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Effective Outcome based assessment methodology for Laboratory course in Engineering Education

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Abstract: Outcome based education focus on outcomes and not the quality of inputs and process within institutions. This new trend strengthens the student learning and teaching quality. The major hurdle in implementation of OBE is lack of uniform and universally accepted methodology.

This paper is an attempt to provide effective outcome-based assessment process which is more objective and minimizes ambiguity in implementation. The proposed methodology is applicable to laboratory courses in engineering education. Project based learning, direct attainment of course outcomes and up to 60 % reduction in assessment time are the strengths of proposed approach.

Proposed methodology is applied to Database management systems laboratory course which is a third year computer science and engineering course. Evaluation plan with knowledge / skills addressed and mapping with Bloom's taxonomy, experiment plan with deliverables, mapping with course outcomes and detailed assessment sheets with rubrics are presented.

Keywords: Outcome based assessment, laboratory course assessment, project based learning.

1. Introduction

National Employability Report, Engineering Graduates – 2014 and 2016 only 18.33% of the engineers are employable. The 82 % engineering graduates are weak in programming and algorithm skills, soft and cognitive skills, domain skills, English speaking and comprehension skills and analytical and quantitative skills (National Employability Report 2014), (National Employability Report 2016). Outcome based education is effective tool to improve the students' abilities. Outcome-based education is gaining attention and interest in education systems around the world in last few years. It is accepted at different levels and different ways by educational systems (Spady, 1994).

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Literature is rich of teaching–learning process demonstrating large number of course delivery methods such as group discussions, audio or visual presentations, case study, project based learning, e-learning and self-paced learning through online mode etc. Outcome based assessment is one of the important pillar of entire OBE system. Purpose of Outcome Based Assessment Method is to helps students to become "more effective", "self assessing" and "self directing learners" (Yigit, 2003). In (Rhodes University, 2012) features of outcomes based assessment are discussed. In outcomes based assessment the focus is on application of knowledge and demonstration of skills and abilities. The outcomes based assessment is criterion referenced, where individual learner is evaluated against set of criteria's. The outcomes based assessment is continuous and used for both formative and summative purpose. The outcomes based assessment practices are valid, reliable and fair which includes integrated assessment. The outcomes based assessment is aligned with teaching methods, course outcomes and also aligned with purpose and outcomes for graduation.

There is lack of uniform and universally accepted methodology for outcomes-based education (Lawson and Williams, 2007). This paper presents outcome based assessment strategy for laboratory course assessment in engineering education.

In the rest of the paper, section 2 is about background. Section 3 presents proposed assessment approach for assessment of laboratory course. Section 4 is about case study. Section 5 concludes the study.

2. Background

There are different assessment's strategies used to measure the achievement of learning goals. Some of them discussed in (Soeiro and Falcao, 2013) are multiple choice questions (MCQ), short answer questions (SAQ), essays, practical case, problems, reflective practice with its relation to knowledge and cognitive dimensions.

In (Crisp, 2012) author has presented different assessment ideas currently used in higher education. Also author has proposed that there must be distinction made between assessment tasks are intended to influence current and future learning, which helps to develop self motivated and life-long learners.

In (Soeiro and Falcao, 2013)proposed a model which aligns assessment strategies based on e-learning. The ALOE (Assessment of Learning Outcomes in Engineering) used to describe the learning outcomes and the proper

assessment and to achieve alignment between these two components of the educational process.

One of the survey reports published in 2014 (Kuh et al., 2014), presented about institutions' current assessment activities and how the institutions were using evidence of student learning outcomes in US colleges and Universities. The study reports increase in assessment activities and a large increase in the use of rubrics, portfolios, and other classroom-based assessments as well.

In (Froyd et al., 2012) it is found that in engineering education, students learn more with methods such as cooperative learning, problem-based learning, and inquiry-based learning when compared to approaches that emphasize information delivery through presentation.

The (FU Tak-wah and YIP Wang, 2012) suggests some of the processes to be included in the implementation of outcomes based assessment and the issues to be considered in the actual implementation.

3. Proposed Assessment Approach For Laboratory Course

This section presents brief about traditional assessment approach for laboratory courses, its limitations and proposed outcome based assessment approach for laboratory courses.

A. Traditional Assessment Approach

The traditional assessment approach for laboratory courses is followed in various universities and higher education institutes in India. The course coordinator prepares list of experiments based on course content, the list usually includes 12-14 experiments based on various concepts. Every week students are expected to perform planned experiment and submit it for evaluation. In traditional approach, evaluation process rarely focuses on the abilities developed within students after performing the experiment or at the end of laboratory course.
The sample assessment sheet is given in Table 1.

Table 1 Sample Assessment Sheet

Exp No.	Title	Attendance & Performance (10 Marks)	Implementation & Understanding (15 Marks)	Timely Submission (5 Marks)	Total (30 Marks)

1) Limitations of Traditional Assessment Approach

Some of the important limitations of traditional assessment approach are summarized below.

- Learners' growth and development is rarely considered.
- It fails to measure the learners' higher order thinking skill, problems solving ability, etc.
- It takes lot of time to complete the assessment process.
- The traditional approach couldn't customize to the needs of individual learners.
- It fails to differentiate among individual learners'.

B. Proposed Assessment Approach for Laboratory Course

1) Methodology:

The proposed assessment approach consists of following steps:

i) The course coordinator prepares course outcomes (COs) before commencement of course.
ii) Map the course outcomes with programme outcomes.
iii) Prepare the In-semester evaluation plan. Identify the broad categories of evaluation and decide the weightages. Map the evaluations to knowledge / skills addressed. Map the evaluations to Bloom's Taxonomy levels.
iv) Prepare the experiments list. Map the experiment to course outcomes.
v) The deliverables and measures for each experiment to be finalized.
vi) Prepare rubrics for required indirect assessment.

2) Strengths of The Assessment Methodology

i) Project based learning.
   - Students are involved in complex problem / project for a period of three months. This project based learning gives them more insight and knowledge than traditional short duration and small problem.
   - Improves knowledge and skill to identify, analyse and solve complex real-world / engineering problem.
   - Improves team work and leadership.
   - Improves Self learning ability.
   - Improves report writing skills.

ii) Evaluation format is specific to outcomes.
   Table 1 shows the sample assessment sheet used in traditional assessment methods. The evaluation criteria's are general and fails to address the course outcomes. Proposed methodology suggests use of specific evaluation formats that directly measures the course outcomes.

iii) Evaluation time reduced.
   The number of students' evaluations is reduced dramatically. In traditional pattern course in-charge needs to spend half of the experiment duration (approximately 50-60 minutes) in evaluation of experiment conducted in previous week. Generally he / she do 12 to 14 assessments in a semester. In proposed system the course in-charge supposed to conduct only three-four evaluations for the identified broad tasks.

4. Case Study: Database Management Systems Laboratory Course

This section presents a case study for Database Management Systems Laboratory course. This is V semester course for Computer Science and Engineering undergraduate students. The principal objective of this course is to study, design and implement relational database management system. This course focuses on the identification of organizations where database management

system is required and designs the system that satisfy the need.

A. Step 1:Course Learning Outcomes

On completion of this subject the student will be able to:

i) Examine the real world organization where database management system is required.
ii) Analyze the need of database management system in the organization.
iii) Develop database design with the help of open source tools.
iv) Design and implement relational database management system.
v) Experiment with RDBMS tools such as SQL and Microsoft Access.
vi) Work in team for database designing and application creation.

B. Step 2: Mapped program outcomes

i) Identify, formulate and analyze real world problems to reach substantial conclusions using computer science and engineering concepts.
ii) Demonstrate principles and practices for software design and development.
iii) Select and apply appropriate techniques, resources and modern engineering tools to complex engineering activities.
iv) Understand the impact of professional engineering solutions in societal and environmental contexts.
v) Demonstrate professional skills and ethics.
vi) Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.
vii) Communicate effectively in written and oral form in professional and societal context.

C. Step 3: In-semester evaluation plan

In first week students are expected to form team of 3-5 students. Based on the student's interest they are supposed to finalize one domain for the laboratory. Few domain selected by student teams are as given below.

- College selection engine
- E-commerce system for retail business
- Automation of Income Tax Department
- Automation of manufacturing system
- Mutual funds management system
- Stock Market
- Land archive (7/12 extract)
- Sales Tax Department
- Online Citizen survey
- Banking system
- Automation of Maharashtra tourism development corporation
- E-Grampanchayat
- Criminal database management system
- E- Scholarship
- Automation of Post office
- Gas agency management system
- Automation of BSNL Office
- Payroll management system

Table 2 Modes of ISE

Sr. No.	Mode of ISE	Weightage
1	Design Document	30%
2	Implementation using SQL	30%
3	Implementation using Microsoft Access	30 %
4	Report writing	10 %

Table 3 Modes of ISE and Knowledge/skill addressed

Sr. No.	Mode of ISE	Knowledge / skill addressed
1	Design Document	- Domain knowledge - Software design process - Communication skills - Professional ethics - Problem identification and formulation - Use of designing tools
2	Implementation using SQL	- Problem solving - Software development process - Use of modern and open source tools
3	Implementation using Microsoft Access	- Problem solving - Software development process
4	Report writing	- Technical report writing - Use of report writing tools

Table 4 Bloom's Taxonomy level addressed in different modes of ISE

Sr. No.	Mode of ISE	Bloom's Taxonomy level addressed
1	Design Document	- Application (Level 3): Apply knowledge to actual situations - Synthesis (Level 5): Propose new / alternative solution
2	Implementation using SQL	- Application (Level 3): Apply knowledge to actual situations
3	Implementation using Microsoft Access	- Application (Level 3): Apply knowledge to actual situations - Synthesis (Level 5): Propose new / alternative solution

D. Step 4 and 5: Experiment list, deliverables & outcomes

Table 5 presents experiment list, deliverables and outcomes of each experiment and proposed mode of ISE.

Table 6 to 9 shows the assessment sheets for proposed four ISE evaluation models.

Table 5 Deliverables and Outcomes Addressed

Exp. No.	Title of Experiment	Mode of ISE	Deliverables	Outcomes Addressed
1.	Survey different organization to identify the problem	Design Document	Questionnaires for customer interactions	Acquire the knowledge of working of different organization where database management system is necessary / important.
2.	Finalize objectives, scope and requirements of the problem		- Mission statement - Objectives - Scope - Requirements Specification	Identify the need and requirement of database management system in the selected organization.
3.	Draw Entity Relationship Diagrams		- Extended ER diagram - Data and Metadata tables - Database schema	- Design relational DBMS - Understand the use of open source tools to draw ER diagram
4.	Create data tables			
5.				
6.	Write queries using - create, default, NULL, check, primary key, foreign key, unique	Implementation using SQL	Data definition language (DDL) queries for stated objectives	Understand the RDBMS tool –SQL (Structured query language) - Data types - Query format - DDL constructs - DML constructs - Advanced features (operators and functions)
7.	Write queries using - insert, alter, update, delete		Data manipulation language (DML) queries for stated objectives	
8.	Write queries using operators -group by, order by, having, nested queries		SQL queries using advanced constructs for stated objectives	
9.				
10.	Write queries using functions - statistical & mathematical, string, date, time		SQL queries using advanced functions for stated objectives	
11.	Database design using Microsoft Access	Implementation using Microsoft Access	Data tables for stated objectives	Understand the RDBMS tool - Microsoft Access. - Table design view - Data insert view - Front end design view - Connectivity
12.	Design front end using Microsoft Access		Front end for stated objectives	
13.	Connect front end with backend using ODBC.		Complete application with front end and backend	

Table 6 ISE Evaluation 1 Assessment Sheet

Enrolment No. (Student Team)	Name of Student	Quality of work (5)	Interaction with end user (5)	Depth of Domain knowledge (5)	Use of ER diagram constructs (5)	Use of open source tool (5)	Leadership and team work (5)	Total (30)

Table 7 ISE Evaluation 2 Assessment Sheet

Enrolment No. (Student Team)	Name of Student	Database schema (10)	SQL queries as per objectives (5)	Use of SQL constructs (10)	Leadership and team work (5)	Total (30)

Table 8 ISE Evaluation 3Assessment Sheet

Enrolment No. (Student Team)	Name of Student	Backend design as per objectives (5)	Front end design (10)	Connectivity (10)	Leadership and team work (5)	Total (30)

Table 9 ISE Evaluation 4 Assessment Sheet

Enrolment No. (Student Team)	Name of Student	Organization and formatting (5)	Language and grammar (5)	Total (10)

E. Step 6: Rubrics for indirect assessment

Table 10 section presents rubrics used for indirect assessment components in assessment sheet. Indirect assessment is divided into three criteria and descriptions of levels of performance quality are provided.

Table 10 Rubrics Developed For Evaluation

Course Outcome	**Level 5 (Completely Attained)**	**Level 3 (Somewhat Attained)**	**Level 1 (Not Attained)**
Work in team for database designing and application creation.	Shows the leadership quality to distribute the work among the team members. Interact with the end user for formulating the problem statement.	Work as a team member. Do the task given by team leader.	Not able to work in coordination with other team members.
ISE Evaluation 1: Design Document			
Quality of work	Objectives and mission statements are written and fulfilling the requirements of end user at greater extent.	Objectives and mission statements are written and fulfilling the requirements of end user at certain extent.	Objectives and mission statements are written but not fulfilling the requirements of end user.
Interaction with end user	Frequent visits to end user.	Few visit to end user.	No visit to end user. Requirements are gathered through other ways such as Internet.
Depth of Domain knowledge	Working of the selected organization /end user is covered at great extent.	Scope of the project is limited.	Very little functionality of the organization / end user is covered.
Use of ER diagram constructs	Concepts of generalization, specialization, cardinality are used.	Concepts of derived attributes, multi-valued attributes, derived attributes, weak entity set are used.	Concepts of entities, attributes of entities and relationship between entities are used.
Use of open source tool	Advanced constructs from open source tool is used to draw the ER diagram.	Basic constructs from open source tool is used to draw the ER diagram.	Tool not used.
ISE Evaluation 2: Implementation using SQL			
Database schema	Database schema is as per ER diagram of system and objectives. Redundancy in database design is removed using concepts of normalization.	Database schema is as per ER diagram of system and objectives.	Some mismatch between database schema and ER diagram of system.
SQL queries as per objectives	All objectives are satisfied.	Objectives are satisfied at major extent.	Only few objectives are satisfied.
Use of SQL constructs	SQL queries are written using- nested queries, string matching, group by, order by, having.	SQL queries are written using- primary key, foreign key, statistical & mathematical functions.	Basic SQL queries are written using- create, select, insert, update, delete.
ISE Evaluation 3: Implementation using Microsoft Access			
Backend design as per objectives	All objectives are satisfied.	Objectives are satisfied at major extent.	Only few objectives are satisfied.
Front end design	User friendly and professional. Covers all fields from database.	Covers all fields from database.	Covers few fields from database.
Connectivity	Navigation to first, last, next, previous records are done.	All fields on front end are connected to relevant database fields.	Only new field on front end are connected to relevant database fields.
ISE Evaluation 3: Report writing			
Organization and formatting	Report is as per guidelines given by reputed universities.	Few violations of the guidelines in the report.	No guidelines are followed in report writing.
Language and grammar	Effective use of scientific and technical terms. No grammatical and typographical error.	No grammatical mistakes. Use scientific and technical terms is not effective.	Many grammatical and typographical error.

Each student is expected to demonstrate the knowledge and skills gained in semester. As the end semester evaluation is for three hours, scope of the problem / project is limited.

Sample end semester questions are as given below.

1. Design the database schema for automation of Post Office Systems. Draw Extended ER diagram. Write SQL queries for following questions.
   i) Display monthly revenue generated by post offices in 'Sangli' district.
   ii) Display information of customers who have saving and RD account.
   iii) Display information of Post-Master served at 'Islmapur' during year 2000 to 2014 in chronological order.
   iv) Display number of Register Letters delivered by 'Islampur' post office.
   v) Display the status of compliant filled by 'Aniket'.
   vi) Display total number of Rs.1, Rs. 2 and Rs. 5 stamps available now at 'Islampur' post office.
2. Design the database schema and create graphical user interface for automation of any Mobile Company. Execute the following queries.
   i) Display information of customers taken the new cards in last month.
   ii) Display the number of customers who have sent the PORT request in last month.
   iii) Display information of customers whose monthly recharge in more than Rs. 500.

5. Conclusions

The proposed outcome based assessment methodology presented in this paper is one of the innovative and effective assessment approaches. The proposed outcome based assessment methodology for laboratory course has strengthened the students learning and teaching quality. The proposed approach helps to minimize ambiguity in implementation of outcome based assessment. The attractiveness of proposed approach is mapping of evaluation plan with knowledge/ skills acquired by students at different levels of Bloom's taxonomy, experiment plan with deliverables and detailed assessment guidelines for students. As there are only four assessment schedules, the proposed approach reduces evaluation time up-to 60%. Also the course outcomes are directly mapped with assessment sheet, the proposed approach helps to compute the course outcome's attainment directly. The proposed approach can be used for other engineering laboratory courses and its effectiveness can be measured.

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