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Practical Implementation of Outcome-Based Education Practices in the Indian Engineering Institutes – An Objective Approach Based Investigation

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Abstract: Outcome-based education (OBE) by Washington Accord (WA) promises to improve the technical education system by clarifying expectations for students and focussing assessment on specific learning outcomes for better measurement of student achievements. Numerous publications describe the process and results of OBE implementation in India. This article is a meta-analysis of research articles documenting the OBE efforts made by Indian engineering institutes. The study implements the established objective approached based reviewing technique. A rubric comprising seven distinct measurements was applied to assess critically selected articles. The detailed assessment indicates that there is a lack of empirical validation of the results obtained by the researchers. The papers were also found to lack a consistent understanding of CO-PO mapping. Hence, there is a clear research gap of statistical validation of the results using pre and post-implementation data for a given improvement.

Keywords: Education; Engineering; Outcome-based education; Students; Undergraduates

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1. Introduction

Technical education in India contributes a significant share to the overall education system. In addition to the technical knowledge through the courses, it deals with the socio-economic development of our nation. The employability of engineering graduates is a major issue in India. One factor is the incapability of the graduates to apply their knowledge to problems requiring higher-order thinking skills. Additional factors include ineffective academic curriculum, lack of qualified faculties and inefficient conventional teaching-learning techniques (Misra and Khurana, 2017; Sahoo and Das, 2019). Outcome-Based Education (OBE), required for accreditation by the Washington Accord, promises to improve the technical education system by improving the standards of the mentioned critical factors. The Washington Accord was initially established between six countries to recognise equivalencies across the accrediting process and measure the process. Since its formation in 1989, other countries, including India, have joined the accord, summing the total members to be 25 at present (Kootsookos et al., 2017). This major problem of declining employability ratio and the need for improvement in the quality of engineers at the grassroots level necessitates the in-depth exploration and implementation of effective OBE. To date, no systematic review of engineering education research papers on the process and quantitative assessments of OBE.

The prime focus of this systematic review article is to evaluate and synthesise the best available empirical evidence of implemented OBE approaches on the competencies of Indian engineering students. The review findings aim to add strong empirical evidence of implementing OBE approaches while supporting their adoption to improve the quality of Indian next-generation engineers.

2. Review Methodology

2.1 Search strategy

The systematic review using the objective approach for searching proves a superior search strategy to the most commonly used conceptual approach for reviewing (Hausner et al., 2015). Most popular electronic databases: Science Direct, Springer, Web of Science, Google Scholar and IEEE is used for identifying relevant studies. However, they are limited to articles published from 2009 to 2019. The literature search is accomplished using the search terms "outcome-based education" AND "Engineering curriculum." The said terms represent the methodology of obtaining the initial development set (Hausner et al., 2015). The comparator set is later searched by breaking down the review questions into concepts of interest. This objective approach of reviewing aims to answer the question: can the proficiency of the Indian Engineering students be improved by replacing the traditional educational approaches with the OBE approaches in the engineering education system? The review question framed follows the PICO clauses: Population (Indian Engineering undergraduates), Intervention (outcome-based education approaches), Comparison (traditional engineering education approaches), Outcome (improved competencies of undergraduate engineering students).

2.2 The inclusive and exclusive part of the review-study

The comprehensive investigation that meets the following criteria is retrieved and evaluated for its methodological quality.

- Peer-reviewed articles related to engineering education/programs/courses and engineering graduate students;
- Outcome-based education and project-based learning approaches;
- Observational or empirical data or observation of the PBL/OBE approach;
- Effects of OBE approach on the competency of the Indian engineering students.

The following are not part of the current study:

- Investigative works that do not assess the effectiveness of the OBE approach in engineering education;
- or a post-graduate and a higher level of technical education because of the difference in the skill sets evaluated;
- or investigations with incomplete documentation.

2.3Screening and assortment of the reviewed articles

The initial search resulted in 358-68=290 potential relevant published peer-reviewed articles through the selected database searching. The remaining 290 papers were initially screened by title, and 186 documents were removed.

In the next stage, screening 104 articles for abstract led to the exclusion of 63 articles. The final screening stage comprised a detailed full-text review of the remaining 41 articles concerning all the earlier stated inclusion criteria. This stage resulted in rejecting 29 articles. The elimination of the articles at this stage was the lack of comparative validation, lack of quantitative results, and vague selection of the population.

Certain individual cases of articles were close enough to get included but rejected due to minor concerns. For example, In one of the discarded articles in the final stage, the authors (Padma and Sridhar, 2015) implanted the mini-project based learning component of OBE. They validated the results in the best possible manner. The article faced rejection because the population selected for the studies were the post-graduate students, and the methodology adopted was to improve the skill set of the undergraduate level. Another rejected article focussed on faculty readiness for the implementation of project-based learning. Though the article comprised a structured questionnaire, the authors (Srinivasa, Niranjan and Shrinivasa Rao, 2018) failed to validate the findings. Only two articles were based on empirical research in OBE in engineering education, which was also rejected.

Authors (Mandal and Banerjee, 2012) conducted an empirical analysis based on the OBE system in engineering education to identify the gap between the industrial requirement and educators provision. The article failed to show any implementation of the gap-filler and validation. Authors (Waychal, 2016) presented empirical research in his article that investigates an engineering student's utilisation of available study resources. Though the article provides a conclusion on the highest preferred study resources by the students in the modern era, it fails to show the interrelationship between them and the student learning outcome. The present work is limited to the final nine articles because there is a scarcity in the availability of the relevant studies.

3. An Overview

The nine critically reviewed articles published between 2009 and 2019 include investigations of Indian engineering institutes. Authors (Pulavarthi et al., 2017; Rout, Mishra and Routray, 2018) focused on implementing project-based learning in one of the laboratory courses to improve student learning outcome attainment. The indirect and direct assessment of the courses and program outcomes indicated an excellent level of outcome attainment by the selected student population. Authors (Dhulavvagol et al., 2015; Kanmani, Shreenivas and Prasanna Kumar, 2016; Naragund et al., 2016) aimed to implement the OBE system by introducing open-ended experiments cultivating an inquiry-based learning environment in one laboratory course. The result of the implementation proved to enhance the learning skills, and the same was evident from the improvements in the grades. Author (Indiramma, 2015) implemented the OBE system in the form of project-based learning in one of the theory courses in the program. The improvement in the grades indicated the validation of the implementation. Author (Pushpavathi, 2015), in her study related to the implementation of the OBE system, slightly modified the course learning outcome and added additional elements to one of the courses without affecting its essence. The implementation improved the attainment level of the student learning outcome. Authors (Kumar, Garimella and Nalla, 2015) investigated the method of inculcating higher-order thinking in engineering students. The article provides a good guideline with validated results on implementing OBE in institutes that do not possess the autonomy to change the curriculum. Authors (Misra and Priyadarshini, 2018) applied OBE in their program by involving the stakeholder's feedback to design the curriculum.

The pre and post-test survey results obtained from students enrolled in the program validated the effect of new implementation on the student's learning acceptable behaviour. The nine articles critically reviewed in this paper have addressed various causes and effects of OBE system implementation. Hence, the results cannot be used for meta-analysis. Author (Pushpavathi, 2015) dealt with the OBE system implementation in the program core course titled "Digital Switching System", handled in the 5th semester of the Telecommunication Engineering Program at BMSCE Bangalore, India. The study population included two cohorts with 60 students in each cohort. In her study, the author (Indiramma, 2015) involved 63 students of Computer Science and Engineering Program at BMSCE, Bangalore, India and evaluated the implementation of the OBE system in the 4th-semester program core course titled "Theoretical Foundation of Computation." Authors (Naragund et al., 2016) considered the laboratory course titled "Scripting Lab" for the 3rd-semester students of Computer Science and Engineering students at BVBCET (now known as KLE Tech SoCSE) for the OBE system implementation. The study population, in this case, was 11 students.

Authors (Rout, Mishra and Routray, 2018) addressed the need for OBE system implementation. Their study involved the selected interested students of the 8th semester of engineering who participated in the final year project. The chosen student population counted ten and belonged to the Department of Electrical Engineering Program at IIIT Bhubaneswar, India. Authors (Pulavarthi et al., 2017) from the Department of Electrical Engineering, RIT, Sangli, India, implemented the OBE system in the laboratory course titled " Automation and Control Lab." The student population selected for the studies were of final year and numbered 60. Authors (Misra and Priyadarshini, 2018) implemented the OBE system in the Information Technology program, CVRCE, Bhubaneswar, India. The study compared four cohorts of undergraduate batches with 180 students in each group. The study was based on the complete change in curriculum structure based on the stakeholder's feedback. Authors (Kumar, Garimella and Nalla, 2015) from NMREC, Hyderabad, India, implemented the OBE system to gauge its effect on employability through in-campus recruitments. The study included a comparison of two consecutive cohorts. It involved

many students as the population from two successive admitting groups from four different programs. Authors (Kanmani, Shreenivas and Prasanna Kumar, 2016) from Telecommunication Engineering, BMSCE, Bangalore, India, investigated the effect of OBE implementation by considering the third-semester s tudents numbering 68 . Authors (Dhulavvagol et al., 2015) examined the impact of OBE system implementation by applying the change in curriculum. The study included a large student population from 3 cohorts of the Information Science Engineering Program at BVBCET (now known as KLE Tech SoCSE).

Since the selected nine articles employ a quantitative approach, the present study uses the criteria established by authors (Bryman, Becker and Sempik, 2008) for assessing their quality. Validity, reliability, replicability, generalizability, explicitness, transparency in the methodology, congruency to the research question and significance of the findings are the categories for assessing the articles. The maximum point of each element is 10. The total point of assessment sums up to 80. Each article's summarised score equals the ratio of the summation of marks obtained for the eight factors to the maximum point. The article inclusion encompasses the cut-off point decided by all the authors of this article in agreement. A minimum quality score (QS) of 40.0, referring to 50% of the total possible maximum score, is mandatory to include the article for the critical review. The articles with QS ranging between 40.0 to 49.0 are the least significant. The peer-reviewed articles with the QS ranging between 50.0 - 74.9 make it moderate significance. The article with QS greater or equal to 75.0 is termed to have a critical finding incorporating potential study. The form used for evaluating the paper is shown in Table 1.

Table 1: Reviewer form used by authors to review the articles

CRITERIA	P1	P2	P3	P4	P5	P6	P7	P8	P9
Validity (10)									
Reliability (10									
Replicability (10)									
Generalizability (10)									
Explicitness (10)									
Transparency (10)									
Congruency (10)	Can the proficiency of the Indian Engineering students be improved by replacing the traditional educational system with the OBE system?								
The significance of the study (10)									

4. Results and Discussion

Table 2 gives the consolidated evaluation of all the nine articles regarding the four authors' eight factors. The critical remarks on each of the selected nine articles by each of the authors of the present article are consolidated and given in Table 3.

Table 2 : Evaluation of The Selected Nine Articles

Author #	Article Code								
	P1	P2	P3	P4	P5	P6	P7	P8	P9
Author 1	59	53	70	59	70	59	56	42	72
Author 2	57	55	68	54	66	58	44	40	67
Author 3	55	54	72	56	68	55	48	36	70
Author 4	58	55	66	55	71	60	49	40	69
Average	57	54	69	56	69	58	49	40	70

The systematic review conducted using the objective approach indicates that though several articles exist in the worldwide database, none of them directly and explicitly describe the efficacy of outcome-based education on the proficiencies of Indian engineering students. The nine assorted articles from the lot of 358 articles, when critically reviewed, indicated that none of them qualified to be an article incorporating potential study. Table 2 shows that two of the nine articles chosen are of least significance and the rest are of moderate importance. As shown in Table 3, data mining indicates that none of the articles provides a direct and clear empirical validation of the OBE implementation. The results are mainly subjective, and reliability is questionable in most cases. The authors have failed to give a statistical comparison of the pre and post-implementation of the respectively selected tool of OBE.

In most of the articles, there is no mention of the course and program outcome. The response result considered is the grade and placement ratio, which are also affected by certain external factors like the quality of students and the number of companies coming for placement, etc. Though few authors have attempted to deal with the learning outcome, it is found that the mapping of CO to PO is not direct and explicit and hence the OBE implementation is inappropriate. Another point that could be inferred is that the project-based learning and open-ended laboratory components of OBE have been focused on the majority of the articles. Since it mainly addresses the student's psychomotor and affective components, the dynamic enhancement of the knowledge component remains unaddressed.

Table 3 : Details of The Reviewed Articles

Article Code	Title	Details
P1	"Defining course outcomes for digital switching systems: An Example."	IEEE conference, (Pushpavathi, 2015) (BMS Bangalore)
	Appreciations: Inclusion of seminar as a part of the assessment and expert talks	**Critical Remarks:** 1. No empirical validation 2. No direct and explicit mapping of COs and POs. Hence inappropriate implementation of OBE.
P2	"Project-based learning- Theoretical Foundation of computation course."	IEEE conference, (Indiramma, 2015) (BMS Bangalore)
	Appreciations: PBL study is praiseworthy.	**Critical Remarks:** 1. No empirical validation 2. The only validation is based on the survey; hence, the results are unreliable. 3. The criteria determining the improvement is subjective.
P3	"Enabling higher order thinking and technical communication – An Indian context for OBE."	IEEE conference,(Kumar, Garimella and Nalla, 2015) NMR Engg, Hyderabad
	Appreciations: Overall, excellent work is done.	**Critical Remarks:** 1. The sustainability of the study is questionable. 2. The work shows improvement in placing two out of the five selected programs. The external factors like the requirement of the companies, the number of companies, etc., are not considered. 3. No empirical validation.
P4	"Development of an Internet of Things (IoT) based Introductory **Laboratory** for Under Graduate Engineering Students."	IEEE conference, (Rout, Mishra and Routray, 2018) IIIT Bhubaneswar
	Appreciations:: An excellent way to measure the outcome of lab-based on a survey	**Critical Remarks:** 1. No empirical validation 2. The criteria determining the improvement is subjective. 3. No comparison between the pre and post-implementation conditions.
P5	Implementation of Course-Mini Project (CMP) in core **laboratory** course for the attainment of PO in OBE	JEET 2017, (Pulavarthi *et al.*, 2017) Sangli, Maharastra
	Appreciations: Both direct and indirect method is used to assess the OBE implementation.	**Critical Remarks:** 1. No empirical validation 2. No direct and explicit mapping of COs and POs. Hence inappropriate implementation of OBE. 3. No comparison between the pre and post-implementation conditions.
P6	Experimental Learning in Scripting Languages Laboratory	IEEE 2015, (Naragund *et al.*, 2016) BVB Hubli
	Appreciations: Good work	**Critical Remarks:** 1. No empirical validation 2. No comparison between the pre and post-implementation conditions.
P7	"Enquiry-based approach for Enhanced Learning in DBA Laboratory: A Case Study."	JEET 2015 BVBCET
	Appreciations: Unlike in Paper 6(P6), the comparison is given here.	**Critical Remarks:** 1. No empirical validation 2. The result graphs are inappropriately represented, and data cannot be interpreted. 3. No clarity between the cohorts compared.

P8	Introducing a 'Modern Tool' in Engineering Education: An Example	IEEE 2015. BMS Bangalore
		Critical Remarks: 1. No empirical validation 2. No comparison between the pre and post-implementation conditions. 3. The study cannot be generalised and lacks transparency.
P9	Stakeholder Feedback System for Curriculum Design and Improvement-A Case Study	JEET 2018 CV Raman, Bhubaneswar
	Appreciations: Overall, excellent work is done.	**Critical Remarks:** 1. No empirical validation 2. The only validation is based on the survey; hence, the results are unreliable.

5. Conclusion

An objective approach based systematic review is conducted to investigate the practical implementation of outcome-based education practices in the Indian engineering institutes. The standard database is searched for the peer-reviewed articles published between 2009 and 2019. The Mendeley reference manager is effectively used to sort and filter the articles. After several phases of rejections, nine relevant articles were selected from the first lot of 358 articles.

This article depicts that there is a lack of empirical validation of the results obtained by the researchers. The review also shows a lack of understanding amongst the researchers about the appropriate CO-PO mapping. The systematic review indicates a clear research gap of statistical validation of the results by using pre and post-implementation data for a given improvement. The study also shows a need for training the faculty to comprehend the student learning outcome mapping. The proposition: can the proficiency of the Indian Engineering students be improved by replacing the traditional educational approaches with the OBE approaches in the engineering education system? remains unanswered due to the lack of empirical validation. Thus it can be considered as a potential explorative investigation.

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