Experiences of Teaching Computer Network Course through Lesson Outcomes

Abhishek Vichare, Prathamesh P. Churi

Abstract: National Board of Accreditation (Abbreviated as NBA) is an official and independent accreditation body of India. Many engineering colleges must adhere to the quality requirements as per the NBA guidelines. Every engineering institute must prepare a Self-Assessment Report (SAR) and submit it to a peer review team for getting NBA Accreditation. In recent years NBA has changed input-output based traditional education system to Outcome-Based Education (OBE). Outcome-Based Education is an approach where each course can have at-least N number of outcomes that students will learn at the end of the semester for a particular course. Later on, these course outcomes can be mapped with Program Outcomes (PO) and Program Educational Objectives (PEO). According to the NBA, CO's are the most granular level of objects that can be defined over a particular course. The problem with particular CO is that they are much generalized and can be mapped to 2-3 chapters of the same course. It becomes very difficult to assess student based on a particular CO. The solution is provided in this paper by dividing CO's in further lesson Outcomes (LO) for effective teaching-learning. The paper also takes a real case study of course – Computer Networks which is an undergraduate course of Mukesh Patel School of Technology Management and Engineering (MPSTME, Affiliated to NMIMS University). After defining LO's of the said course, the paper shows different Course Exit Survey Records in a graphical manner for better understanding. The methodology defined by author outperforms the current existing method defining CO's.

Keywords— OBE; outcome-based system; learning outcomes; SAR

I. INTRODUCTION

National Board of Accreditation (Abbreviated as NBA) is an official and independent accreditation body of India. Many engineering colleges must adhere to the quality requirements as per the NBA guidelines. Every engineering institute must prepare a Self-Assessment Report (SAR) and submit it to a peer review team for getting NBA Accreditation. In recent years NBA has changed input-output based traditional education system to Outcome-Based Education (OBE). OBE is defined as a methodology in which every course is defined by a particular outcome. And the outcome is a result of the assessment which every student earns after the end of every semester for a particular course.

Traditional Education system has input-output based strategy in which students are evaluated based upon certain inputs in terms of mugging up the contents of the course, memorizing equations and theorems and outputs them in the final examination. The traditional education system does not taste the knowledge, rather it just tests your memory. On another side, the traditional education system does not provide a suitable learning environment which is favorable for industry requirements. There is always a huge gap between industry and education in India. Several types of research speak about the gap between industry and education system [21, 22, 23, 24, 25]. Another aspect of traditional education is that it emphasizes student on rote learning [26, 27] and it does not define a proper strategy for teaching and learning.

On the other side, OBE is experienced based teaching-learning approach and based on ISO 9000 principles of continuous quality improvement (CQI) which was defined according to requirements of the industry. The first implementation of OBE was in USA [28, 29]. The industry is happier with the graduates that they are recruiting and the society is gaining more involved global citizens [4]. NBA has adopted the principles of OBE aiming at the fact that Indian students will get recognition not only in industry but at international level where product research and development is important.

Self-Assessment Report (SAR) emphasizes on Course Outcomes (CO), Program Outcomes (PO) as well Program Educational Objectives (PEO). As per the NBA SAR, PO attainment is done on the basis of CO. For each course, there are three to six-course outcomes, which are mapped with predefined PO's. Many researchers, academicians have proposed and proved methods for this mapping from CO to PO. But there is scope to map Learning outcomes of each unit/lecture/session with CO.

Different assessment tools are used to measure student performance and CO attainment. Similar methods can be used for LO attainment.
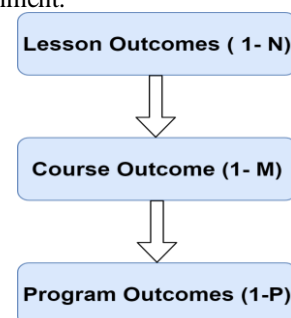

Fig. 1. Role of Lesson Outcomes in OBE

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NBA Requirement to achieve PO
- Define Course Outcomes.
- Perform Course Outcomes attainment.
- Map Course Outcomes attainment with predefined PO.

The proposed method to achieve PO-1. Define Lesson Outcomes (LO's)
- Prepare attainment of LO's. (This can be done in similar way CO's are attained.)
- Perform CO attainment.
- Map CO attainment with predefined PO.

II. OUTCOMES PREPARATION

A. Program Educational Objectives(PEO)

PEO is the feasible statement/s that describes the expected objectives of any graduate student within a few years of graduate study from the desired program [9]. Ideal characteristics of PEO is as follows :

- PEO's are real time and must be achievable enough.
- PEO statement must not be too long and must be simple and clear to understand.
- The PEO must satisfy the global and societal needs, parallel to vision and mission of the institute, etc.
- While defining PEO's, every institute must involve stakeholders like employers, industrialist, alumni, students, etc.

B. Program Outcomes [18,19,20]

The Accreditation Board for Engineering and Technology (ABET) defines Program Learning Outcomes as "statements that describe what students are expected to know and be able to do by the time of graduation. [30, 31]"

The above definition is about testing skills, knowledge and attitude of graduate expected at the completion of the program. Like the NBA, ABET has the mapping of all Students Outcomes (SO) to corresponding course outcomes. Based on these graduate attributes, the NBA has also mentioned twelve PO (program Outcomes) in their self-assessment report format. There is a lot of research has been cited about how to make effective CO's and PO's [32, 33].

C. Course Outcomes

Course outcomes are the feasible statements which define the learning expectation and outcome of a student at the end of the course. The course outcome is the heart of OBE which is then mapped with PO's. course outcomes are generally defined by faculty and verified by concern domain expert of the institution. There is as such no limit of defining course outcomes but for better learning maximum 4-6 outcomes are better.

III. PREPARING LESSON OUTCOMES

A new approach of this paper is a lesson outcome (LO) which can be defined as a simple statement which reflects the outcome of a lesson. A lesson is a small topic and has a limited scope of learning. The group of LO's constitutes Course Outcomes (CO's). LO's are considered as the lowest form of making outcomes [7].

Lesson outcomes for each lesson may play an integral role in achieving course outcomes. The mapping process of

LO to CO is the same as the mapping process of CO to PO. There are three broad types of learning outcomes according to [34] :
- Disciplinary knowledge and skills
- Generic skills
- Attitudes and values

1. Use of simple and specific action verbs

According to blooms taxonomy [11, 12], Action words help to define an appropriate method for any outcome which can be satisfied over a period of time. In this step, the focus must be on student behavior and simple, specific action verbs must be used to describe what students are expected to demonstrate.

The action verb helps to structure the alignment of any graduate program and course outcomes as well as lesson outcomes with all the feasible assessment that are defined over course[7]. The detailed blooms taxonomy action verbs are given in [11, 12]

2. Select the appropriate assessment method

According to [9, 10] assessment methods are different ways to determine whether learning outcomes are achieved. Few examples of assessment methods are listed in [35]

A number of assessment procedures are available for Course Outcomes and Program Outcomes[13, 14, 15]. Similar procedures can be used with respect to Lesson Outcomes.

IV. MAPPING LESSON OUTCOMES WITH COURSE OUTCOMES- A CASE STUDY FOR COMPUTER NETWORKS COURSE

In order to explain the two steps which are defined in Section III, authors have taken the course "Computer Networks" which is an official course at NMIMS University-School of Engineering – B.Tech in Computer Engineering Program.

The credit structure prerequisite for Computer Networks course is given in Table I below.

TABLE I. CREDIT STRUCTURE OF COMPUTER NETWORKS

Program :	B. Tech. (Computer Engineering)			Semester: IV	
Course	Computer Networks			Code :BTCO04004	
Teaching Scheme				**Evaluation Scheme**	
Lecture Hours per week	Practical Hours per week	Tutorial Hours per week	Credit	Theory (3 Hours, 70 Marks)	Internal Continuous Assessment (ICA) As per Institute Norms (50 marks)
3	2	0	4	Scaled to 70 marks	Scaled to 30 marks
Pre-requisite: Data Structures(BTCO03002)					
Objectives: This course provides the fundamental knowledge of computer networks through the understanding of the ISO-OSI model and TCP-IP model.					

Course outcomes defined for subject Course Outcomes are as follows in Table I :

TABLE II.   COURSE OUTCOMES OF COMPUTER NETWORKS

Course Outcome	Statement
CO 1	Discuss the fundamentals of computer networks, their types, transmission modes, and different reference models.
CO 2	Implement error-free transmission of data and analyze data collision with various protocols.
CO 3	Implement various routing and congestion control algorithms over a network.
CO 4	Identify Quality of service parameters and addressing techniques.
CO 5	Understand the working of application layer protocols.

The contents of the course syllabus are given in Table III.

TABLE III.   SYLLABUS CONTENTS OF COMPUTER NETWORKS

Unit	Description	Duration
1	**Introduction:** Communicating in a network-centric world, network as a platform, Architecture of the internet, Classification of Networks, Layered Models, Network Addressing, components of the network, topology, and transmission mode, Internetworking devices	06
2	**The Physical Layer:** Communication Signals, Purpose of the Physical Layer, Physical Layer Operation, Physical Layer Standards, Physical Signaling, and Encoding Physical Media: Types of Physical Media and Media Connectors, Performance, Circuit, and Packet Switching The Public Switched Telephone Network, Cable Television.	05
3	**The Data Link Layer:** Data link layer design issues, error detection, and correction, elementary data link protocols, Sliding Window Protocols, Example of Data Link Protocol: HDLC.	06
4	**Medium Access Sub-layer:** The channel allocation problem, Multiple Access Protocols, Ethernet, Data link layer switching.	06
5	**The Network Layer:** Network Layer Design issues, Routing Algorithms, Congestion Control Algorithms, and Quality of Service, X.25 and Frame Relay architecture. IPv4, IPv4 Addressing.	08
6	**The Transport Layer:** Introduction to TCP, The TCP Service, Elements of Transport Protocols, A simple Transport Protocol, The TCP Segment Header, Connection Establishment, connection release, Modeling TCP Management. The Transport: UDP, Performance Issues.	08
7	**The Application Layer:** DNS, E-Mail Services and SMTP/POP Protocols, File Transfer Protocol (FTP), WWW Service and HTTP, Multimedia, SNMP Protocol.	06
	Total	45

Text Books:
- Andrew S. Tanenbaum, "Computer Networks", Pearson Education, Fourth Edition, 2009.
- B.F. Forouzan, "Data Communications and Networking", TMH, second edition, 2008.

Reference Books:
- Mark Dye et.al, "Network Fundamentals", CCNA Exploration Companion Guide, Cisco Press, 2011.
- Kurose, Ross, "Computer Networking: _A Top-Down Approach ", 5th Edition,_ 2009, Pearson Education.
- D.E. Comer, "Computer Networks with Internet Applications", 5th edition, Prentice Hall, 2008.
- B.F. Forouzan, "TCP/IP Protocol Suite", TMH, Fourth edition, 2010.

Internal Continues Assessment Structure of Course – Computer Networks is given in Table IV below:

TABLE IV.   INTERNAL ASSESSMENT FOR COMPUTER NETWORKS COURSE

Term Work: As per the Internal Continuous Assessment (ICA) norms of the Institute
1. Minimum 10 practical experiments covering all the topics.
2. Minimum two Assignments covering the syllabus content.
3. Two class tests (15 marks each)

Table V contains individual chapter associated with corresponding course outcomes.

TABLE V.   MAPPING CHAPTERS WITH COURSE OUTCOMES OF COMPUTER NETWORKS

Chapter Number	Chapter Name	Course Outcome
1	Introduction	CO1
2	Physical Layer	CO1
3	Data Link Layer	CO2
4	Medium Access Sub Layer	CO2
5	Network Layer	CO3 CO4
6	Transport Layer	CO3 CO4
7	Application Layer	CO5

Mapping of learning outcomes to course outcomes for subject Computer Networks is done in the following manner.

Table VI and VII show the mapping of learning outcomes with course outcomes for a few topics. This is an attempt made to enhance the granularity level of the said course outcome.

TABLE VI.   MAPPING COURSE OUTCOMES TO LESSON OUTCOMES FOR CHAPTER 1 – COVERS CO1

Chapter No.	Topic name	Learning Outcome	Course Outcome
1 Total Duration – 6 Hrs	Communicating in a network-centric world, network as a platform, Architecture of the internet	LO1- Recognise the importance of network-centric world by the understanding architecture of the Internet.	CO1
	Classification of Networks, network, topology	LO2- Classify and compare different types of network based on physical size, geographical location, and communication type.	CO1
	Layered Models, network	LO3- Describe and compare ISO-OSI and TCP/IP network model.	CO1
	Addressing, components of and transmission mode,	LO4- Understand different addressing techniques and transmission modes of a network.	CO1

	Internetworking devices	LO5- Select appropriate networking devices based upon the case study given.	CO1

From table VI, It is clear that the generalized course outcome is divided into specific lesson outcomes. The granularity level reflects the following aspect of the said research:

- It helps to select appropriate pedagogy for a specific lesson instead of a specific chapter. For example: from table VI, the topic name- Internetworking devices, we have arranged a tour of network lab of our university to our undergraduate students. Whereas for the topic name- Layered Model, we have shown a graphical presentation of ISO OSI and TCP/IP model for to the class. Instead of sticking to only pedagogy per course outcome, It helped to use different pedagogy as per the changing lesson outcomes of the same course outcome.

- It helps to select the appropriate assessment tool for a specific lesson instead of a specific chapter. For example, from Table VI, the topic name – Internetworking devices, we have conducted the quiz about which internetworking devices can work on which layer of the ISO OSI layer. Whereas for the topic name- Layered Model, we have asked a question on the differentiation between the ISO/OSI model and TCP/IP model. It helped to use different assessment tool as per the changing lesson outcomes of same course outcome.

From table V, It can be seen that CO 1 covers 2 chapters. Table VI shows the mapping of lesson outcomes to course outcomes for chapter 1, Therefore table VII shows the mapping of lesson outcomes to course outcomes for chapter 2.

TABLE VII.   MAPPING COURSE OUTCOMES TO LESSON OUTCOMES FOR CHAPTER 2 – COVERS CO1

Chapter No.	Topic name	Learning Outcome	Course Outcome
2 Total Duration – 5 Hrs	Communication Signals, Purpose of the Physical Layer, Physical Layer Operation, Physical Layer Standards.	LO6- Understand the purpose, operation, and standards of the Physical layer.	CO1
	Physical Signaling and Encoding	LO7- Identify and explain appropriate signaling methods to the given problem.	CO1
	Physical Media: Types of Physical Media and Media Connectors,	LO8- Describe different types of physical media and media connectors.	CO1
	Circuit and Packet Switching	LO9- Differentiate between circuit switching and packet switching.	CO1
	The public switched Telephone Network, Cable	LO10- Describe the working of Public Switch Telephone Network and cable television	CO1

	Television.			

From table VI and VII, Total 10 lesson outcomes are listed from course outcome – I. Similar work is also done for other course outcomes.

V. RESULT AND ANALYSIS THROUGH A COURSE EXIT SURVEY

At the end of the semester, the course exit survey of the subject is taken. The questionnaire was also kept based upon the lesson outcomes. The mode of collecting responses from students made online. The sample list of a questionnaire for CO1 is given in the table below. The rating has been kept from 4 to 1 whereas 4- Very Good, 3- Good, 2-Satisfactorily and 1-Poor.

TABLE VIII.   QUESTIONNAIRE FOR CO1 – COMPUTER NETWORKS

Questionnaire for Course Outcome-I	Target Lesson Outcome	4	3	2	1
Did you understand the importance of the network in the Education and Healthcare Industry?	LO1	Different Responses from students can be recorded.			
Can you classify the network based on geographical area and type of connection?	LO2				
Did you understand the functionality of each layer in the TCP/IP and ISO-OSI model?	LO3				
Did you understand why different types of addressing schemes are required in networking?	LO4				
Did you identify the correct internetworking devices with its function?	LO5				
Can you explain why the physical layer is necessary for networking?	LO6				
Are you able to remember the different types of signaling methods and encoding techniques in the physical layer?	LO7				
Did you understand different types of physical media and their purpose at different types of communication?	LO8				
Are you able to differentiate between circuit switching and packet switching?	LO9				
Did you understand all the components involved in PSTN?	LO10				

We have made such a form for all course outcomes. An online form (given in table VIII) is circulated among students and the response of each lesson outcome is recorded. Table IX, X, XI, XII, XIII holds students responses of each course outcome. For course outcome- I, II, III, IV, V total 58, 54, 56, 51, 49 students have participated respectively. Table XIV represents, the consolidated average score of individual course outcome rating based on individual lesson outcome.

TABLE IX.   COURSE EXIT SURVEY FOR COURSE OUTCOME –I

Lesson Outcomes for CO1	LO1	LO2	LO3	LO4	LO5	LO6	LO7	LO8	LO9	LO10	The average number of students for CO1
Total Number of Students Participated in Survey	58	58	58	58	58	58	58	58	58	58	58
Total Number of Students who have marked 4	28	26	28	29	29	28	25	21	31	19	26
Total Number of Students who have marked 3	29	23	30	22	21	29	25	29	21	21	25
Total Number of Students who have marked 2	1	7	1	4	4	1	7	7	5	10	5
Total Number of Students who have marked 1	0	2	0	3	4	0	1	1	1	8	2

TABLE X.   COURSE EXIT SURVEY FOR COURSE OUTCOME –II

Lesson Outcomes for CO1	LO1	LO2	LO3	LO4	LO5	LO6	The average number of students for CO2
Total Number of Students Participated in Survey	54	54	54	54	54	54	54
Total Number of Students who have marked 4	34	31	25	27	21	28	28
Total Number of Students who have marked 3	15	13	25	26	29	21	22
Total Number of Students who have marked 2	3	8	1	0	2	5	2
Total Number of Students who have marked 1	2	2	3	1	2	0	2

TABLE XI.   COURSE EXIT SURVEY FOR COURSE OUTCOME –III

Lesson Outcomes for CO1	LO1	LO2	LO3	LO4	LO5	LO6	LO7	LO8	The average number of students for CO3
Total Number of Students Participated in Survey	56	56	56	56	56	56	56	56	56
Total Number of Students who have marked 4	38	29	29	28	33	26	32	31	30
Total Number of Students who have marked 3	18	27	22	38	23	31	24	26	26
Total Number of Students who have marked 2	0	0	3	0	0	1	0	1	0
Total Number of Students who have marked 1	0	0	2	0	0	0	0	0	0

TABLE XII.   COURSE EXIT SURVEY FOR COURSE OUTCOME –IV

Lesson Outcomes for CO1	LO1	LO2	LO3	LO4	LO5	LO6	LO7	The average number of students for CO4
Total Number of Students Participated in Survey	51	51	51	51	51	51	51	51
Total Number of Students who have marked 4	25	23	28	24	21	19	27	24
Total Number of Students who have marked 3	24	21	17	24	21	18	24	21
Total Number of Students who have marked 2	2	5	5	3	9	10	0	5
Total Number of Students who have marked 1	0	2	6	0	0	4	0	1

TABLE XIII.   COURSE EXIT SURVEY FOR COURSE OUTCOME –V

Lesson Outcomes for CO1	LO1	LO2	LO3	LO4	The average number of students for CO5
Total Number of Students Participated in Survey	49	49	49	49	49
Total Number of Students who have marked 4	31	36	37	38	36
Total Number of Students who have marked 3	10	12	12	10	11
Total Number of Students who have marked 2	8	1	0	1	2
Total Number of Students who have marked 1	0	0	0	0	0

TABLE XIV.   CONSOLIDATED COURSE EXIT SURVEY

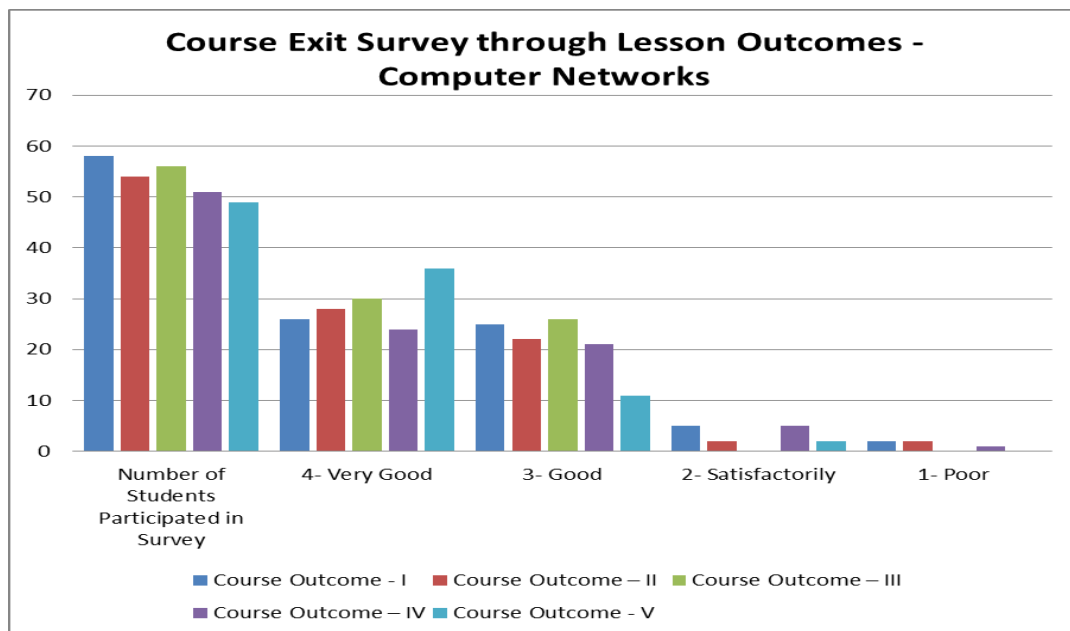| Course Outcome	Number of Students Participated in Survey	4- Very Good	3- Good	2- Satisfactorily	1- Poor
Course Outcome - I	58	26	25	5	2
Course Outcome – II	54	28	22	2	2
Course Outcome – III	56	30	26	0	0
Course Outcome – IV	51	24	21	5	1
Course Outcome - V	49	36	11	2	0

Fig. 2.   Graphical Representation of Course Exit Survey through Lesson Outcome

VI.   CONCLUSION

The research proposed the mapping of course outcomes to lesson outcomes by taking computer networks as a sample course with the analysis of the results through the course exit survey. Since the problem of course outcome is a scope which covers multiple topics. Some of the slow learners take time to understand a particular topic of same course outcome. Since assessment is generally based upon course and not on an individual topic, it is almost unpredictable for a course teacher to find out students that which topic is very difficult to understand. Dividing course outcome into lesson outcome ensures that students have understood each topic and results can be produced later on.

To conclude from results and discussions, it is observed that 87.93% (rating 3 and 4) students understood the outcome of the lesson of Course Outcome- I. 92.59% Students understood the outcome of lesson of Course Outcome –II, 100% students understood the outcome of lesson of course outcome- III, 88.23% students understood the outcome of lesson of course outcome- IV, 95.91% students understood the outcome of lesson of course outcome- V.

VII.   FUTURE RESEARCH

Future research can be summarized as follows:

- Preparation of laboratory outcomes along with lesson outcome for experimental subjects can help the student to understand practical concepts better.

- Since this research only maps corresponding lesson outcome to course outcome, in the future research mapping of individual assessment tool with individual lesson outcome will provide for granularity in Outcome-Based Curriculum.

- Mapping of Lesson Outcome with the appropriate assessment method ensures the fruitfulness of the innovative method and students can be continually assessed.

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