Journal of Engineering Education Transformations ,
Volume 37 , No. 3 , January 2024 , ISSN 2349-2473, eISSN 2394-1707

10.16920/jeet/2024/v37i3/24008

OBE Framework for Assessing Laboratory / Practical Courses in Engineering Programmes

N.M.Nandhitha[1], S.Emalda Roslin[2]
[1,2]Department of Electronics and Communication Engineering,
Sathyabama Institute of Science and Technology, Jeppiaar Nagar, Old Mamallapuram Road, Chennai 600119, India
[1]nandhi_n_m@yahoo.co.in,
[2] roemi_mich@yahoo.co.in

Abstract : Irrespective of the branch of study, practical/laboratory courses are integral parts of engineering curriculum. These courses develop the knowledge, skill and attitude of the graduates. It is thus necessary to frame the laboratory experiments, to create a student centric learning environment and to have suitable assessment methodologies to enhance the cognitive, affective and psychomotor skills of the engineering students. This paper proposes a framework of the above three from the authors' perspective for a software laboratory. The proposed framework can be extended to the laboratory/practical with suitable modifications in the Course Outcomes. Also in this paper, a methodology is proposed for converting the scales into marks and also the formula for calculating the marks under various heads (record, viva voce and experiment) is given. Rubrics are defined for the Performance Indicators (PIs) as specified in the Examination Reform Policy of AICTE for the Program Outcomes (POs defined by National Board of Accreditation (NBA), India).

N.M.Nandhitha
Department of Electronics and Communication Engineering,
Sathyabama Institute of Science and Technology, Jeppiaar Nagar,
Old Mamallapuram Road, Chennai 600119, India
nandhi_n_m@yahoo.co.in,

Keywords : Laboratory/practical courses, OBE, Rubrics, Course Outcomes (COs), Program Outcomes (Pos)

1. Introduction

Laboratory experiments can be classified into four groups as open-ended experiments where the algorithm, procedure and implementation are done by the students through handholding. Semi open experiments are one in which the algorithm or procedure is stated and the student has to perform the experiment on one's own and must collect the observations, analyse the observations and derive conclusions from the observation. Also, the merits, limitations, scope and applications of the experiment can be identified. The next group is the open-ended experiments where the student has to understand the problem definition, identify various solutions, analyse the feasibility of implementation of these solutions, identify the most suitable solution, implement it and obtain the observations, analyse the observation and derive the conclusions from the observed readings. Finally, a complex engineering problem is included as the last experiment of the practical courses. Here the students must frame the problem definition, identify a set solution and so on.

Devasis Pradhan (2021) discussed the effective methods for the empowerment of the performance of students undergoing Engineering course. Comparison on the traditional assessment methods and OBE, various Pedagogical methods followed in Engineering Programme, various assessment tools for OBE, difficulties in the implementation of OBE , and the various Steps to be followed for the effective Implementation of OBE in Engineering Programme were also discussed by the author [1]. Jifeng Liang (2022), proposed a novel training model based on big data analysis for the specialized professionals in electronic information science and technology. Correlation index (CI) was calculated between the demand in the knowledge required by the organization and the talent inculcated in their employees. Training candidate is identified with highest CI and trained according to the requirement of the organization. The author also developed an evaluation model based on big data for talent cultivation and a model for predicting the scores using Neural Network [2].

Genelza (2022), discussed on the various policies proposed and the various challenges faced on implementation of the OBE curriculum by philippines. The author also suggested the methods for further study of the concepts in detail and have given awareness to Filipinos about the working of the system [3]. Syeed et al (2022) implemented an OBE framework for the CSE program in Independent University (IUB), Bangladesh and have provided a direction for other Engineering programs also. The authors provided a deep insight on the following three phases. I) OBE process and its practices II) various steps involved in the development of program curriculum and the related teaching, learning, various assessment methodologies in the OBE model III) following the monitoring procedure of the academic process, assessment and accreditation for maintaining the continuous quality improvement (CQI). The proposed model can be used for tracking, monitoring, measuring and planning of OBE process [4].

Loay Alzubaidi (2017), proposed a novel comprehensive combinational approach utilizing course learning outcomes (COs) and Student learning outcomes (SOs). The proposed approach makes use of threshold, average and performance vector for assessing the CO attainment. The key performance indicators (KPIs) were used for SO attainment. This also provides a quantitative value on each COs attainment level. The author also gave an insight on the various assessment tools for measuring each course outcomes [5]. Keshav Kumar Arnepalli and Kuchu Jayasree (2022), demonstrated a tool for assessment of student level student outcomes by identifying the strengths of each individual and mapping with the individual student career progression. In this work, they have compared two different assessment tools by considering the merits and flaws at course level. One tool was question wise attainment and the other tool was student wise attainment. The tool that considers the student level outcomes was proved to be the promising one [6].

This paper also attempts to provide a useful framework for laboratory courses to the skills of engineering students. This paper is organised as follows: Chapter 2 discusses on OBE based curriculum and teaching learning in laboratory/practical courses, chapter 3 dealt with OBE based assessment, chapter 4 discusses on the course outcome attainment, conclusion with the future scope is presented in chapter 5.

2. Obe Based Curriculum and Teaching Learning in Laboratory/Practical Courses

In general, OBE starts from framing the list of experiments for the laboratory to meet the Course Outcome statements, CO-PO/PSO mapping and the methodology used for delivering the experiments [7][8].

The first step is to frame the list of experiments for the concerned laboratory along with the CO statements and CO-PO/PSO mapping matrix. Prerequisite and co-requisite requirements must also be stated in the syllabus. Irrespective of the laboratory/practical courses, the experiments can be divided into the four categories (Close ended Experiments, Semi Open-ended Experiments, Open-ended Experiments and Complex Engineering) based on the level of handholding provided by the teacher[9][10][11][12].

Number of experiments can be in decreasing order from closed ended to open ended categories and there can be a single complex engineering problem in each course. However, weightage for the marks must be in the increasing order. Assessment must be at the open-ended level where the student is allowed to formulate the problem statement. Table 1 shows the level of handholding by the teacher for each category of experiments.

Table 1: Level Of Handholding For Each Category Of Experiments

Course Outcomes/Type of Experiments	Closed ended Experiments	Semi Open-ended Experiments	Open-ended Experiments	Complex Engineering Problem
Problem Definition/Formulation (Ability to convert scenario into solvable problem statement)	Given	Given	Given	Not given
Design and development of Solution Identifying suitable mathematical formula/relationship for solving the problem	Given	Given	Not given	Not Given
Selecting a suitable algorithm Having identified the mathematical formula, various methods for implementing the same have to identified and the selection of the best algorithm based on various factors (computational complexity, scalability, robustness)	Given	Not given	Not given	Not given
Conversionof the algorithm/pseudocode in the specified programming language	Not Given	Not Given	Not Given	Not Given
Implementation of the program, debugging the errors, test cases and modifying the program if necessary	Not Given	Not given	Not given	Not given
Collecting the observations, Analysing the observed readings and deriving a conclusion based on the results.	Not Given	Not Given	Not Given	Not Given
Comment on the merits, limitations, scope and applications of the program	Not Given	Not given	Not given	Not given

As an example, list of experiments in each of the four categories for Digital Signal Processing Laboratory (B.E. ECE) is given below:

Close Ended Experiments - Generation of Periodic and non-periodic signals, Determination of Z Transform and Inverse Z Transform, Impulse response of first order and second order systems and Implementation of Linear Convolution & Correlation

Semi-Open Ended Experiments -Design and Implementation of FIR and IIR filter, Determine the frequency contents of a continuous-time signal in the discrete-time domain (Spectral Analysis), Design and Implementation of Sampling & Reconstruction, Design and Implementation of Circular Convolution

Open Ended Experiments- Design and simulation of Modulation & Demodulation, Design and Implementation of Discrete Fourier Transform & Inverse Discrete Fourier Transform.

Complex Engineering Problems - Problem 1: For a certain application, it is necessary to identify a suitable thermocouple based on its frequency response. Develop a suitable code for helping the user in this scenario. Problem 2: In forensic department, it is necessary to identify the speaker from the speech signal. Develop a code for the above scenario.

The Course Outcome statements are stated in such a way that they can be made specific for any programming laboratory. These CO statements are listed below: Table 2 gives CO-PO mapping for the defined CO statements.

After the end of the course, the students will be able to

CO1: Define the problem statement for the given scenario/Real World Problem

CO2: Develop algorithms by identifying the mathematical formula/relation

CO3: Develop the program code for the selected (the most suitable) algorithm

CO4: Analyse the suitability of the implemented program code for various test cases

CO5: Develop the final version of the program by retaining the same code/by modifying the program if necessary

CO6: Examine the results to derive conclusions and to comment on the merits, limitations, scope and applications of the developed program

Table 2: Co-po Mapping For a Programming Laboratory

CO statements	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Define the problem statement for the given scenario/Real World Problem	3											
Develop algorithms by identifying the mathematical formula/relation			3		3*	3	3	3			3	
Develop the program code for the selected (the most suitable) algorithm			3		3*	3	3	3			3	
Analyse the suitability of the implemented program code for various test cases		3		3			3					
Develop the final version of the program by retaining the same code/by modifying the program if necessary			3		3*	3	3	3			3	
Examine the results to derive conclusions and to comment on the merits, limitations, scope and applications of the developed program				3			3		3	3		3
Average	3	3	3	3	3*	3	3	3	3	3	3	3

Mapping with first four POs (which are assessing the knowledge domain) is self explanatory. For PO5 which is Modern Tool Usage, * indicates that a mapping can be done across a CO only if a modern tool is used. While developing the code or program, the student must consider the public health, safety, etc and economic perspective and hence PO6 (Engineer and Society) and PO11 (Project Management and Finance) can be mapped. In accordance with the recent trends, the code must be developed so that its lifetime is at least five years and hence PO7 (Environment and Sustainability) is mapped. Plagiarism in the code must be avoided and hence PO8 (Ethics) is mapped across those COs. Student must be capable of interpreting the results and study its advantages, disadvantages and scope of the code. Student must be capable of recording the findings in his observation and record notebook during regular class hours and also during viva voce examination with a good attitude. Hence PO9 (Individual and Team work) and PO10 are mapped with the corresponding Cos [13][14][15][16].

Having clearly planned the course delivery for the syllabus, teacher then proceeds with the student centric teaching approach where handholding is done is for close ended experiments and guidance is provided for the other two groups. Complex engineering problem is then given to the students and the teacher assesses the overall performance of the student.

3. OBE Based Assessment

Continuous assessments insist a definite methodology for collecting data from the regular laboratory experiments, model practical examination, End Semester practical Examination. In each case performance is measured in terms of student's ability to formulate/develop/implement/modify the program and his ability to record the observations, analyse the recordings, conclude the results and one's ability to answer the viva questions. In order to proceed with the assessment, it is necessary to formulate the rubrics and inform the same to the students in the very beginning of the course.

As an example, let us consider that out of overall 50 marks allotted for End Semester Practical Examinations, 30 marks are allotted for Written Examination (WE), 10 marks are allotted for Viva voce Examination (V) and 10 marks are allotted for Record notebook (R). Sample rubrics for the assessment of PO1, PO2, PO3, PO4, PO5, PO8, PO9, PO10 and PO12 along with their impact on the calculation of marks under three heads (WE, R and V) are explained in Tables 3 and 4.

Table 3: Sample Rubrics for PO1, PO2, PO3, PO4, PO5, PO8, PO9, PO10 and PO12 and Corresponding Marks (out of 50)

Performance Indicators (Examination Reform Policy, AICTE) /scales	Poor (0)	Fair (1)	Good (2)	Excellent (3)	Marks
1.4.1	Shows minimal or no ability to apply engineering concepts	Shows ability to use some Electronics engineering concepts	Able to apply most of the Electronics engineering concepts to solve engineering problems correctly	Shows skilful 3 ability to apply all the suitable Electronics engineering concepts to solve engineering problems correctly	(WE)
2.4.4	Shows no interest in drawing the conclusions	Shows interest in extracting the conclusions and could extract few conclusions	Identifies the correct conclusion statements and limitations but could not relate to the objectives	Identifies the correct conclusion statements and limitations and relate to the objectives in a consistent manner.	3 (WE)
3.4.1	Shows minimal or no ability to refine conceptual design in to a detailed design	Has an idea towards detailed design but not with the available resources	Able to have a detailed design with available resources	Shows skilful ability to improve conceptual design in to a detailed design with the available resources	6 (WE)

3.4.2	Unable to get information from the tests	Exhibits minimal ability in getting information from the tests	Shows ability to generate information through appropriate tests with less improvisation/ revision on design	Shows ability to generate information through appropriate tests with effective improvisation/ revision on the Design	6 (WE)
4.3.3	Unable to represent data in appropriate forms (table or graph)	Uses tables/graphs to represent data but lacks ability to analyze data properly	Uses tables/graphs to represent data and analyze data properly but unable to draw conclusions	Effectively uses tables/graphs to represent data and analyze data properly and draw conclusions on the analysis	6 (WE)
5.1.1	Shows minimal or no ability in identifying the need for modern tools	Shows some ability in identifying the need for modern tools	Can clearly identify the need for modern tools	Can clearly identify the need for modern tools, explain the principle and application	3 (WE)
8.1.1	Shows minimal or no interest in identifying situations of unethical professional conduct (safety procedures, cleanliness,punctuality)	Can identify unethical conduct but could not propose alternatives	Can identify unethical conduct, propose alternative but not following it	Could clearly identify unethical professional conduct and not only propose but also follow them	6 (V)
9.2.4	Breaks down at difficult situations	Sometimes composed at difficult situations	Handles difficult situations with at most composure but could not resolve the situations	Handles difficult situations with at most composure and dignity and provides solutions to resolve the situations	3 (V)
10.1.1.	Unable to read or interpret the information	Reading and understanding is limited to technical information only	Reading and understanding is not limited to only technical information but also to non -technical information	Shows skillful ability in reading, understanding and interpreting both technical and non - technical information	3 (V)
10.1.2	Unable to write a report adhering to standards of engineering documents	Can produce few concepts as clear, well constructed manner.	Most information is presented in a clear, well constructed manner.	All information is presented in a clear, well constructed, logical, interesting, well supported with engineering documents and novel sequence and is easyto follow.	6 (R)

12.1.2	Shows no or minimal ability in identifying the deficiencies	Shows ability in identifying the deficiencies but lacks knowledge in identifying information to close the gap	Shows skillful ability in identifying the deficiencies and shows some proficiency in identifying information to close the gap	Shows skillful ability in identifying the deficiencies and shows extreme proficiency in identifying information to close the gap	5 (V)

Table 4 : Rubrics To Mark Conversion For Written Examination, Viva Voce and Record

Description/ split up	Written Examination (WE)	Viva Voce (V)	Record (R)
Maximum marks	30	10	10
Performance Indicators	1.4.1, 2.4.4, 3.4.1, 3.4.2, 4.3.3, 5.1.1	8.1.1, 9.2.4, 10.1.1,12.1.2	10.1.2
Formula	Marks_WE=(Total_WE/27)*30 Where Total_WE=(Scale_1.4.1/3)*3 + (scale_2.4.4/3)*3 + (scale_3.4.1/3)*6 + (scale_3.4.2/3)*6 + (scale_4.3.3/3)*6 + (scale_5.1.1/3)*3	Marks_V=(Total_V/17)*10 Where Total_V=(scale_8.1.1/3)*6 + (scale_9.2.4/3)*3 + (scale_10.1.1/3)*3 + (scale_12.1.2/3)*5	Marks_R=(Total_R/6)*10 Where Total_R=(scale_10.1.1/3)*6

4. Course Outcome Attainment-a Discussion

Data collected as discussed in Section 3 is used for the calculation of direct attainment of Course Outcomes and a Course End Survey can be used for obtaining data for the calculation of Indirect Attainment of Course Outcomes. Course attainment procedure must also be well defined and approved by the appropriate committees at the program level and department level. Though there is no hard line in fixing the thresholds and levels for the attainment of Course Outcomes. However in general, the ratio of direct to indirect attainment is 80to 20 in percentages. Also while calculating the direct attainment, three different levels of attainment are kept as 0,1 and 2. Threshold levels and the number of students securing a particular window are fixed by the programme based on the previous year performance. Also the courses are classified into three groups namely ‘easy’, ‘medium’ and ‘Difficult’ and the thresholds and windows are different for different difficulty level of the courses. Having unique threshold and window levels for each course is not impossible.

5. Conclusion and Future Work

In this paper, OBE based curriculum, OBE based teaching learning and a framework for OBE based assessment of laboratory courses is provided in authors’ perspective. A mapping between the rubrics and marks is also provided along with the Course Outcomes and Course Outcome-Program Outcome articulation matrix. As the conventional mark split up is an even number not divisible by 3, at least for one Performance Indicator, the allotted mark is not divisible by three which needs an approximation (as the scales are 0,1,2 and 3). This can be avoided if the mark split ups can be had as a multiple of 3. Though the rubrics and framework is provided for software laboratory courses, the same can be customized for laboratories/practical with hardware experiments.

References

[1] Devasis Pradhan (2021), Effectiveness of Outcome Based Education (OBE) toward Empowering the Students Performance in an Engineering Course, Journal of Advances in Education and Philosophy, DOI: 10.36348/jaep.2021.v05i02.003, 5(2): 58-65

[2] Jifeng Liang (2022), OBE Concept for New Training Mode of Electronic Information Science and Technology Professionals under Big Data Analysis, Computational Intelligence and Neuroscience,Volume2022, Article ID 8075708, https://doi.org/10.1155/2022/8075708

[3] Genesis Gregorious c (2022), Higher education's outcomes-based education: Bane or boon?,West African Journal of Educational Sciences and Practice, Vol.1, No.1,, pp 34 - 41,

[4] Mm Mahbubul Syeed , Asm Shihavuddin, Mohammad Faisal Uddin, Mahady Hasan, And Razib Hayat Khan,(2022), Outcome Based Education (OBE): Defining the Process and Practice for Engineering Education", IEEE Access, Volume 10, pp 119170-119192

[5] Loay Alzubaidi (2017), Program Outcomesassessment Using Key Performance Indicators, Proceedings of 62 nd ISERD International Conference, Boston, USA, ISBN: 978-93-86291-88-2

[6] S Keshav Kumar Arnepalli, Kuchu Jayasree,(2022), Direct Program Outcome Assessment Tool for Creation of Student Portfolios in OBE Framework, International Journal of Mechanical Engineering, ISSN: 0974-5823 Vol. 7 No. 2

[7] https://www.aicte-india.org/sites/default/files/ExaminationReforms.pdf

[8] Muhammad Zunair Zamir, Muhammad Irfan Abid, Muhammad Rayyan Fazal, Muhammad Ali Aqdas Rehman Qazi, Muhammad Kamran, (2022), Switching to Outcome-Based Education (OBE) System, a Paradigm Shift in Engineering Education,

[9] Yenchun Jim Wu, Chih-Hung Yuan (2022), Crowdfunding Curriculum Design Based on Outcome-Based Education, Frontiers in Psychology, https://doi.org/10.3389/fpsyg.2022.845012

[10] Bimal Kumar Mawandiya, Shashikant Joshi, Bharatkumar Modi, Kaushikkumar Patel, Vikas Lakhera, Rajesh Patel, Alka Mahajan (2022),A New Comprehensive Methodology for Evaluation of Course Outcomes and Programme Outcomes, Journal of Engineering Education Transformations Vol 36, Issue: 1, Pages: 95-103

[11] Ritesh Bhat, C. Raghavendra Kamath, Kevin Amith Mathias, Prashant Mulimani (2022), Practical Implementation of Outcome-Based Education Practices in the Indian Engineering Institutes – An Objective Approach Based Investigation, Journal of Engineering Education Transformations, Vol 36, Issue: 1, Pages: 26-32

[12] Bidyadhar Subudhi , G.r. Sinha (2022),Development of Employability Skills Through Pragmatic Assessment of Student Learning Outcomes, IGI Global Publisher of Timely Knowledge, Pages: 16 DOI: 10.4018/978-1-6684-4210-4.ch004

[13] K. Premalatha, Course and Program Outcomes Assessment Methods in Outcome-Based Education: A Review, Journal of Education, Volume 199, Issue 3,

[14] T Sasipraba, R Kaja Bantha Navas, NM Nandhitha, S Prakash, J Jayaprabakar, S Poorna Pushpakala, Ganesan Subbiah, P Kavipriya, T Ravi, G Arunkumar (2020), Assessment tools and rubrics for evaluating the capstone projects in outcome based education, Procedia Computer Science, Volume 172, Pages 296-301

[15] Naveen Goel, Kusumanjali Deshmukh, Bhagwati Charan Patel , Saji Chacko (2021), Assessment Tools for Mapping Learning Outcomes With Learning Objectives, IGI Global Publisher of Timely Knowledge Pages: 44, DOI: 10.4018/978-1-7998-4784-7.ch013

[16] S. Amirtharaj, G. Chandrasekaran, K. Thirumoorthy, and K. Muneeswaran (2021), A Systematic Approach for Assessment of Attainment in Outcome-based Education, Higher Education for the Future,Volume 9, Issue 1,https://doi.org/10.1177/23476311211017744