International Journal of Learning, Teaching and Educational Research
Vol. 12, No. 1, pp. 53-63, June 2015

An Effective Approach for Teaching Database Course

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Abstract. Teaching a Database course in general is a challenging task, due to several influencing factors such as increasing expectations of the job market, different and ever-changing database products, quality standards and limited time frames of a regular semester system. This course is different from other courses in the sense that hands on training is essential to train students to maximize learning effectiveness. Learning database principles and concepts involves various activities, starting from fundamental concepts to state of the art in the area. This paper presents a typical balanced approach that has been designed and implemented in teaching the database course to students of a taught master's program at the University of West Indies. The course design in this approach ensures both skills and knowledge training to meet the requirements of prevailing job market and international quality standards. Course design, composition, content delivery, independent learning through coursework, hands-on skills training, and assessment criteria are presented in a detailed manner.

Keywords: Database and Information Systems; Problem Based Learning, Course Design; Engineering Education; Graduate teaching.

1. Introduction

Information Technology (IT) world is witnessing phenomenal change on a continuous basis at faster rates when compared to other, non-IT technologies. Teaching in Computer Science and Information Technology related courses is influenced by several factors such as a) Rapid and continuous development in tools and technologies b) Increasing expectations of IT employers from new recruits c) Procurement and management of laboratory infrastructure d) Wide range of IT knowledge e) Different, stricter quality assessment frameworks. Hence, teachers and laboratory personnel are required to keep apace (when compared to their peers in other specializations) with the rapid changes in IT field especially in using the development tools and technologies to be able to train the students effectively. Obviously, IT courses, in particular at master's level courses should be designed to satisfy a wide range of requirements and standards (EC-UK, 2013). In particular databases have matured from one stage to another such as stand-alone, client-server, web and cloud models.

Database course is an integral component of any degree program specializing in Computer Engineering. The general thinking pattern about teaching databases is centered on learning normalization techniques, SQL statements, operating a given database product and to design a single, large database for the entire class in a semester. However in reality, this approach will not satisfy the master's level course organization, especially in programs of applied nature. Traditional delivery techniques emphasize the theoretical aspects of databases, which may not capture skills building and knowledge in state-of-the art; and often exclude exposure to real world projects. Yet, time limits of the semester system; experience, skills and professional background of teachers; and the need for extensive laboratory support often present significant challenges to the planning and delivery of more effective approaches. Naturally, the development and delivery of database courses have attracted a great deal of attention on account of the many pressing challenges in a typical university environment. Over the years, researchers have presented various aspects of teaching a database course. Most of the authors have focused on teaching database course to undergraduate students with major emphasis on database design, normalization and E-R diagrams. Mata-Toledo et al (2002) presented their experiences in teaching both undergraduate and graduate students using Oracle 8i. They also raised the issue of most universities not teaching Database Administration (DBA) and illustrated few reasons too. However, the database course taught by Mata-Toledo et al (2002) focused only on database administration aspects alone. Some authors (Connolly, 2006; Shaw et al, 2007) felt that the usage of real world problems and examples will help students learn Database courses better. Few authors have used Problem Based Learning (PBL) approach, though they did not explicitly discuss the issues with PBL in database teaching. Hoque and Bashiry (2014) used SQL learning and evaluation system with PBL teaching for databases. Kam et al (2013) used gaming and Gudivada and Nandigarm (2007) used large datasets to teach databases. The approach suggested in this paper also uses PBL for coursework. Few authors (Mata-Toledo et al, 2002; Guimaraes, 2006) presented a detailed discussion on contents of their database course. Guimaraes (2006) course has major emphasis on database security and networking aspects. However, it should be noted that contents of the course vary from university to university based on requirements, level of course of offering, overall program requirements etc. And teaching databases to engineering students is a different undertaking from that of non-engineering students. Abe and Sagar (2008) discussed the difficulties in teaching IT courses to engineering students and presented a model to teach database. Few authors even developed special tools and strategies for teaching database courses. Chen and Ray (2004) suggested a step-by-step approach for teaching; Kung and Tung (2006) developed a Java applet based e-learning tool for teaching normalization; Kaschek and Kinshuk (2005) developed a knowledge management system for teaching; Shaw et al (2007) developed a 'real-word integration' approach and used role playing techniques in classroom; Murray and Guimaraes (2009) developed an interesting, animated courseware and kept their courseware openly for wide circulation. However, these strategies mostly are limited to teaching fundamental concepts of databases especially normalization, E-R diagrams and design. Other reported strategies for teaching databases include

– using a simple Database server using JDBC (Sciore, 2007) and extensive laboratory training (Guimaraes, 2006). From the above, it can be seen that there are several teaching approaches and methodologies for this course. However, the circumstances, needs, requirements and objectives will be different from place to place. In essence, it can be seen that there is a significant interest in database course design, different approaches and teaching methodologies. However, issues like international accreditation standards, challenges such as ever-changing database products, licensing and ownership issues/ related costs to the teaching departments, job market expectations, independent learning aspects etc. This paper addresses such major issues by focusing from course design to meet the IET, UK standard specification for learning outcomes through a systematic discussion. This paper is divided into five sections. Section 1 provides the background and experiences of earlier contributors. The factors that influenced the course design are typical, which are explained in section 2. The course design, contents, learning outcomes and assessment strategies are illustrated in section 3. Student feedback and feelings on the course is presented in section 4 and a brief discussion on the approach is presented in section 4. Then section 5 has the conclusion.

2. Influencing factors

In general, designing a database course can be very complex, due to vastness of the content, limiting factors such as laboratory infrastructure, costs of commercial licenses and various influencing factors. These aspects are discussed below.

2.1 Internal and External Quality Processes

This course is offered in a department where classical British Educational model is followed for all undergraduate and postgraduate programs. The quality process naturally is driven by both internal and external reviews. All the undergraduate programs are accredited by Institution of Engineering and Technology (IET), UK. Hence the programs are expected to maintain the quality standards and satisfy the requirements of both internally and external quality review exercises. The EPC Engineering Graduate Output Standard (EC-UK, 2013) clearly states the importance of courses meeting certain standards and uses phrases such as 'an ability to use techniques, skills, and modern engineering tools necessary for engineering practice', 'ability to carry independent research' and 'knowledge of contemporary issues'. The internal quality process checks the fitness of the courseware, alignment of course learning outcomes with those of overall program.

2.2 Learning Outcomes and Overall Program Outcomes

Learning Outcomes based assessment is followed widely and strictly in IET accredited programs. This is also one of the requirements for the internal quality assurance framework. This database course uses a departmental standard course outline template, in which the learning outcomes are stated clearly and tied to the assessment. The learning outcomes are aligned to the overall program outcomes.

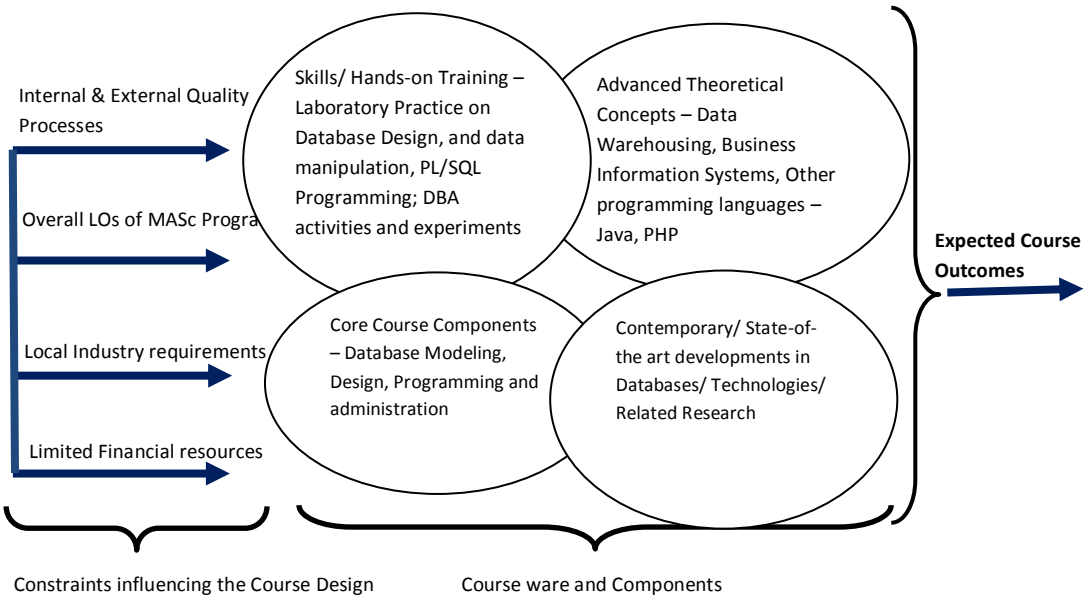

Figure 1: A thematic model for Database Course Design with influencing factors, content and outcomes

2.3 Local Industry Practices and Job market requirements

Oracle is the most preferred database for this course as it is widely used in the local industries. Oracle had kept their latest versions of the products on their site for free download for limited usage purposes. Students are encouraged download the latest version and install on their personal machines, so that they can have flexibility in practice at home or at office or in classroom.

2.4 Issues related to Student Learning at the Masters' level

Trinidad and Tobago is blessed with a vibrant local economy which is mainly supported by oil, gas and energy industries; and offers an excellent job opportunities for the qualified students immediately after completing their undergraduate programs. Hence, the master's programs are offered on evening basis to serve the students who are full time employees of the local industries and utilities. Departments appoint a panel of experts (chosen from local industries and serving as honorary consultants) in each thematic area to help the teachers to set the appropriate course content and learning outcomes. The members of this panel help the departments in building the appropriate courses that might impart necessary skills to the students to help their work environment and career prospects. The panel also reviews courses periodically.

Keeping in view of wide ranging requirements and existing resources, the course is designed in a typical fashion to balance both skills training and theoretical knowledge gain. The overall course design with influencing factors, content outlines and expected outcomes is shown in Figure 1.

3. Course Content, Learning Outcomes and Assessment

The course is divided into five major areas – 1) Database design and practical training on Oracle database; 2) Database Administration 3) Programming with PL/SQL to provide user interface with the database. 4) Design and development of Information systems. 5) Research on state-of-the-art technologies related to Databases and Information Systems. At the graduate level, students must be able to model any existing system and then design an appropriate database. The emphasis is more on design rather than understanding internal mechanisms of database products, data storage and retrieval. Programming with PL/SQL is aimed at imparting logic development skills and information extracting from an existing database(s). The learning outcomes are specified based on these five areas. Upon successful completion of this course, the learning outcomes are (in other words, students will be able to): 1. Construct SQL statements to query the database for specific information. 2. Design a DBMS for information processing of a given system 3.Understand the concepts, tools and technologies related to information systems 4. Manage and administer different database users with appropriate privileges and roles 5. Design, Development and implement PL/SQL programs for existing databases for information extraction and decision making. 6. Design, development and implement Database applications using different platforms and technologies (emphasis: APEX) 7. Independent learning on cloud database tools through research. The learning outcomes are coupled to the assessment. The table 1 shows the Assessment Breakdown.

TABLE I. ASSESSMENT BREAKDOWN

Assessment Component	**Weight %**	**Details** **(e.g. type - written, oral, practical; duration)**
PL/SQL Lab Exam	25%	Two separate Exams in the class/ Students must bring their own machines for this exam
SQL / DB Design (Take Home) CW1	20%	Design & Development of Database for a business application/ problem
DBA (Take Home) CW2	10%	Add on layer for DB Administration and Security for the DB developed in CW1
Information System with APEX (Take Home) CW3	20%	Design and Development of Front-End user screens using APEX for the DB designed
Research on State-of-art Information Technologies	25%	Reading articles on cloud databases such AWS, and implementing a prototype for the same chosen problem

The classroom lectures are delivered over 3 hours every week. Students are encouraged to bring their personal laptops to the classroom. Students are

provided with a guided installation of oracle on their laptops. Teacher installs the product on one machine, which is connected to the projector and students follow the same steps on their machines. In case of any specific issues with any student's installation process is dealt with the staff on the spot.

Every class will provide interactive learning opportunities for students through teaching, hands-on practice and assessment based on the Oracle database throughout semester of thirteen weeks. Students can also practice and learn outside the class hours, since Oracle is installed on their laptops. Students typically choose one major topic (or problem) for all the coursework components CW1, 2, 3 and 4. The focus is to learn and operate the database product and design effective solutions; as opposed to learn about the topic itself. This approach is based on the principles of PBL Hoque and Bashiry (2014). Different coursework components are discussed below.

3.1 Course Work1 (Design):

This part of the course aims at students to understand how to specify a problem with specific objectives; design and development of a database for meeting the set specific objectives; and testing the database design. Some of the problems given for this part are 1. Information System for Police Department 2. Vehicle Insurance Company 3. Information System for Income Tax Transactions 4. Software for Cricket Matches 5. MIS for Property Insurance Company 6. MIS for a Bank 7. Prison Management System 8. MIS for chain of Restaurants owned by different individuals 9.MIS for Property Insurance Company 10. MIS for Vehicle Rental Company. Expectations of CW1 are: A report (MS-Word Document not more than 16 pages) and a DB script (txt file). The report contains a) Problem specification, abstract, objectives and scope b) Overall design strategy for the problem c) Database table design with at least 8 tables d) E-R Diagram e) automated checks and data control using Triggers f) Usage and Test report g) Conclusions.

The contents of the report should include - complete table create scripts, removal scripts, test data insert scripts, triggers for automated processes and information/ URLs, screen shots of any tools used. Students have used different developmental tools like SQL developer, Tool for Oracle Application Development (TOAD), Computer Associate's (CA) Erwin (a data modeler product) in solving their course work problems. From the above it can be seen that the stages of work, level of challenge, amount of efforts spent in each course work are more or less same. Also, students have ample opportunities to acquaint themselves with standard software tools and technologies and build their information technology skills. From the above, it can be seen that though the course work problems are different from each other, their solutions have common pattern and stages.

3.2 Course Work2 (DBA):

A report (MS-Word document, not more than 8pages) and a DB script (txt file). The report contains a) Description of different users, need to have them and the hierarchy (show in a figure). b) Explanation on user privileges who should

have access to what information. c) Purpose for creating a trigger – usually to automate a computational process, or generating complex information based on a DB event.

3.3 Course Work 3 (Front End Design and Development):

Expectations of CW3: A report (MS-Word Document) + DB script (txt file) + APEX file The report contains a running notes and screenshots of ALL of your activities step-by-step. a) APEX admin - user creation b) invoking existing DB users c) be able to provide login screen for users d) accessing existing DB tables and the data e) information generated in different formats (pie, line, bar) f) export and import with testing

3.4 Course Work 4 (Research)

This coursework challenges masters' level students in their independent learning skills. Students are expected to research and understand on their about latest cloud databases such as Microsoft Azure, Google Spreadsheets etc and to implement a prototype database of the same problem that they worked in previous assignments. Students make a 15 minute presentation at the end of the semester summarizing their experiences. This benefits other students as many recent developments in the area will be presented.

3.5 Laboratory Examination

A three hour laboratory examination is held to assess the PL/SQL programming skills. Students need to answer three questions using conditional statements, loops, functions and triggers. This examination ensures the skills of programming and logic building.

It can be observed that complete, ready-made solutions for these coursework problems are not commonly available on the internet. However, it is a normal practice among the students to look for help over the internet for solutions. So, generally the course work problems should not be based on well-known problems, algorithms or so called stereo type problems. Every student is given with a particular problem though a lottery process. Only a short description on each course work problem is provided and this is deliberate. This provides students to think without limits and come up with their original ideas, specifications and features. In both course works, students are expected to define the scope, develop requirement analysis and then approach the solution for the given problem. Students are openly encouraged to consult each other on database design, application development, documentation standards, screen design, use of standard development tools etc. This strategy of assigning individual problems is opposed to the well-known, classical method of assigning a large, single problem to the entire class. This approach automatically ensured an effective learning process and also prevented the students from plagiarism as the problems are different and the solutions are not available on internet. Table 2 summarizes the overall learning activities and associated tools and technologies.

TABLE II. LEARNING ACTIVITIES WITH TOOLS AND TECHNOLOGIES

Activity / Stage of DB design	**Expected Tools to be used**	**Learning activities**
Table design with checks columns and primary and secondary keys linking to other tables	SQL Developer or CA Erwin data modeler or TOAD	Students develop the 'DB Scripts' by modeling the objects, identifying the data components and developing a relational model by linking these objects
Development of E-R diagram	SQL Developer or CA Erwin data modeler or TOAD	Techniques of representing information using diagrams and also analyzing the diagrams of large information systems
Development of Database Removal script with a specific sequence	SQL Developer or CA Erwin data modeler or TOAD	Students learn how to insert and delete data in the tables. Also learn the development of 'Delete Table Scripts' to understand the need to have a specific sequence.
Triggers	SQL Developer or CA Erwin data modeler or TOAD	Students identify the possibilities of bad entries, data items and then generate the necessary triggers to related data manipulation and computation tasks
Functions and Subroutines	SQL Developer or CA Erwin data modeler or TOAD	Students generate necessary functions and subroutines to automate most of the calculations and report generating activities in a modular fashion
Data Loading	SQL* Loader	Knowledge of bad data, importance of data formats, experiencing large data transfers from different database products and data migration
Design and development of Front End Screens	Oracle Application Express (APEX)	This is a versatile tool which requires no programming effort. By using this tool students can develop ready-to-use and corporate style applications on existing databases and to provide versatile reports with valuable information.

4. Overall Student Performance and Feedback

The attention and participation of students registered for this course is very good as evident from their response and overall feedback in the classroom. As the master's students are more matured and belong to a full time working class; they have enjoyed their individual project problems. As the assignments are take home type, students had all the freedom to discuss, research and collaborate among themselves in understanding the concepts and techniques of various aspects of databases and effectively attempted the course works. All students have shown great deal interest in the course works and the quality of

solution development is also found to be good. Figure 2 shows a sample report generated by a student in the topic 'MIS for Health Diagnostic Tests Laboratory' as a part of CW3 using APEX. In fact, students develop a small database driven web applications as part of CW4. This is an indicative and supporting factor that the developed course design is a success.

Students are appreciative of overall course delivery mechanism, theoretical content and the hands-on-training aspects. Students felt that they had the freedom in solving the course work which is essentially take home type. The strategy of having one problem to each student paid rich dividends. When students completed the first coursework, they felt the experience of completing one complete database design and implementation cycle involving use of various IT tools. Students liked the principles of PBL approach, as they do not have to research much on the problem itself and can focus on providing a database solution to the problem.

Figure 2: A Report Generated by a student in CW3

5. Discussion

Though this type of course design is both interesting and challenging to the students, this poses an equal amount of challenge to the teacher as well. Teacher needs to prepare a new set of database design problems (with same level of difficulty, yet different in nature) in every offering. The approach of giving one problem to each student for smaller class sizes up to 15 to 20 students and if the student numbers are higher; then the class needs to be divided into groups. Also, the laboratory infrastructure (in terms of hardware, software and training material) needs to be prepared and verified every time. Initially it may appear challenging, but after few offerings, course will be effective in training the

students. It should be noted that the course work problems must have same level of challenge in solving, a common solution frame work. Variations to the course contents may be taken up by inclusion or omission of some selected topics without changing the pattern of learning outcomes and the overall design approach. Such attempts of making variations to course contents will broaden the scope of course material and supports variation in assessment patterns in university internal quality frameworks as well the externally driven accreditation processes.

From the student point of view it will involve similar thought process though the problems are different. Students have specifically shown greater interest in learning database design and developing front end screens using APEX; PHP/ HTML; Java technologies. Projects combining database backend and web-enabled front-end are quite common in building information systems in local industries and hence, that is reflected in the interests expressed explicitly by students. Few students expressed interest in using Dynamic SQL and developing search techniques and algorithms.

Conclusion

Teaching IT courses and in particular database course is always challenging as there are several factors influencing the course design, delivery and assessment processes. Keeping in view of various needs and expectations, a new design strategy for has been developed and implemented for teaching a database course. This typical design has well defined learning outcomes, assessment strategy and combines skills training and theoretical concept coverage. From the analysis of student feedback and overall experiences gained, it can be seen that course design achieves the expected outcomes and satisfies all the influencing factors. This design strategy and our experiences may be useful to those who are similar situations and engaged in continuous improvement of courseware.

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