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Analysis of Outcome-based educational model in Engineering Education with preliminary Findings

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Abstract

The notion of outcome-based educational paradigm and its adaptability for higher education has become a recent growing and quite stirring trend. In the year 2017-18, this educational philosophy has been embraced by some of the higher educational institutions in Pakistan as well. This research attempts to investigate OBE and non-OBE systems in the context of students learning outcomes and academic attainment levels in engineering education in Pakistan. The study has been conducted on undergraduate students of MUET, Jamshoro, Sindh Pakistan. The students of the software engineering department are taken as the sample. Student cohorts are formed i.e., OBE and non-OBE (traditional/teacher-centered approach) cohorts. The summative assessments of semester exams are used for data analysis descriptive statistics and independent samples t-test is performed to set up the group statistic. The findings of this study show that, in terms of students' performance, the OBE system outperforms the traditional system and this transition in engineering institutions might be beneficial in the future.

Keywords: *Outcome-based education; efficacy of OBE; Traditional learning system; Engineering education*

1. INTRODUCTION

Escalation in technological trends, growing pedagogical needs, and thrust for excellence in Engineering education in recent years has witnessed the shift in educational paradigm to a new form of education which is called Outcomes-Based Education (OBE) [1]. The term OBE did not exist in literature until recently in the field of software engineering or general studies related to computer science. In various scholarly articles and academic journals, some different terms, for example, outcome-based approach (OBA), outcome-based learning (OBL), and outcome-based teaching and learning (OBTL) have been used. No matter, whatever the term has been referred to by academicians and researchers, the components, structure, and framework are more or less the same [2]. There is no single agreed-upon model to define OBE. The Literature demonstrates that the OBE framework emphasizes measurable learning outcomes, system-level change, and "no child left behind" strategy [3]. The learning outcome is a result that learners/students must demonstrate at the end of the learning phase.

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The present era demands engineering graduates to be equipped with technical skills, personal abilities, communication proficiency, teamwork skills, and good know-how of problem-solving tactics to make them capable of industrial needs [4]. This signifies the conception of OBE. OBE system includes curriculum design, teaching pedagogies, and assessment methods to focus on what students can do for society once they are graduated [4]. It keeps the students/learners at the center to produce future graduates of global equivalency and comparability [5].

Initiative steps have been taken by higher education sectors around the world to shift the educational system from the traditional "Chalk and Talk" approach to outcome-based education which makes student involvement mandatory thereby realizing student-centered learning. This approach, however; has brought issues and challenges that have become a trending research concern these days. Hence, this research work has been conducted to understand, analyze and investigate OBE system implementation in Engineering education in Pakistan. The purpose of this study is to create a baseline and establish preliminary findings for analyzing if OBE adoption in Pakistan is effective in terms of students learning outcomes (considering summative assessment) as compared to the traditional educational paradigm.

2. RELATED WORK

Presently, because of the shift in the educational process, there is a remarkable prominence of outcome-based education around the world thereby making it a very significant research field.

Even though the concept of the OBE educational system is having deeper roots but its realization and adoption by higher education sectors in different countries around the world like Europe, Australia, Canada, and the US are relatively young [5]. Researchers around the world have made contributions to this emerging educational system and conclusions encompass diverse opinions, success stories, and problems [6]–[11].

A study conducted in [6] in Hong Kong clearly outlined OBE as a success. The evaluation was performed on students in a managerial accounting course and the results indicated that the desired attributes were met. Research conducted at the University of Putra Malaysia highlighted that the students were lacking behind the attainment of soft skills typically related to attitude and emotions as compared to knowledge, mental and motion skills [8]. A study in [9] conducted at the University of Kuala Lumpur Malaysia has discussed OBE implementation problems typically focusing on assessment methods and has proposed a measurement method that can be incorporated as a framework for assessment. Research work in [12] stated that the OBE approach in Philippines University has been adopted recently and the first graduating batch over this system was in 2013-14. Hence the study evaluated and identified knowledge of College of Engineering faculty members regarding OBE implementation, as they are responsible to deliver knowledge, revise curriculums and assess students. An action plan was suggested to ensure proper understanding and utilization of this system. OBE adoption in India is discussed in [13]. This paper highlights that the OBE framework efficiency declines up to some extent with a larger class size. It has also proposed a game-based learning approach in such an environment to overcome the disadvantages. Work accomplished in [11] analyzes OBE practices at the University of Kelaniya, Sri Lanka. The analysis was performed in terms of teaching & learning, assessment, evaluation, and CQI.

These research studies are significant and provide remarkable evidence that OBE is not a panacea for educational institutions. Certainly, there are advantages as well as downsides and challenges to OBE [10][14][15]. Aside from this, in comparison to other engineering disciplines and fields, the OBE approach is relatively new to software engineering and computer science [16][17][18]. Hence it is of vital importance to explore this new model and to evaluate how well it translates in the classroom in the context of students learning outcomes.

3. OBE IMPLEMENTATION IN PAKISTAN

In the year 2010, Pakistan was allowed a provisional membership of the Washington Accord. Later in June 2017, Pakistan became a full signatory member of the Washington accord [19]. Hence, to fulfill accreditation criteria and call for uplifting standards to stand up with other emerging countries on a global platform has led Pakistan to incorporate outcome-based educational policies for Engineering education. OBE is a new vision for education in the higher education sector of Pakistan and is still in the adoption and implementation phase in most of the Universities' offerings.

Hence, there is a huge significance to analyzing and understanding the implementation of OBE and its efficacy in the context of developing countries like Pakistan. This research work reports a case study performed at the Department of software engineering [20], Mehran University of engineering and technology Jamshoro [21], Pakistan. The details of the case study are given in section 5.

Interest conventional chalk and talk educational approach centers around what should be provided for the students. In contrast to this, the OBE system insists on students showing what they know and can do after graduation. OBE is an outcome-oriented and learner-centered approach that believes in the 'all students can learn' assertion. OBE emphasizes outcomes that are measurable [22].

4. ILLUSTRATION OF OBE AND TRADITIONAL PARADIGMS

In a traditional learning system, students are assigned grades and rankings compared to each other. Performance expectations are merely based on what was taught to a learner by an instructor who sits at the center. However, in the OBE system students are assessed based on predefined outcomes (course learning outcomes- CLOs mapped to specific taxonomy levels) and assessment criteria as depicted in figure-2. The outcomes are designed in a way to fulfil industry needs and students' attainment level is checked against these outcomes as shown in figure 1 for the course of object-oriented programming (OOP).

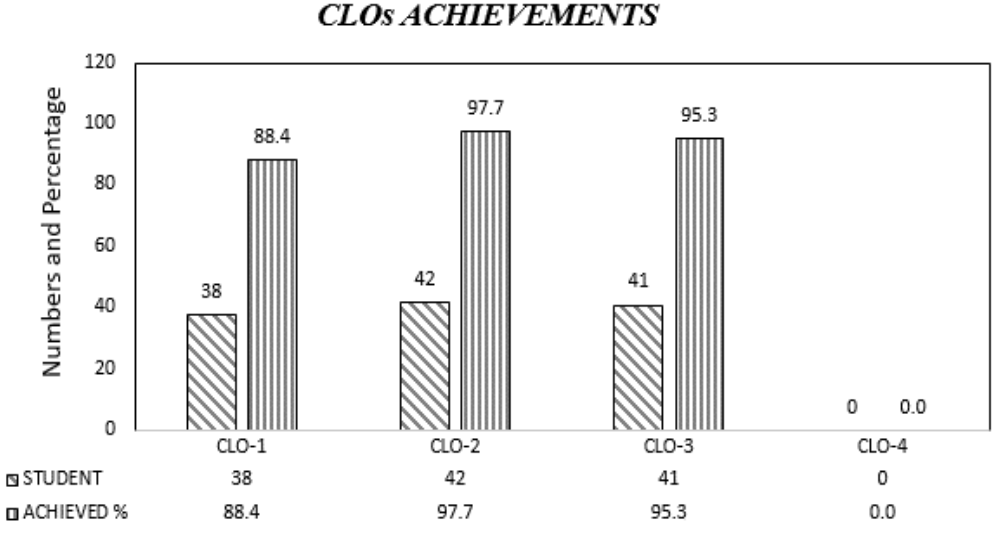

Figure 1. CLO achievement for the course OOP

Each CLO is further divided into taxonomy levels based on Cognitive, Affective, and Psychomotor domains as shown in figure 2.

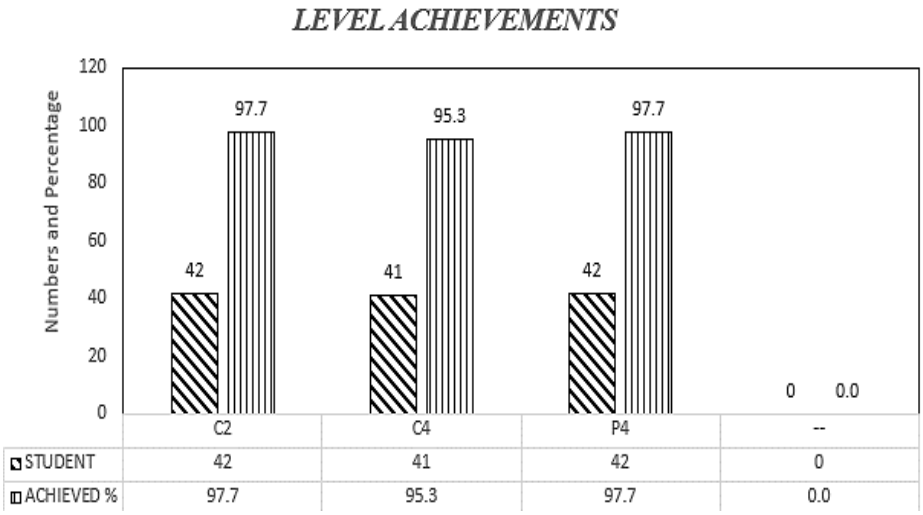

Figure 2. Taxonomy level achievement

The CLOs are further mapped to check PLO attainment as shown in figure 3.

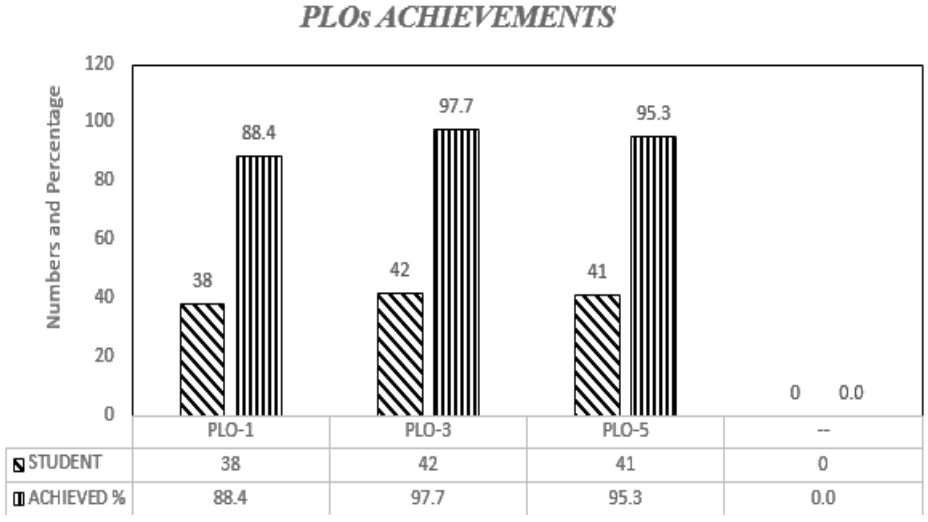

Figure 3. Program Level Objectives achievement

Syllabus design in a traditional system is merely content-based, whereas each course syllabus in an outcome-based approach is designed to address different learning domains with taxonomy levels. Emphasis is put on course learning outcomes rather than contents only. These outcomes are designed in a way to ensure that the students are equipped with mandatory skills after graduation to compete at the international level.

Instruction delivery is based on the learning outcome and program level outcome that is to be achieved. The instructor plans the number of contact hours for the defined CLOs and learning mode/delivery method to be lecture delivery, task performance, discussion, group activity, class exercises, etc. These delivery methods try to keep the students at the center so that learning can be enhanced. The traditional method uses direct instruction delivery to cover the pre-specified topics. The above discussed parameters are summarized in table 1.

Table 1. Summarization of Parameters

Parameter	Traditional	OBE
Learners status	Passive	Active
Learning approach	Student-centered	Teacher centered
Assessment strategy	Invisible descriptors (Assessment and grading is based on marks in assignments exams etc)	Visible descriptors i-e CLOs (Assessment and grading is based on attainment of predefined learning outcomes in the syllabus)
Syllabus	Content-based	Outcome-based
Instruction	Direct instruction	Outcome-based instruction
Graduate skills/attributes	Not predefined	Focuses on knowledge and academic skills, physical skills, attitude development, behavioral and communication skills

5. CASE STUDY DESIGN

5.1 Data collection

This paper is a preliminary part of a research project (under progress) that seeks to evaluate the OBE paradigm in the higher education sector of Pakistan via machine learning techniques. The case study has been performed at Mehran University of Engineering & Technology, a leading public sector university, and is situated on the right bank of the Indus River adjacent to the third largest city of Pakistan - Hyderabad, Sindh. This research includes the Fall 2016(F-16) batch of the Department of Software Engineering. This batch has recently been shifted towards Outcome-based Educational Paradigm from traditional learning system as per the PEC accreditation criteria for the degree of Bachelor of Engineering. In total 8 data sets consisting of students' academic records were included in the study referring to 8 courses of the fall 16 batch. The Details of courses including course codes, Semesters in which they were taught, classification (Courses are classified in two categories CAT-1 and CAT-2 based on Genre), Genre and related learning paradigm that was adopted by faculty members are shown respectively in Table 1. Out of the 8 courses, 4 were being taught using traditional instructional methods and 4 were taught using the OBE approach.

Table 2. Classification of Courses for F-16SW batch (Datasets)

Course Code	Semester	Classification	Genre	Learning Paradigm
MTH108	1st	CAT-1	Mathematical	Traditional/non-OBE
MTH112	2nd	CAT-1	Mathematical	Traditional/ non-OBE
MTH212	3rd	CAT-1	Mathematical	OBE
MTH217	4th	CAT-1	Mathematical	OBE
SW110	1st	CAT-2	Programming	Traditional/ non-OBE
SW120	2nd	CAT-2	Programming	Traditional/ non-OBE
SW243	3rd	CAT-2	Programming	OBE
SW233	4th	CAT-2	Programming	OBE

Data was collected for 106 students enrolled in an undergraduate program. This data comprised of students' academic performance records including summative assessments of learning outcomes in tests, projects, assignments, quizzes, mid-semester examination, and final semester examination.

5.2 Data cleaning and preprocessing

Data cleaning and preprocessing, in the context of the knowledge discovery process, is immensely important since the quality of actionable knowledge and decisions is always based on the quality of data. Data taken from the OBE system and traditional educational system was inconsistent and incomplete. The data was cleaned to avoid any unbiased comparison of the systems (e.g., the data with missing values of attributes; For example, a student who has not appeared in one course taught using the OBE paradigm may create a huge variation in the results). The outliers were also identified and removed. The result of this step was clean and transformed raw data. This transformed raw data were categorized into two groups:

1. Controlled group: Fall 2016 intake students who took courses MTH108, MTH112 (CAT-1), SW110 and SW120 (CAT2).
2. Experimental group: Fall 2016 intake students who took courses MTH212 MTH217 (CAT-1), SW243, SW233 (CAT-2)

The two selected groups of students share identical demographic information (i-e family backgrounds, gender ratio, etc.), and the same size i.e., the same number of data records have been taken.

6. PRELIMINARY FINDINGS

The results for group statistics and independent sample test for CAT-1 subjects belonging to the mathematical genre are depicted in tables 3 and 4 respectively. The total sample size for each group was 228. Group 1 comprised of learners after the adoption of the OBE model and the group comprised of learners before the adoption of OBE i.e., on a traditional model. The test was conducted at 95% confidence interval i.e., α was 0.05. Levene's test for equality of variances states sig value = .001 which is less than .05, hence unequal variances are assumed. Group statistics suggest that the outcome-based paradigm was a bit more effective as compared to the traditional model. However, the magnitude of mean difference and effect size value (<0.02) is trivial. Sig value (Two-tailed)>.05 so the difference between the two paradigms is statistically not significant. The cause is perhaps because this educational reform is in its infancy in Pakistan.

Table 3. Group Statistics of OBE and Traditional Model (F-16SW batch)

Academic Performance	Learning Paradigm	N	Mean	St. Deviation	Std Error Mean
	OBE model	228	71.1579	18.87057	1.24973
	Traditional model	228	69.7719	22.30408	1.47712

The second Experimental setup consists of CAT-2 subjects. These subjects belong to the programming genre. The results for group statistics and independent sample t-test for CAT-2 subjects are depicted in tables 5 and 6 respectively. The total sample size for each group was 173. The test statistic of Levene's test (F value) and sig. p-value corresponding to this test statistic is significantly larger hence equal variances are assumed. Even though the Two-tailed test statistic suggests the difference in two paradigms is statistically not significant but is comparably greater than the mathematical subjects.

Table 4. Independent Sample test results of OBE and Traditional model (F-16SW batch)

Academic Performance	Levene's Test for Equality of variances		t-test for Equality of Means					95% Confidence Interval	
	F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	10.282	.001	.716	454	0.474	1.38596	1.93487	-2.41645	5.18838
Equal variances not assumed			.716	441.878	0.474	1.38596	1.93487	-2.41673	5.18866

Table 5. Group Statistics for Cat-2 Subjects

Academic Performance	Learning Paradigm	N	Mean	St. Deviation	Std Error Mean
	OBE model	173	69.2254	17.19894	1.30761
	Traditional model	173	71.9480	17.43502	1.32556

Table 6. Independent Sample test results of OBE and Traditional model (F-16SW batch)

Academic Performance	Levene's Test for Equality of variances		t-test for Equality of Means					95% Confidence Interval of the difference	
	F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	.026	.871	-1.462	344	0.145	-2.72254	1.86198	-6.38483	.93975
Equal variances not assumed			-1.462	343.936	0.145	-2.72254	1.86198	-6.38484	.93875

7. CONCLUSION

The instructional process in the higher education sector has been shifted from teacher-centered learning to student-centered learning giving rise to a new form of education that is outcome-based education. Due to increasing demand of software engineers, it is important to measure their learnings with new pedagogical skill set. This research work is conducted to analyze and evaluate the newly implemented educational system in Pakistan. The hypothesis was designed to make this evaluation. Experiments were conducted on a real dataset taken from the Department of Software Engineering, Mehran University of Engineering and Technology,

Jamshoro. Experiments conducted in this study provide evidence that the OBE model is effective in terms of knowledge acquisition as compared to the traditional model, but the change is trivial. In future, the students' learnings could be measured in core software engineering subjects and non-core software engineering subjects.

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