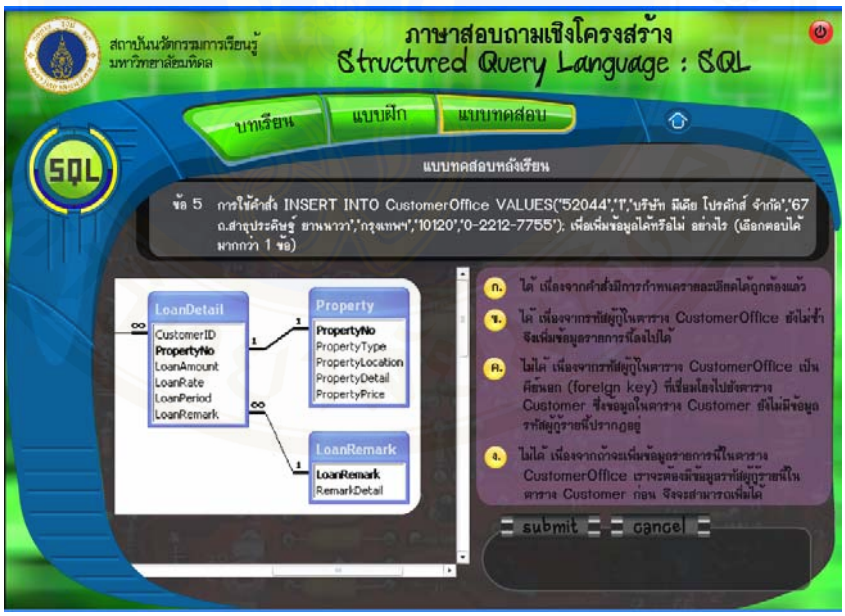
Screen shot of SQL syntax section



Snap shot of post-test section

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BIOGRAPHY

NAME	Miss Hongsiri Piyayodilokchai
DATE OF BIRTH	11 November 1971
PLACE OF BIRTH	Bangkok, Thailand
INSTITUTIONS ATTENDED	Mahidol University, 1994: Bachelor of Science (Public Health) Mahidol University, 1999: Master of Science (Technology of Information System Management) Mahidol University, 2011: Doctor of Philosophy (Science and Technology Education)
HOME ADDRESS	341/18 Soi Charoenkrung 107, Bangkorlaem, Bangkok, 10120 E-mail: h_pinyo@hotmail.com
EMPLOYMENT ADDRESS	Department of Business Information Technology, Faculty of Business Administration, Rajamangala University of Technology Rattanakosin, Borpitpimuk Chakrawad Campus 264 Chakrawad Road, Chakrawad, Sampantawong, Bangkok 10100 Tel. 66-2222-2814
PUBLICATION / PRESENTATION	1. **Piyayodilokchai, H.**, Panijpan, B., & Dahsah, C. (2008). Enhancing students' learning in the base number system by using hands-on activity on abacus and marked & unmarked techniques.

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