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A Case-Study on Leveraging the Policies on Outcome-Based Education

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Abstract: India has a broad, varied, and multifaceted technical and higher education system and is behind China and the United States in terms of the world's largest system of higher education. Accreditation is a mechanism intended to assess whether an educational institution or program satisfies the specified academic standards. While in the US the accreditation body is Accreditation Board for Engineering and Technology, Inc. (ABET), in India, it is the National Board of Accreditation (NBA) and National Assessment and Accreditation Council (NAAC). NBA accreditation model is linked to ABET via Washington Accord. The task in front of these authorities is introducing the policies to ensure that students receive the type of education they require in today's complicated and volatile world. This paper demonstrates a case-study on how the Electronics and Telecommunication Engineering Department of Fr. C. Rodrigues Institute of Technology (FCRIT) leveraged the policies and models adapted by NBA for Outcome Based Education (OBE) for raising the quality of the Bachelor of Engineering Program. It reviews the history and role played by ABET and NBA in continuously evolving the criteria for the accreditation of engineering courses. It presents the systems and processes established by the Department as per the NBA-OBE model for enhancing students' Course Outcome (CO) and Program Outcome (PO) attainments. There has been increase of 4.1% and 5% in averaged CO and PO attainments, respectively, for the 2016-20 passed out batch compared to 2014-18 batch. In conclusion, the NBA-OBE model can be leveraged further for enhancement in outcomes in the proposed autonomy model at FCRIT.

Keywords: Outcome Based Education, National Board of Accreditation, Education, Quality

1. Introduction

Implementation of Outcome-Based Education (OBE) in engineering institutes and getting the courses accredited is now becoming a top priority across all the engineering institutes spread all over the world (Willis & Kissane, 1995; Association of American Colleges and Universities, 2009; International Engineering Alliance, 2013; Bhatti & Ahmed, 2015; Wargo, 2006; MacFarlane & Brumwell, 2016) including India (Ratnalikar, 1990; Komives, 2015; Desai & Patil, 2016; Sawant, 2016; Reddy, 2018; Prasad er al., 2019; Komives, 2020). Every country has some 'Body', either government or a non-government, which shoulders the responsibility of maintaining excellence in engineering learning. While in the US this body is Accreditation Board for Engineering and Technology, Inc., (Accreditation Board for Engineering and Technology, Inc. [ABET], n.d.), in India, it is the National Board of Accreditation (National Board of Accreditation [NBA], 2019) and

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National Assessment and Accreditation Council (NAAC) (NAAC, n.d.). According to the report from the Association of American Colleges and Universities (Association of American Colleges and Universities, 2009), academic excellence in college cannot be measured entirely on the basis of enrolment, perseverance, and degree completion, as it generally is. While these widely used indicators are significant, they ignore the question of whether students who have placed their hopes for the future in higher education are receiving the type of education they require to succeed in a complicated and turbulent environment. According to MacFarlane & Brumwell (MacFarlane & Brumwell, 2016), more research is required to find how and to what extent assessment data is used to make evidence-based conclusions about effective learning techniques.

This paper attempts to demonstrate evidence-driven conclusions based upon NBA-OBE model implementation for the assessment of various learning-outcomes. It demonstrates a case-study on how the Electronics and Telecommunication Engineering (EXTC) Department of FCRIT leveraged the policies and models adapted by NBA for OBE and accreditation for raising the quality of the Bachelor of Engineering Program. The honest and sincere efforts by the teachers have helped in making the three pillars of the educational outcomes among graduating students, namely: knowledge, skill, and behavior, much more substantial. It also presents how the EXTC Department is leveraging on the policy decision on quality education and examination reforms from All India Council for Technical Education (AICTE) (All India Council for Technical Education [AICTE], 2018a; AICTE, 2018b), India, for improving the standard and quality of the question papers and evaluation methodologies. The outcomes of this study will have a significant impact in further decision making at the Institute level in carrying out corrections in the adapted OBE model.

Section 2 of this paper introduces ABET and NBA and highlights it's continuously evolving OBE models. Section 3 shows the implementation details of the OBE model by the Electronics and Telecommunication Engineering Department of FCRIT. Section 4 presents some of the results obtained related to various outcomes and discusses how it has helped in further improving our model to ensure the attainment of some of the outcomes with new policy decisions. Section 5 is the last section giving conclusions of this work.

2. Literature Review

This section presents the history and role played by ABET at the international level and NBA in India at the National level in continuously evolving the criteria for the accreditation of engineering courses.

The following paragraphs briefly explain the purpose of accreditation and OBE. It also shows how the accreditation model of NBA is linked to ABET via Washington Accord, thus bringing an international quality perspective to the Indian engineering education system.

Accreditation (ABET, n.d.; NBA, 2019) is a mechanism intended to assess whether an educational institution or program satisfies the specified academic standards. The key objective is to ensure that future learners and other participants have attained the required level of outcomes in their selected field of study for graduates in a school that offers various approved programs. Accreditation of engineering courses is the need of the hour under the current scenario where the mushrooming of low-quality institutes blurs good quality institutes, particularly in developing countries like India. Honest and sincere efforts by faculty can leverage the National level accreditation policies for raising the quality education bar in their program.

Outcome-based education (NBA, 2019) seeks to produce desirable results in the graduating students after the curriculum (in terms of knowledge, skills, attitudes, and behavior). This mainly includes course outcomes for each course in a semester, program outcomes, and program-specific outcomes at the end of a program. Based on prior experience, a sincere and honest implementation of the OBE helps a lot in understanding the importance of various outcomes and their attainment, which consequently leads to quality improvement in the program offered. In the US, ABET (ABET, n.d.), a non-governmental body, accredits applied and natural science, computing, engineering, and engineering technology post-secondary education programs. ABET also delivers diplomatic leadership through conferences, memoranda of understanding, and mutual recognition arrangements, such as the "Washington Accord".

The Washington Accord (ABET, n.d.) allows for a global accreditation arrangement between the accrediting authorities of its signatory nations and territories, for undergraduate technical engineering

academic degrees. The accord was functional in 1989 and the full signatories as of 2020 are "Australia, Canada, China, Costa Rica, Hong Kong, India, Ireland, Japan, Korea, Malaysia, New Zealand, Pakistan, Peru, Philippines, Russia, Singapore, South Africa, Sri Lanka, Taiwan, Turkey, the United Kingdom, and the United States". It recognizes the significant equivalency of programs approved by its signatory bodies and recommends for graduates of programs accepted as having fulfilled academic standards for engineering practice within the field of their jurisdiction by one of the signatory bodies. In 2007, the NBA became a conditional member of the Washington Agreement and on 13 June 2014, it was given permanent subscriber status (NBA, 2019).Accreditation Board for Engineering and Technology, Inc. (ABET, n.d.; Volkwein et al., 2004; ABET, 2019; ABET, 2020; ABET, 2017) is an ISO 9001:2015 certified non-profit, non-governmental organization in the US. ABET is voluntary accreditation, and to date has provided accreditation for 4,144 programs at 812 universities and colleges in 32 countries. Every year, over 100,000 students graduate from ABET-accredited programs, and since 1932, millions of graduates have earned degrees from ABET-accredited programs.

ABET is a professional and technical federation of member societies. Via ABET, these societies and their affiliates work to establish professional requirements, known as ABET Criteria, on which their monitoring teams base their reviews of programs under accreditation consideration.

A. Historical Overview: A Post-War Shift to Scientific Research (ABET, 2020)

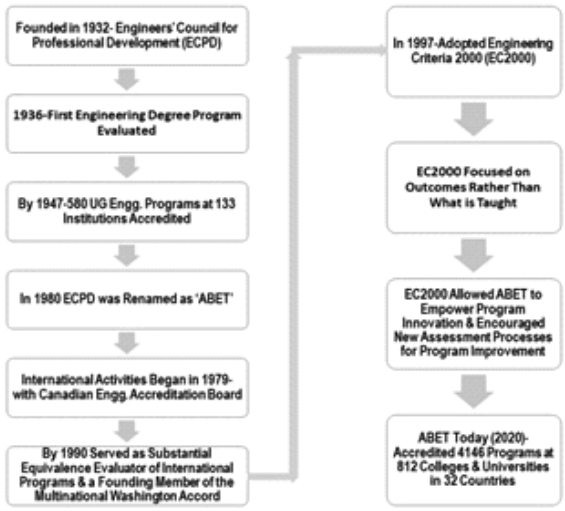

Fig. 1 : ABET history from 1932 till date (ABET, n.d.)

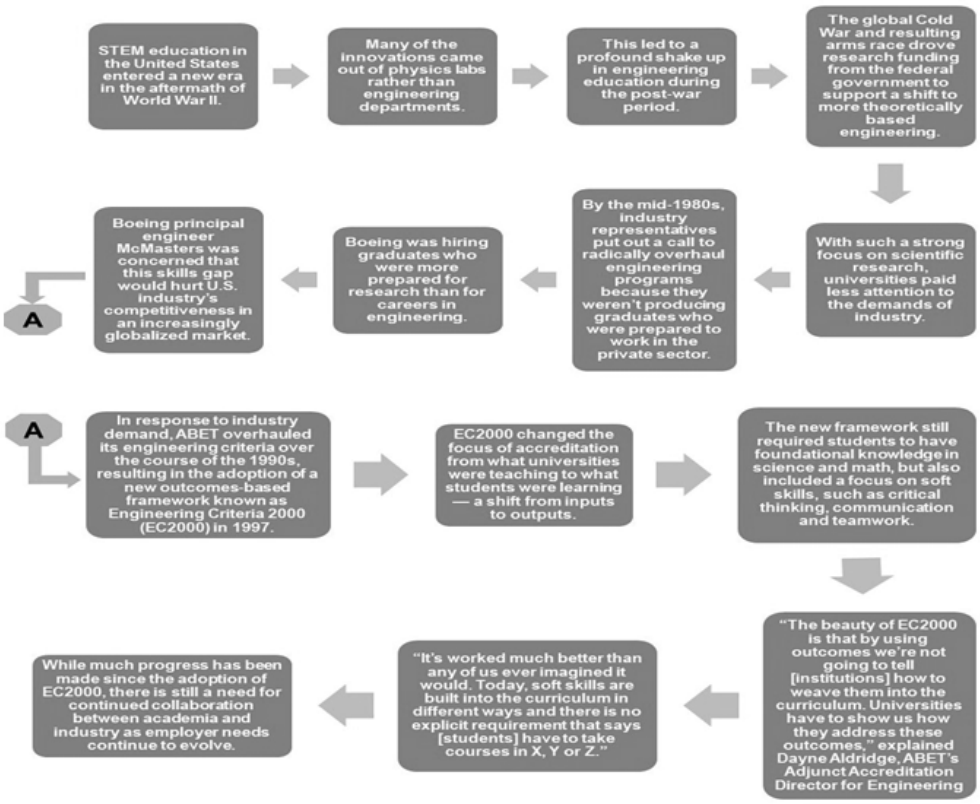

Fig. 2 : How ABET supports STEM initiatives to respond to the evolving needs of industry (ABET, 2020)

A pictorial presentation of the ABET history from 1932 until date (ABET, n.d.) is shown in Fig. 1.

It is nice to understand the link between World War II, STEM education, and the adoption of Engineering Criteria 2000 (EC2000). Fig. 2 explains this link in detail (ABET, 2020).

It is very interesting to understand how the US education became more 'theoretical' during World War II which resulted in engineers not trained and useful for the private sector and consequently industries forcing ABET to come up with outcome-based education with EC2000. ABET has approved the strategic priorities as shown in Fig. 3 for the years 2019 to 2022 (ABET, 2019).

B. National Board of Accreditation (NBA, 2019)

The review in this and the following paragraph is based on General Manual for Accreditation prepared by NBA (NBA, 2019). NBA has a broad, varied, and multifaceted technical and higher education system and is behind China and the United States in terms of the world's largest system of higher education. It comprises of "903 universities, 39,050 affiliated colleges, 10,011 standalone institutions, 12,84,755 teaching faculty and 3,41,86,925 students including 40,91,720 post-graduate and 2,07,009 research scholars". There has been phenomenal growth in total enrolment, from two lakhs in 1947 to 341 lakhs in 2017-2018. Colleges, which are affiliated with 285 affiliated universities, make up the majority of India's technical education system, resulting in about 73.93% of the overall registration. In India, various types of institutions are created, such as central government, state-supported, self-financed institutions, and colleges of national importance.

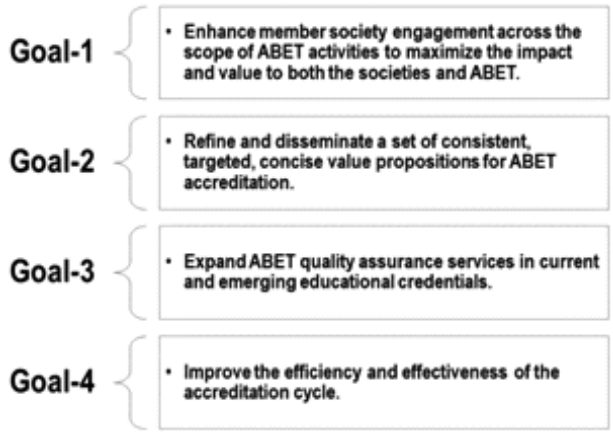

Fig. 3 : ABET strategic priorities for 2019 to 2022 (ABET, 2019)

In September 1994, AICTE founded the NBA to evaluate qualitative skills in approved technical education programs by the regulatory authorities ranging from polytechnic level to the degree level in engineering and technology, management, pharmaceutical, architectural and related disciplines.

Fig. 4: Evolution of NBA and its policies since its inception (NBA, 2019)

Fig. 4 and Table 1 show the evolution of the NBA and its policies since its inception in 1994. It is observed that the NBA became a permanent member of a Washington Accord on 13 June 2014. All the NBA accreditation evaluation processes before June 2009 were based on the input-output model. In June 2009, there was a transition in the evaluation processes from input-output to OBE. Some further fine-tuning in the OBE accreditation model was carried out until May 2015 and from June 2015 the OBE accreditation model of the NBA is stabilized for Tier-II institutions.

2. Implementation details of the OBE model by the Electronics and Telecommunication Engineering (EXTC) Department of FCRIT

The history regarding NBA accreditation awarded to the EXTC Department is shown in Fig. 5. It is noted that while the first NBA accreditation in 2006 was

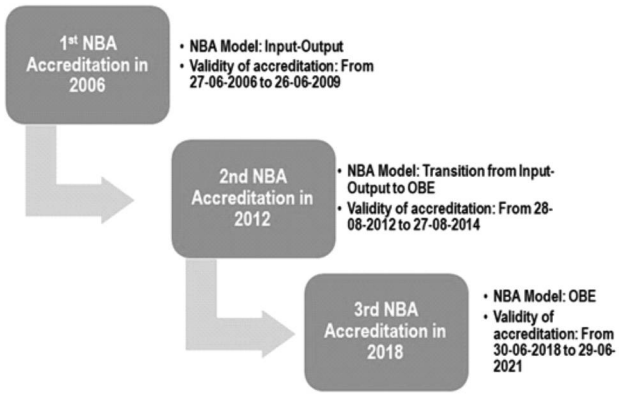

Fig. 5 : History of the EXTC department NBA accreditation

purely based on the Input-Output model, in 2012 the model was in the transition phase from input-Output to OBE. In 2012, the Department teachers were referring the terms like “Program Educational Objectives (PEOs), Course Outcomes (COs), Program Outcomes (POs)” for the first time and they did not have any meaningful understanding of these terms. This accreditation was valid until 27-08-2014.

However, FCRIT Management and the Principal decided not to apply for accreditation in a hurry without actually implementing the OBE model in a true sense and generating the three complete year's data as per the NBA requirements. In addition, from June 2015 onward the NBA OBE model was stabilized, as by that time NBA has become a permanent member of the Washington Accord. The Principal-FCRIT, the HOD of the EXTC Department, and other department teachers attended various workshops and conferences organized by the NBA to understand the OBE model in a true sense and learn the meaning of the terms like CO, PO, PSO, etc. The Self-Assessment Report (SAR) for the EXTC Department was submitted in 2018 and consequently after visit by the NBA Team the Department was awarded accreditation for the three years from 2018 to 2021. The SAR report copy submitted to the NBA in 2018 is available in reference (Department of Electronics and Telecommunication Engineering-FCRIT, 2018). This copy gives a detailed implementation of the Department OBE model for various criteria's. The following sections briefly explain some of the key policies introduced in the Department for implementation of OBE.

A. Formation of the Department Advisory Board (DAB)

The DAB was established in the year 2015. It included the representatives from various stakeholders including domain experts from reputed external educational institutes, industry representatives, alumni, students, a representative from a professional society, parents, and teachers from the Department. The DAB meetings were conducted a minimum of once a year. The main objectives of the DAB were to

- Discuss, modify, and approve Department Vision, Mission, PEOs, PSOs based on the Institute vision/mission and Department Strength, Weaknesses, Opportunities, and Threats (SWOT) analysis.

Table 1 : Evolution of NBA and its Policies are Reflected in its Accreditation Manual (NBA, 2019)

04	UG Accreditation Manual: May, 2011 (Revised and updated version of June, 2009)	□ Still, NBA-Provisional member of the Washington Accord □ Criterion I to X □ Graduate Attributes defined by the NBA □ Model: OBE □ Evaluation guidelines were given	July 2011 to January 2013.
	Available at https://www.nbaind.org/Files/engineering-programs.pdf		
05	UG Accreditation Manual: Tier-II System	□ Still, NBA-Provisional member of the Washington Accord □ Criterion I to IX □ eNBA-Online process introduced □ Model: OBE	Applicable from February 2013 to May 2015
	Available at https://www.nbaind.org/Files/NBA%20-%20Tier%20II%20Manual.pdf		
06	Current Manual for Accreditation for the Tier-II Institutions	□ NBA became permanent signatory of the Washington Accord in 2014 □ Criterion I to X □ Model: OBE-PSO introduced □ Pre-qualifier concept was introduced	From June-2015 - Till today
	Available at https://www.nbaind.org/files/NBA_UGEngg_Tier_II_Manual.pdf		

i	Chalk & Board Teaching	v	Self-Learning Online Resources	ix	Industry Visit
ii	Tutorial	vi	PPT	x	Group Discussion
iii	Remedial Coaching	vii	Simulations/Demonstrations	xi	Seminar/Oral
iv	Lab Experiment	viii	Expert Lecture	xii	Case Study

CO Mapping with Content Delivery

S. No.	Course Outcome	Mode of Delivery										
		i	ii	iii	iv	v	vi	vii	viii	ix	x	xi	xii
1	CO1	X	X	X	-	X	X	-	-	-	-	-	-
2	CO2	X	X	X	-	X	X	-	-	-	-	X	-
3	CO3	X	X	X	-	X	X	-	-	-	-	X	-
4	CO4	X	X	X	-	X	X	X	-	-	-	-	-
5	CO5	X	X	X	-	X	X	-	-	-	-	-	-

Fig. 6 : CO wise tools selected by the course-coordinator for innovative content delivery

- Discuss sample CO statements and modify them based on suggestions.

After the formulation of CO statements the course-coordinator prepares a course plan which includes innovative teaching-learning methodologies adapted by the teacher (Refer Fig. 6) and assessment tools to be used for the calculation of CO attainments based on Continuous Internal Evaluation (CIE) (Refer Fig. 7).

Next, the attainment levels of CO, PO, and PSO are calculated by following the steps given below:

- CO-PO Mapping carried out by the team consisting of course-coordinator and domain experts individually & then averaged.

	What	When (Frequency in the course)	Max marks	Evidence collected	Contributing to Course Outcomes
C* I E	Online Quizzes or Assignment Test (AT)	One each	20	Online Quiz Summary Generated in Nearpod / AT record in MS Teams	AT: CO-1 AT: CO-2 Quiz-1: CO-5
	Internal Assessment Tests	Twice	20	Test papers kept in the exam cell.	IA-1: CO-1 & CO-2 IA-2: CO-3 & CO-4
	Tutorial (NOTE-Attainment will Calculated under Home Assignment)	One Hour for Every Week	-	Recorded Sessions	Problems from Module 1 to 5 will be Covered
	Home Assignments / Oral	Minimum 8	Grading	Assignments attached in a journal	Assig-1: CO-1 Assig-2: CO-2 Assig-3: CO-2 Assig-4 to 6: CO-3 Oral: CO-3 4, 5 Assig-7: CO-4 Assig-8: CO-5

Fig. 7 : Assessment tools to be used for the calculation of CO attainments based on Continuous Internal Evaluation (CIE)

- For every CO Assessment tools are assigned by the course coordinator.
- Attainment levels are defined based on goal setting (past three years results)
- As per academic calendar & assessment tools decided CO-wise evaluation is carried out Based on pre-defined weights for various tools and goal setting CO attainment is calculated.

- PO & PSO attainment calculation Based on pre-defined weights for various tools and goal setting.
- In case CO & PO attainment is below the set goal Appropriate action is planned for the future.
- In case CO & PO attainment crosses the set goal Goal setting is enhanced as per the guidelines in OBE.

B. Introducing the Academic Audit Mechanism

Process of course Audit and Department Academic Audit through Department Quality Assurance Cell (DQAC) and Institute Quality Assurance Cell (IQAC) started from the first half of 2017. The objectives were to evaluate student, faculty, and Department performance about outcome-based education and to analyze the Action Taken Report (ATR) based on feedback collected from various stakeholders. The DQAC included an external expert and the audit was carried out at the end of every semester. IQAC audit was carried out once a year.

C. Quality Check of Internal Question Papers

FCRIT being an affiliated institute does not have control over the quality of the end-semester examination question paper. However, all the internal examination question papers are checked for quality by the Department's senior faculty members. It included cross-checking the appropriateness of the assigned Blooms levels, coverage of COs as per the assessment plan prepared by the teacher, and introducing new questions compared to previous year's question papers.

D. Other Procedures Introduced

Procedures for motivating bright students and helping weak students were introduced. Bright students were encouraged to participate in internships, national-level technical competitions, etc. while remedial classes were conducted for the weak students.

For the betterment of the standard and consistency

Table 2. Learning Outcomes While Implementing NBA-OBE Model by EXTC Department of FCRIT

Sr. No.	Process Introduced	Learning Outcomes
1.	Active involvement of various stakeholders for monitoring and enhancing quality of OBE	□ Importance of Department Advisory Board (DAB) involving all the stakeholders for further fine-tuning of the OBE model including Department vision, mission, SWOT analysis, PEOs, CO, PO, PSO, etc. via Action Taken Report (ATR). □ Importance of Industry Advisory Board (IAB) in understanding current gaps in the curriculum, communicating them to the University, and conducting various activities to fill the gaps via ATR. □ Critically analysing and implementing the suggestions given by the Department Quality Assurance Cell (DQAC) and Internal Quality Assurance Cell (IQAC) audit teams for enhancing quality of curriculum delivery and attainment of various outcomes via ATR. Based on PO attainment levels we introduced a new Students' Council at the Department level called Sustainable, Environmental and Ethical Development (SEED) to take care of some of the POs not getting covered through the syllabus. □ Deciding the top priorities by the teachers and department by self-preparing and following the five-year road map.
2.	Sponsoring teachers for Ph.D., Conferences, STTPs, Workshops, etc.	□ Our Management realised long back importance of teachers quality and they continued to sponsor teachers for Ph.D., conferences, STTPs, etc. which helped in enhancing teaching methodologies, filling the curriculum gaps, applying for research-grants, etc.
3.	Opportunities for bright students for sustaining their motivation	Following initiatives helped fast-learners in sustaining their motivation for further acceleration of their learning: □ Felicitation of the toppers; □ Internship opportunities at international and national level with concession in their attendance; □ Permitting them to carry out their projects from reputed institutions and industry;

		Encouraging them to participate in national and state level Project, hackathon, TPP , and other competitions.
4.	Remedial classes for the students 'weak' in academics	Our statistics shows that remedial classes for students weak in academics help them in passing the end-semester examinations.
5.	Feedback from various stakeholders	Feedback from students on teaching style, course- and program-exit surveys, infrastructure, etc. for further improvement in teaching and computation of attainment levels via (ATR). Feedback from employer, alumni, parents for improvement in curriculum, soft and hard skill requirements, etc. via (ATR).
6.	Student mentoring process	One teacher and few senior students assigned to every new student for mentoring them to understand academic, co- and extra-curricular related, personal or family problems and help them in sorting it out. Institute level professional councillor handles the some typical cases as and when needed. This process helps students in their confidence building, their personality development, and solving personal issues.
7.	Outside world interaction	Following outside world interaction has helped us in reducing the gap between industry and academia in terms of knowledge, skills, and attitude of our students: Guest lectures; Industrial visits; Internships; Inviting alumni for project evaluation and guidance on higher studies, etc.
		Various MoUs with reputed institutes for conducting advanced courses.
8.	Infrastructure development	Purchasing new equipment, consumables, etc. for smooth conduction of laboratories, projects, etc. as per the approved budget provision. Regular maintenance and stock verification of existing equipment.
9.	Record keeping of documents	We realized importance of record keeping of documents and preparing reports for the various activities that is very important as a 'proof' of what we are doing and what our teachers and students achieved.
10.	Faculty performance appraisal system	Our faculty performance appraisal system is developed as per the UGC guidelines and help staff to see the areas they need to improve further.
11.	Quality check of question papers	Being affiliated institute, we do not have control over quality of end-semester examination question-papers. However, all the in-semester examination question papers go through a quality check in terms of Blooms level, CO being mapped, etc. which helped in improving the quality of question papers.

of question papers and methodologies for the assessment, the EXTC Department is further exploiting the AICTE policy decision (AICTE, 2018a; AICTE, 2018b) from 2019 onward.

4. EXTC Department Learning Outcomes from NBA-OBE Model

Integrating the systems as per the NBA-OBE Model and executing them on a day-to-day basis is the commitment of FCRIT Management and Teachers. It has truly helped all the Departments of FCRIT in establishing processes, which are contributing to the overall growth of teachers and students. Table 2 on the next page shows the various well-established processes in the EXTC Department and the learning outcomes because of them.

Table 3 : Revised CO Statements by the Teacher

Course: Digital Communication, EXTC-Semester VI, FH-2017		
CO No.	CO Statement as Per University Curriculum	Revised CO Statement
	At the end of the course student will be able to:	
CO1	Understand the basics of information theory and coding techniques.	Illustrate the concept of coding, baseband, bandpass, and spread spectrum modulation systems.
CO2	Determine the minimum number of bits per symbol required to represent the source and the maximum rate at which a reliable communication can take place over the channel.	Analyze the bandwidth requirements of line codes and methods to mitigate intersymbol interference
CO3	Describe and determine the performance of different waveform techniques for the generation of digital representation of signals.	Analyze the efficiency of various source coding algorithms and the upper bound on channel capacity
CO4	Determine methods to mitigate inter-symbol interference in a baseband transmission system.	Design encoders and decoders to perform error control coding
CO5	Describe and determine the performance of different error control coding schemes for the reliable transmission of digital representation of signals and information over the channel.	Enhance their written and presentation skills related to the subject

The implementation of various OBE-related procedures mentioned in Section 3 helped the Department, teachers, and students as explained below.

A. Learning from DAB

Apart from analyzing vision/mission statements, the inputs from DAB members helped in properly writing the CO statements. For example, Table 3 shows the original CO statements for a Digital Communication course as provided by the University of Mumbai and the modified CO statements prepared by the teacher based on the understanding acquired from the DAB members regarding correct CO statements. It can be seen that the revised CO statements are more precise and appropriate confirming that teachers had learned the meaning of 'CO' and how to write them.

Step-1: CO Statements for DSD (Refer Fig. 8):

At the end of course student will be able to:	
C203.1 / ECC303.1	Explain concepts related to basic logic gates, Number systems, combinational and sequential circuits, Logic families and memories, and Programmable Logic devices.
C203.2 / ECC303.2	Illustrate reduction techniques of combinational circuits and prove Boolean identities.
C203.3 / ECC303.3	Design and implement a digital logic circuit for a given task.
C203.4 / ECC303.4	Analyze a logic circuit and identify the state transition diagram and / or output.
C203.5 / ECC303.5	Illustrate usage of VHDL for designing a combinational / sequential logic circuit.

Fig. 8 : Course outcome statements for Digital System Design course

Step-2: CO-PO mapping (Refer Fig. 9):

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C203.1 / ECC303.1	3	-	-	-	-	-	-	-	-	-	-	-
C203.2 / ECC303.2	3	2	-	-	-	-	-	-	-	-	-	-
C203.3 / ECC303.3	3	2	3	-	-	-	-	-	-	-	-	-
C203.4 / ECC303.4	3	3	-	-	-	-	-	-	-	-	-	-
C203.5 / ECC303.5	2	-	-	-	3	-	-	-	-	-	-	2
Course C203 / ECC303	3	3	3	-	3	-	-	-	-	-	-	2

Fig. 9 CO-PO mapping for Digital System Design course

Step-3: Assessment tools assigned to DSD (Refer Fig. 10):

CO-ID	CO Statement	Tool1	Tool2	Tool3
C303.1	Students should be able to explain concepts related to basic logic gates, Number systems, combinational and sequential circuits, Logic families and memories, and Programmable Logic Devices.	Internal Assessment-1	Internal Assessment-2	Assignment Test-1
C303.2	Illustrate reduction techniques of combinational circuits and prove Boolean identities.	Internal Assessment-1	Assignment Test-1	---
C303.3	Design / implement a digital logic circuit for a given task.	Internal Assessment-1	Internal Assessment-2	Assignment Test-2
C303.4	Analyze a logic circuit and identify the state transition diagram and/ or output.	Internal Assessment-2	Assignment Test-2	---
C303.5	Illustrate usage of VHDL for designing a combinational/ sequential logic circuit.	Assignment-2	MOCK Practical/Oral	---

Fig. 10 : Assessment tools assigned to Digital System Design course

The step-by-step outcomes of the process followed for the Second Year Engineering (SE) EXTC Semester III course on 'Digital System Design (DSD)' for getting the CO, PO, and PSO attainment levels are displayed

	SH2012	SH2013	SH2014	Average
Average Marks (in %)	61	58.7	60	59.9 %
% of students above Average marks	54.33	45.49	50.48	50.1 %

So the middle level goal set can be 50% students scoring 60% marks (Level-2) and others are:

- 50 - 5 = 45% students scoring 60% marks (Level-1)
- 50% students scoring 60% marks (Level-2)
- 50 + 5 = 55% students scoring 60% marks (Level-3)

This procedure is to be done for all courses to set the goal.

Fig. 11 : Goal setting for CO attainment calculations for Digital System Design course

Step-5: CO attainment calculated based on goal setting and marks obtained by each student as per the assessment tools (Refer Fig. 12):

Subject Code	Subject Name	Revised Year	Goal	Level-2	CO-1	CO-2	CO-3	CO-4	CO-5	CO-6
					Attainment Level	Attainment Level	Attainment Level	Attainment Level	Attainment Level	Attainment Level
ECC303	DIGITAL SYSTEM DESIGN	2016	60%	50%	3	3	3	1.8	3	--

Fig. 12 : Course outcome wise attainment calculations for Digital System Design course

Step-6: An action plan for the COs not attained (Refer Fig. 13):

Action plan for CO-4 which is not attained:
(a) Keep record of students who are reluctant to analyze analytical questions or unable to identify the state transition diagram output.
(b) Make it compulsory to solve and submit worksheets with analysis problems and problems related to identifying the state transition diagram output.
(c) Inculcate thinking habit by frequent and diverse questioning.

Fig. 13 : An action plan for Digital System Design CO-4 which is not attained

Step-7: PO attainment (Refer Fig. 14):

Digital System Design													
CO-ID	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C303.1	Students should be able to explain concepts related to basic logic gates, Number systems, combinational and sequential circuits, Logic families and memories, and Programmable Logic Devices.	3	--	--	--	--	--	--	--	--	--	--	--
C303.2	Illustrate reduction techniques of combinational circuits and prove Boolean identities.	3	3	--	--	--	--	--	--	--	--	--	--
C303.3	Design / implement a digital logic circuit for a given task.	3	3	3	--	--	--	--	--	--	--	--	--
C303.4	Analyze a logic circuit and identify the state transition diagram and/ or output.	1.8	1.8	--	--	--	--	--	--	--	--	--	--
C303.5	Illustrate usage of VHDL for designing a combinational/ sequential logic circuit.	3	--	--	--	3	--	--	--	--	--	--	3
Average		2.8	2.6	3	--	3	--	--	--	--	--	--	3

Fig. 14 : PO attainments because of Digital System Design course CO attainments

below in Figs. 8 to 14:

FCRIT is currently affiliated to the University of Mumbai. In the curriculum made available by the university the performance of the students need to be evaluated (i) during the semester by conducting two Internal Assessment (IA) examinations of 20 marks each for the theory course; and (ii) at the end of the semester by conducting final theory examination for 80 marks at the university level.

While in the IA examinations a course coordinator can set the question paper CO wise and can also carry out evaluation of answers CO wise, thus enabling him or her in calculating CO attainments based on IA performance. However, as the ESE is centrally conducted by the University and the question paper

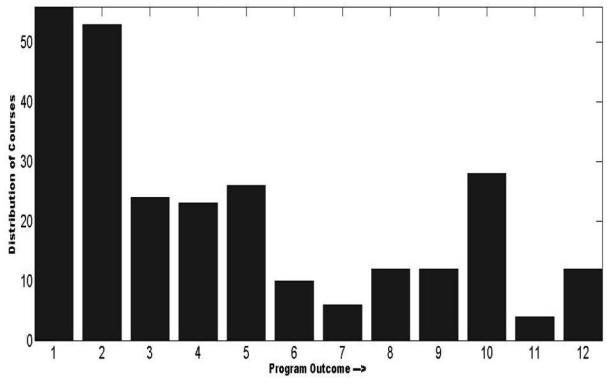

Fig.15 : Distribution of EXTC courses based on POs getting mapped

setter as well as evaluator will be from the approved panel of teachers at the University level, neither explicitly CO wise questions are set nor question wise marks are made available to the course coordinator.

Hence, it is not possible calculate CO attainments for the ESE by the course coordinator.

Also, calculating all the CO attainment with only two IA examinations is very difficult. Hence, as per the institute policy additional two assignment tests are conducted for proper evaluation of CO attainments.

Hence, for different COs different in-semester assessment tools are selected by the course coordinator.

Step-4: Goal setting for CO attainment calculations (Refer Fig.119): Please NOTE: SH2012 means Second Half of 2012 (i.e., July to December of 2012).

Based on the inputs from DAB, the compliance of the University of Mumbai EXTC curriculum for attaining POs and PSOs was analyzed at three levels:

(a) Compliance concerning weightage to the courses in HSS, Basic/Engineering Science, Core Courses, Allied / Applied courses, and Electives;

(b) Compliance concerning Pre-requisite courses;

(c) Compliance concerning the overall mapping of all the courses to POs & PSOs.

The compliance of the curriculum concerning

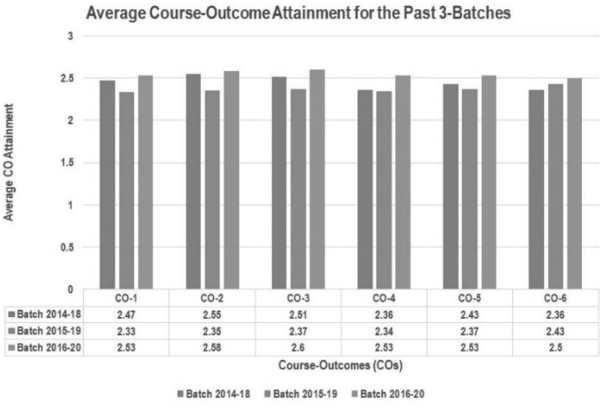

Fig.16 : Average CO wise attainment for all the courses for batches 2014-18,2015-19 and 2016-20

'Weightages', 'Prerequisite' & 'CO-PSOs' was found to be good. The distribution of courses concerning all the POs was as shown below in Fig. 15.

From this Figure, it is noted that the following three POs are not getting mapped regularly or more

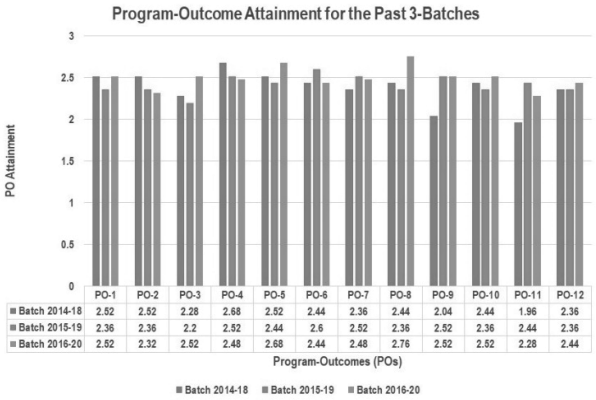

Fig. 17 : The twelve PO attainment for batches 2014-18, 2015-19, and 2016-20

frequently throughout all the semesters and they are identified as a gap in the curriculum.

- Gap 1: PO6: The Engineer & Society;
- Gap 2: PO7: Environment and Sustainability;
- Gap 3: PO11: Project Management and Finance.

The gaps identified in the curriculum were communicated to the Chairman, BoS, MU for further action. To take care of the above three POs, at the Department level a new students' chapter called 'Sustainable Ethical and Environmental Development (SEED) was started. It conducted various activities including an e-waste drive, guest lectures, etc. for creating awareness about the above three POs.

It has helped the Department in ensuring all the 12 POs are inculcated in every student.

To understand the impact of NBA-OBE model on learning outcomes by the students, the COs and POs for the three batch of students was compiled. Fig. 16 compares the CO attainments for the 2014-18, 2015-19, and 2016-20 batch students. It shows average CO attainment for CO-1 to CO-6 for all the courses from semester-1 to semester-8 for each of the three batches. It is observed that there is improvement across all the average CO attainments. To get further clarity, batch wise average of all the attainments shown in Fig. 16 was calculated and it showed increase in CO attainments by 4.1% for 2016-20 batch compared to 2014-18 batch.

Fig. 17 compares the PO attainments for the 2014-18, 2015-19, and 2016-20 batch students. It shows attainment for PO-1 to PO-12 for each of the three

batches. It is observed that there is improvement across almost all the PO attainments. To get further clarity, batch wise average of all the attainments shown in Fig. 17 was calculated and it showed increase in PO attainments by 5.0% for 2016-20 batch compared to 2014-18 batch.

B. Learning from Various Audit Mechanisms

The inputs from the DQAC audit helped the Department in introducing the following procedures.

- Based on attainment levels of CO, PO, and PSO, action to be taken report is now prepared by teachers and it is verified by DQAC.
- Started taking students feedback on infrastructure and other facilities apart from academic-related feedback.
- Format for the course audit slightly modified based on feedback.
- Curriculum gaps identified at the Department level.
- Feedback on new teaching methodologies taken.
- Process for quality check of IA question paper established.

Based on the inputs from the IQAC audit the Department modified the following processes.

- Course audit is done by the internal team.
- PSOs are now program-specific.
- All course files are now checked and signed by the HOD.
- Curriculum gaps were identified and communicated to the University of Mumbai.
- Lab utilization details are displayed in the labs.

C. Learning from Quality Check of Internal Question Papers

The process of quality check of internal question papers has helped teachers in ensuring that questions are not just belonging to Bloom's 1st two levels but level 3 and 4 as well thus enhancing the standard of the question paper.

D. Remedial Classes for Weak Students

Those students who scored less than 60% marks were identified and remedial classes were organized for them. Students were able to cope up with the difficulty levels they faced. Among all the weak students more than 68% pass the end-semester examination after remedial classes.

5. Conclusions

There has been increase of 4.1% and 5% in averaged CO and PO attainments, respectively, for the 2016-20 passed out batch compared to 2014-18 batch. This leads to the following conclusions regarding advantages in effective implementation of the NBA-OBE model.

The Department of Electronics and Telecommunication Engineering could enhance the quality of education because of serious efforts by the teachers in honestly implementing the NBA and AICTE policies announced from time-to-time and thus leveraging on it.

Teachers are now competent in writing COs mapping it to POs, calculating their attainment levels, and writing action to be taken report. The academic audit has helped teachers in understanding areas for further improvement. Now the students are aware of POs and their importance, what are the expected course outcomes, and they appreciate the importance of active participation in co-curricular and extra-curricular activities.

This success will ensure a smooth transition in achieving Institutes goal to become an autonomous institute in near future. With the recent introduction of National Education Policy 2020 by the Ministry of HRD, Government of India (Ministry of Human Resource Development-Government of India, 2020), the gaps between the current state of learning and what is needed will continue to be bridged by major reforms in higher education, that will bring the highest quality, equality, and integrity to the system.

In future this study can be extended for analysing the outcomes because of implementation of AICTE's examination reforms by the Department.

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