Teaching Database Management Systems in Higher Education: An Efficient Approach for Introductory Courses

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1. Abstract

The software tool used for teaching database courses plays an essential role in the learning process and its outcome. It enables students to implement the concepts of database and transfer it into real word applications. This paper examine two of the most famous Database Management Systems: Oracle Database, and Microsoft Access. The examination will aim to identify the most suitable software that should be used to introduce the students into the database concepts. Both Database Management Systems are explored and compared based on analysis of a survey results.

Keywords: Database, SQL, Access, Oracle, Education.

2. Introduction

One of the main purposes of computers since they were invented is to organize and host large amounts of data, and to provide efficient ways for retrieving and updating them. This process plays a critical role in almost all places where the computers are used [1] and it is known as Database (DB) management. Ever since, many software companies, (such as Microsoft, IBM, and Oracle) have been working to provide their own technical solutions (Database Management Systems DBMS) in order to serve a various levels of business, ranging from personal use to large institutes such as banks, airports and ministries … etc. [2]

Database has a major impact on the growing use of computers, [1] consequently, It became an essential part of the educational sector, especially the computer related degrees. The common teaching approach of Database subjects is usually a series of courses that qualify the students to deal with DB as a major employment sector for computer related degree holders. Database curriculum usually starts with an introductory course, which introduces the students to the basics of the database and familiarize them with the terminology used as well as the pre-implementation stages (design types). The introductory course is also given accompanied with software that gives students the ability to implement the physical database, as well as embody their design and acquired knowledge into an actual database.

For teaching database, appropriate software should be used in order to overcome any difficulties that might obstruct the learning process. There are different difficulties in teaching the database for the students for the first time. For example, typing errors, visualization of tables and their relationships, and many other computer-user interacting issues that will definitely result in a negative influence on the students' performance as well as the learning outcome. Therefore, many educators are trying to find solutions to simplify the learning process for the students. One

of the solutions is to use Microsoft (MS) Access as an introduction tool to the database management.

In this paper we will answer our main question of whether MS-Access can introduce fundamentals of database course in a better way than Oracle or not. First, we go through each program (Oracle DBMS, MS-Access) from education point of view. Then we tried to inspect the software used in the introductory courses at some universities. After that an analysis based on a survey is conducted at Qatar University. The survey questions is in the appendix.

3. Oracle Database Management System (DBMS):

Oracle DBMS is one of the most popular relational database systems that was introduced in 1979 and in less than 20 years oracle system was able to become the market leader in Database management systems. [3] Oracle was able to dominate 50% of DBMS markets in 2011and it made the market of RDMS more popular. [4]

Although ORACLE DBMS is an enterprise level database that was mainly designed to work through networks of devices connected through a server but it can also be used for a single user applications. It can be integrated with more than 100 difference integrated development environments (IDE's) which facilitate finding the right tools for everyone. We can use it to manipulate databases in many different ways from creating to managing, backup and recover the databases. All of that can be through the application command-line. [5]

Oracle DBMS provides SQL functionality used from command-line "SQL*Plus", it comes with an interface that is able to give wide variety of options to programmers such as manipulating the database, Managing its security and backup operations, and configuring any part of the application. [6]
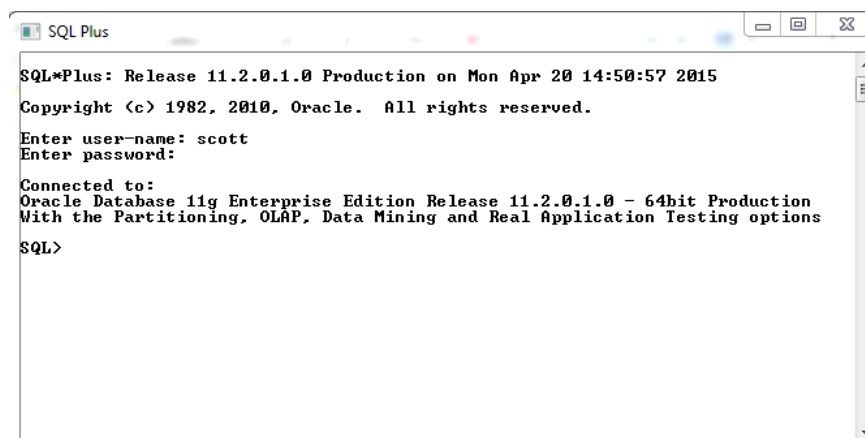

Figure 1 SQL Plus interface (Oracle 12).

Oracle also has an application called "Oracle JDeveloper" which is a free integrated development environment that simplifies the development of Java-based Service-Oriented Architecture (SOA) and Java Enterprise Edition (EE) applications. JDeveloper offers complete end-to-end

development to Oracle Fusion Middleware and Oracle Fusion Applications with support for the full development life cycle.

Although Oracle offers an advanced developer interface (JDeveloper IDE), this software is not specialized only in databases and SQL commands, it is rather used to build full enterprise applications. This IDE utilizes database functionalities in order to build a full software developed through other programming languages like Java and JavaScript, which is a great feature indeed, but not at the stage where students are just trying to catch the structure and working nature of the databases. At these beginner stages, a simpler approach is required. [7]

MS-Access is a Relational Database Management System (RDBMS) tool that was released by Microsoft starting from 1992. For more than two decades, Microsoft worked to provide a simple, powerful, easy to learn, and integratable tool to manage database. Furthermore, MS-Access is part of Microsoft Office package which also consists of other tools such as the text editor, Microsoft Word, and the spreadsheet Microsoft Excel. These tools shared the same techniques, commands, and shortcuts to open and edit the data. [**8**]

MS-Access is specialized in creating and manipulating databases only, and it provides the required interface for the main functionalities that can be performed by a database, so it represents a simple approach to go through the phases of building a database, starting from designing and creating tables, to the end-user interface, all in one program and one window.

The main interface of MS-Access 2013 consists of the ribbon section, navigation pane, and backstage view.
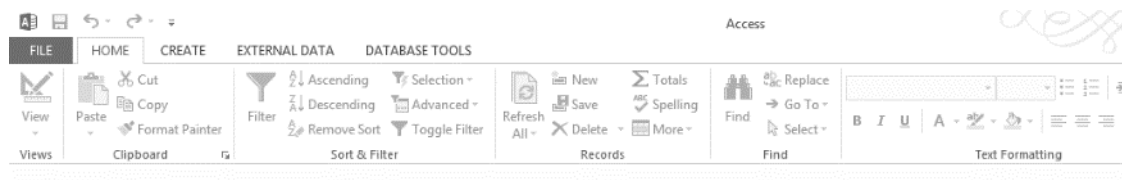

Figure2 the ribbon of the main interface in MS-Access 2013

4. Microsoft Access Adoption in Different Colleges.

We observed how other universities teach the fundamentals of database to its students and whether they use MS-Access in their learning methodology or not. That will help to get some ideas to enhance the teaching methodology and to find out if MS-Access is useful tool in education. Unsurprisingly, we found that most of the universities use the same approach as Qatar University. Although, Oracle DBMS is commonly used as an education tool for intermediate to advanced database course, MS-Access has been widely used for the introductory courses. Furthermore, there are some universities which use it to introduce student to databases design for example, Nova Southern Universities uses MS-Access as the main application for the course. They first start by teaching students the concepts of design using MS Access modeling then they start to teach them SQL commands using the same program. [**9**]

In addition to Nova University, The university of Toronto has a course called "An Overview of Database Technologies" this course actually teaches the basics of databases, the course mainly use MS-Access to help students to understand the basics of database structure and design then it moves to Microsoft Server for more complicated designs and modeling. But most of their code are compatible with Oracle DB and other DBMS Applications. [10]

Furthermore, there are other universities teach specific database topics using MS-Access. For example, the University of Oxford has a course that teach students how to create a user interface using MS Access, which consist of a groups of forms, that is clearly laid out and formatted. They also have a course that teaches querying and analyzing data using MS-Access. This course facilitates the process of managing the data and building complex queries using this program. [11] [12]

The rest of universities we found just teach MS-Access as an independent course from databases, it is mainly intended for people who don't want to program or just want to run their business using MS Access. Some universities teach MS-Access through different levels and courses. For example, The University of Sydney has three MS Access courses in term of level. They start teaching the fundamental until they reach advanced database topics and techniques in the third level. [13]

The significant thing is that we were not able to find a university who teaches both applications (Oracle and MS-Access) together or as introduction which actually makes it very interesting to study the impact of using Microsoft Access as an introductory course for students who are studying databases at Qatar University.

5. **Case Study At Qatar University:**
   a. **Fundamental of Databases as a Course in Qatar University:**

The introductory course of database systems at Qatar University (CMPS 351 Fundamentals of database) is a three credit hours course which covers mainly the theoretical aspect of DB that is modeling, designing, and Mathematical concepts. However, this course must be taken along with one credit DB lab course in which the students practice and implement the DB using software such as oracle database and JDeveloper. These two concurrent courses are expected to provide students with a certain level in database. Students are expected to design and Transform an ER/EER-diagram into a relational database schema and formulate queries in relational database languages (e.g., relational algebra, relational calculus, SQL). [14]

The content of the course is distributed over 11 subjects to be delivered during sixteen weeks. In the first phase of the course the focus is usually on DB modeling (Entity Relationship, Enhanced Entity relationships) which is supposed to reinforce the conceptual understanding of basic structure of a DB. With such basement, the course then concentrates on more in depth subjects such as the mapping and actual queries command constructions and data base security. These theoretical backgrounds in designing and modeling are reflected as an actual implementation during the lab sessions, the sessions will deal mostly with the practical aspect of

DB, that is, the code of the SQL queries and its construction, writing techniques, and optimization.

b. Methodology:

This will be done through an analysis of students' answers to a questionnaire of 20 multiple choice questions and some optional comment question that was distributed to the students of Fundamental of DB course at Qatar University. The survey asks the students about their previous knowledge in MS-Access and Oracle and also about their evaluation of the course difficulties. We try to analyze and link the answers so that we can have a conclusion about the efficiency of using MS Access as introductory software to the database. A group of 10 male students and 29 female, in total 39 students participated in this survey and their answers are available with the authors.

c. Analysis and Results:
i. Lab Sessions Importance

The importance of the lab session is actually an embodiment of a known fact in the world of engineering which states that the practical part of any field of study is essential. Indeed, this is the definition of engineering itself: the use of the knowledge of different fields to solve practical problems that confront society. [**15**] This fact becomes even more important and effective in education; to learn and master something, one needs to have good experience and practice.

Because of the importance of the lab sessions, the software used to build the database is chosen very carefully. There are many famous software packages that are used world-wide to build and manipulate databases, e.g. Microsoft SQL Server, IBM DB2, MS Access, and Oracle. Each software uses different approaches and tools to build databases. This is normal since each of them is directed to a specific market and serve specific customers. Thus, choosing a software for database learning or development will depend on the needs and expectations, which is the actual use of it. Following such choosing criteria will make us avoid any unneeded complexities that might waste efforts especially in educational sector. Likewise selecting a less capable software tool might lead to disappointment and unsatisfaction, in educational context, that means the learning outcomes will not be met. In Qatar University, CMPS351 course, Oracle Database software package was selected to be used in illustrations, exams, assignments, projects and lab sessions' exercises in order to deliver the course contents. We tried to inspect the efficiency of this choice (Oracle) over other well-known software package, MS Access, by analyzing facts obtained from students' experiences.

ii. Students Difficulties with installing and using oracle.

Oracle DBMS is multi-edition software aimed primarily to be used in enterprise applications [16]. Due to this factor, it contains a lot of features that are not useful at the introductory phase of

the database course such as Oracle Real Application Cluster (RAC), Oracle Advance Security (ASO) and Oracle Data Mining, these features make the software relatively complex for students, especially that the introductory course is supposed to simplify the concepts and introduce the fundamentals of the DB like the structure of database, modeling and its mapping...etc.

These complexities actually starts from the installation phase, for example, after four weeks of the beginning of the spring 2015 semester, about 72 % of the students did not succeed in running the software on their machines due to various installation and configuration problems. Moreover, the labs computers also have problems related to configuring the software and connection errors (e.g. the TNS protocol error).
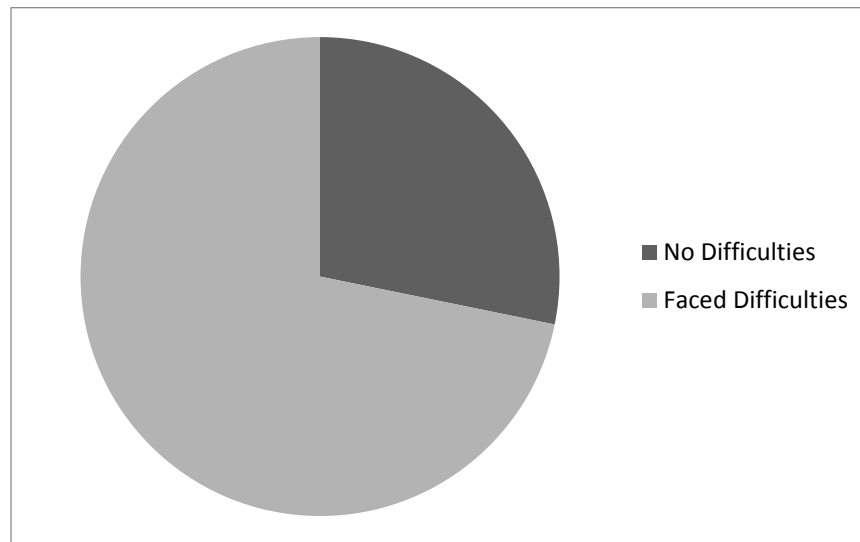
Figure 3 Student's ability to install and Configure Oracle DB in the first 4 weeks at Qatar University Spring 2015

In terms of the actual use, the interface of the SQL Plus (Oracle edition of SQL) is very plain. Students faced many difficulties in typing the queries in the command window (syntax and typing errors). Such inconveniences made them look for other text editors with features like auto completion and corrections in order to enhance the programming experience (like Notepad++, Sublim Text…etc). This procedure makes typing mistakes more likely to occur. Other clear example of the lack of the interface appears In case of table join and grouping data. It is very hard to visualize the effect of an SQL command (e.g. tables join, data grouping...etc.) because the system does not respond with illustrative interface, but rather the response of the system is the actual result if the command is right, and an error otherwise. This actually lengthens the time of understanding and analyzing the commands and their results.

In general, the main difficulties as reported by the students mainly understand the structure of a database, that is, table creation, tables relationships, in addition to the formation of long queries. These essentials factors are not presented in an introductory course level in oracle software, and by introductory level we mean a comprehensive and intuitive interface that helps

student to interact more efficiently with the software and helps reinforce the ease of use, such factors will enable students to grasp and understand the main concepts in DB.

iii. MS Access case study.

At CMPS351 spring 2015 course, we asked the students about their prior knowledge of MS-Access in order to identify its effects on students' performance throughout the course if any. About 56.4 % of them had prior knowledge and experience with using Access and the rest of students, 43.6 %, did not have enough experience so that we can analyze MS Access effects on them (students). Based on these numbers, we divided the students into two groups, Group A with prior knowledge, and Group B that includes students who did not have prior knowledge in MS-Access.
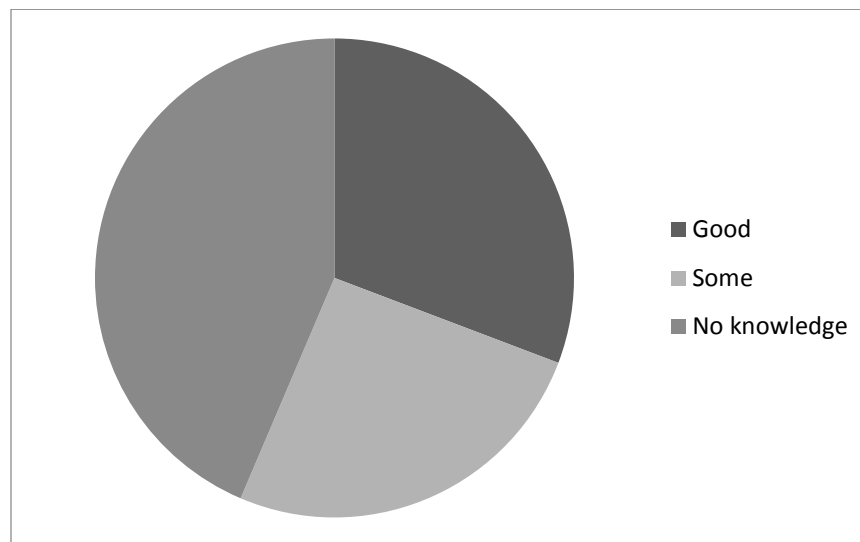

Figure 4 Students answers about their previous knowledge in MS-Access

Figure 5 shows the two groups of students, (students with previous knowledge in MS Access and students without previous knowledge) and the course difficulty as rated from each group. The figure shows that both groups have some difficulties in mastering the contents of the course. However, 64.0 % of the students who have no previous knowledge in MS Access found that the course content is difficult, whereas 69.2 % of students who have previous knowledge in Access rated the course difficulty as easy or moderate. The following bullets explain figure 5 classification.

- Student with previous knowledge: students who answered the question six of the survey with three or more.
- Student without previous knowledge: students who answered the question six of the survey with less than three.
- Course content is easy or moderate: the answer of question seventeen three or less.
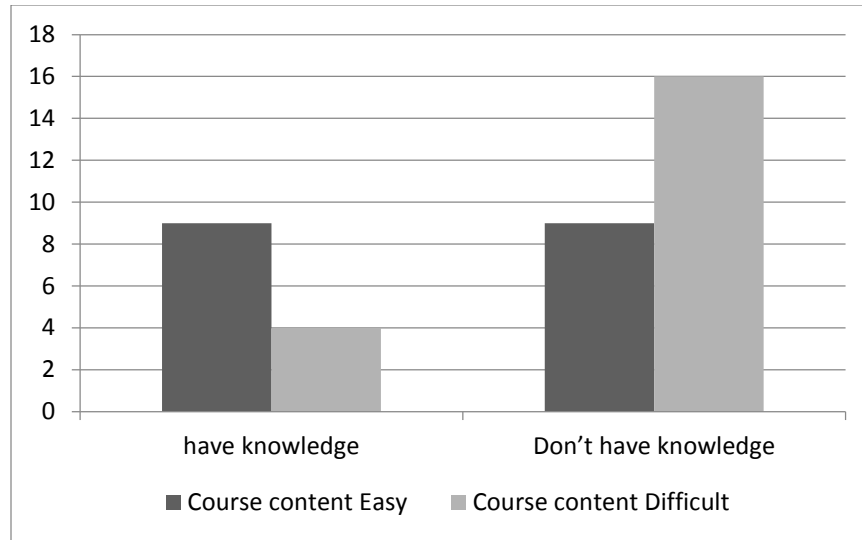- Course content is difficult: the answer of question seventeen more than four.

Figure 5 Distribution of students' knowledge and difficulties

iv. Interface Importance and MS Access Interface Analysis

Our survey asked the student about the effects of using an interface while coding SQL. Unsurprisingly, most of the student (85%) reported that using an interactive interface will help them learning SQL coding and understanding the database structure in general. The interface of any program forms a layer between the user and the actual program. This layer will simplify the interface of any program because it represents and shows the actual functionalities and capabilities to the user in a way that is easy to interact with. This will give the user the ability to be more productive and make the most benefit out of the software.
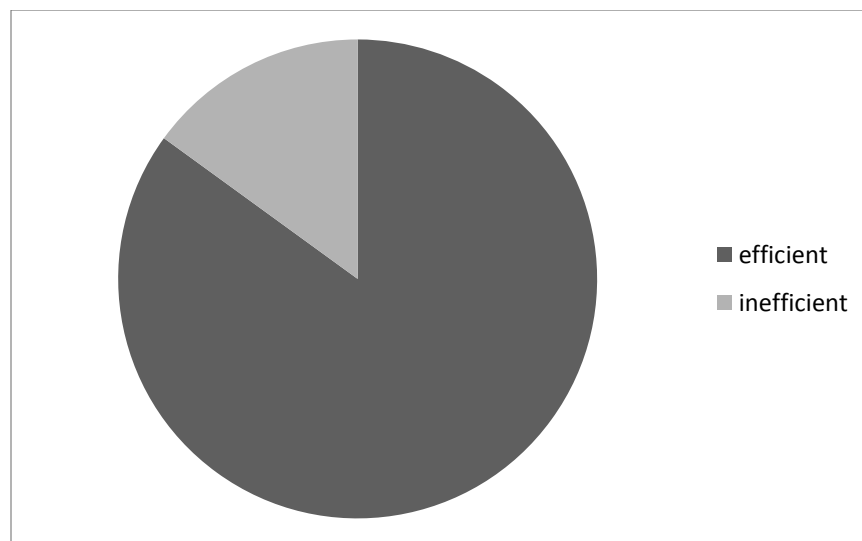

Figure 6 students opinion about the efficiency of using GUI tools to learn the DBMS's concepts

The most prominent feature of MS-Access is the intuitive software interface; this feature is the most important for students who are new to the databases. Having dedicated buttons for creating tables and editing fields and fields type of the table makes students more comfortable using the software. Consequently, Students don't have to worry about mistyping a field type, or choose it appropriately; MS Access will simply show a drop list where students can choose the field type. The simplicity of MS Access interface is not alone what makes a beginner student attracted to this application. In addition, the real time effects that appear on the resultant information whenever the input (information-filters) changes allow the students to precisely identify the effect of each segment in the command. Such features will matter most during learning the formation of SQL commands.

The "query interface" of MS-Access for example, will simply ask the user about the table from which the information are needed, and after that the user will have freedom to write any condition on any field simply by selecting it and writing the condition. Other features like grouping and ordering are only check-box click away, and these features (applied filters) will be reflected on the table on real-time, which means that the user can compare the effect of different actions (filters) very simply, only by checking, and un-checking the box. However, these simple and very intuitive interfaces are translated into actual SQL commands, and the user can actually see these commands to know how the filters that he applied through the interface are translated into an actual command. This helps many students when forming long queries.

To give an example of the simplicity of MS-Access, we tried to build a query that get data from different tables by using the wizard. Figure 7 shows one of the wizard's steps while figure 8 shows the result in the form of SQL command. Finally, it is important to mention here the visual representation of relationship between tables, figure 9 shows an example.
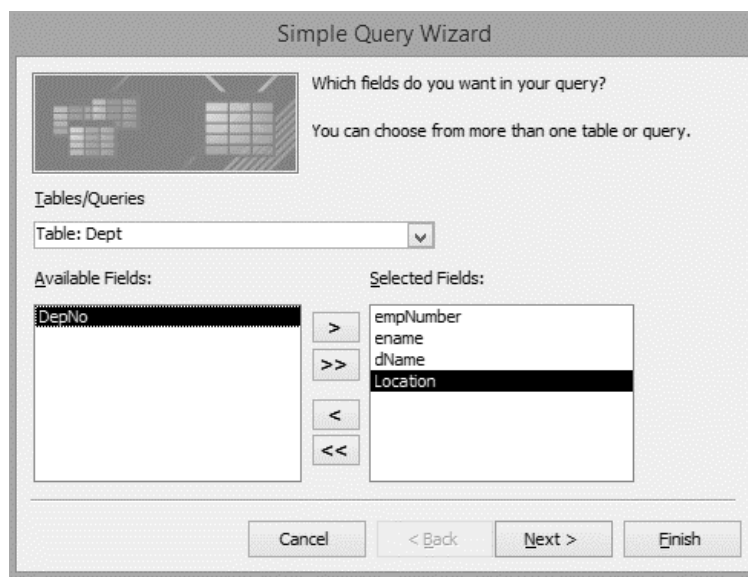

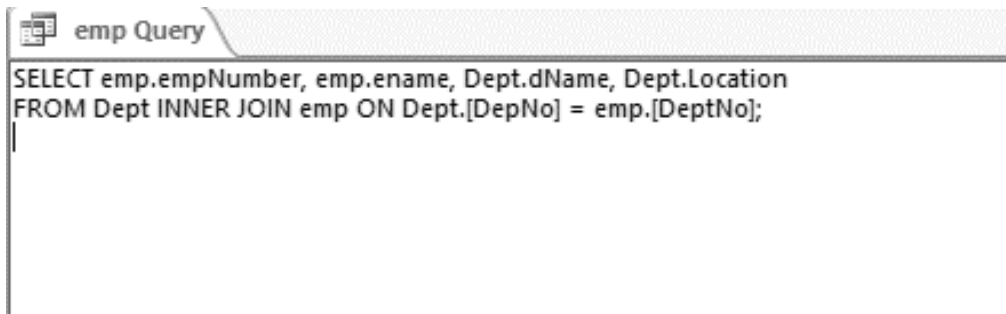**Figure 7 A wizard to create query (MS-Access 2013)**

Figure 8 SQL command formed automatically by using wizard. MS Access 2013)
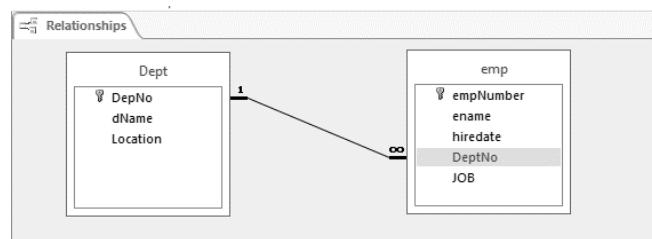

Figure 9 Relationship representation (MS-Access 2013)

6. Conclusion.

The common aim of the database course at all universities is to prepare the students for the industry requirements, and to give them the necessary knowledge so they can succeed in their career field. Considering this point we should understand and admire the choice of the Oracle DBMS by Qatar University and many other universities to teach database. It is one of the market leader's applications, and has a lot of powerful features that matter most to the companies and industrial market in general.

However, according to the results of our analysis, Oracle DBMS is not the best suitable application to introduce student to the database world. But a simple interface specialized in database manipulation only -like MS Access- will benefit the students more. An introduction to database systems that uses MS Access will facilitate the learning process for students at the earlier stages, and will pave the way for them to learn more advanced software.

Finally, once the student grasp the basic ideas and form a foundation in database structure and DBMS's, it will be necessary to progress and keep up with the most recent technologies used these days. Thus, the leading software's solutions in the industry must be taught to the student - regardless of its complications- in intermediate to advanced database courses.

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8. Appendix

CMPS351 – Fundamental of Database Systems	Database software Survey
CMPS352 – Fundamental of Database Systems – Lab	

General Information

1. Semester: Spring 2015   2. Gender: ☐ Male   ☐ Female

3. Major: ☐ Computer Science   4. Accumulated Credit Hours: ....
           ☐ Computer Engineering
           ☐ Other: ....

Microsoft Access

5. Do you have any previous knowledge in Microsoft Access Software?   ☐ Yes   ☐ No

6. To what extent do you find yourself proficient in MS Access:

No knowledge ☐ 1   ☐ 2   ☐ 3   ☐ 4   ☐ 5   Expert

7. Have you installed MS Access on your own computer?   ☐ Yes   ☐ No

8. Did you have any difficulties in installing or Configuring MS Access on your own PC ?

☐ Yes. specify (optional): ....   ☐ No   ☐ N/A

9. Do you find MS Access interface helpful in understanding Database structure?   ☐ Yes   ☐ No   ☐ N/A

10. Do you find MS Access interface helpful in forming SQL commands?   ☐ Yes   ☐ No   ☐ N/A

Oracle DBMS

11. Do you have any previous knowledge in Oracle DBMS (before the course)?   ☐ Yes   ☐ No

12. To what extent you find yourself proficient in Oracle DBMS (before taking this course):

No knowledge ☐ 1   ☐ 2   ☐ 3   ☐ 4   ☐ 5   Expert

13. Have you installed Oracle DBMS on your own computer?   ☐ Yes   ☐ No

14. Did you have any difficulties in installing or Configuring Oracle DBMS on your own PC ?

☐ Yes. specify (optional): ....   ☐ No

15. Do you find Oracle JDeveloper interface user friendly?   ☐ Yes   ☐ No

16. Do you have difficulties in Using / learning SQL syntax in Oracle?

☐ Yes. specify (optional): ....   ☐ No

Fundamental of Database course

17. How do you classify the lab course contents difficulty?

Easy   ☐ 1   ☐ 2   ☐ 3   ☐ 4   ☐ 5   Hard

18. How many hours, per week, you spend to master the concepts using Oracle DBMS?   .... Hours   ☐ N/A

19. Do you think having an interactive interface software specialized in Database Management will help you learn SQL commands and DB structure better?   ☐ Yes   ☐ No

Comments (if any) : ....
....
....

Figure 10 A copy of the survey that is used for the study