

Assessment of student outcomes of an electrical and electronics engineering technology programme: a case study

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ABSTRACT: In this article, the authors describe in detail the Accreditation Board for Engineering and Technology (ABET) student outcomes assessment process of the historically ABET-accredited Electrical and Electronics Engineering Technology (EEET) associate degree programme at Hafr Al Batin Community College (HBCC) in the Kingdom of Saudi Arabia. Challenges faced in the students' data collection and assessment during the Covid-19 pandemic are discussed as the student data is of paramount importance for the ABET student outcomes assessment process. Best practices of the EEET Department are outlined in preparation for the forthcoming ABET accreditation of the EEET programme at HBCC. The EEET associate programme at HBCC and its outcomes are presented and discussed including the percentage attainment of ABET student outcomes of the EEET programme for the academic year 2019-2020.

Keywords: ABET, accreditation, assessment, student outcomes

INTRODUCTION

Universities employ various methods and tools for the assessment of student outcomes. At the National University of Malaysia (Universiti Kebangsaan Malaysia), Bandar Baru Bangi, Selangor, Malaysia, both the direct and indirect assessment methods were used to evaluate the electrical engineering programme outcomes achievement in order to enhance the quality of teaching and learning process for the programme [1]. In earlier publications, the authors of the current article and others, presented and described the faculty course assessment report methodology used for the assessment of student outcomes [2][3], while preparing for the previous ABET accreditation of the Electrical and Electronics Engineering Technology (EEET) programme at Hafr Al Batin Community College (HBCC) [4].

In the literature review, the authors learned that Memon and Harb presented the main components of the electrical engineering programme assessment process at UAE University [5]. A software application was also developed in an effort to automate the programme assessment process to some extent [5].

The assessment of student outcomes of the industrial and management systems engineering programme at Kuwait University was described by Allahverdi and Aldowaisan [6]. An optimisation strategy to measure programme outcomes of the electrical engineering programme at Universiti Kebangsaan Malaysia was developed by Nordin et al [7]. The results of flipping two courses in an electrical engineering technology programme in order to increase student achievement and enthusiasm were described by Turner and Webster [8]. It was observed that engineering technology courses do not necessarily benefit from the use of the flipped course format [8].

A comparative study of all ABET-accredited associate degree programmes in Saudi Arabia was presented by Almutairi [9]. The usefulness of a comprehensive exit examination given to senior students in their final year of the electronics engineering technology programme at Texas Southern University in the USA was examined by Thomas and Darayan [10]. The data obtained from this exit examination was used for the self-assessment of the programme, as a tool for its continuous improvement, and also for ABET's assessment criteria [10].

Specific actions were proposed for the period of two years in order to adjust the conceive-design-implement-operate (CDIO) project courses in the electrical and electronic engineering programme at Duy Tan University, Da Nang, Vietnam, to better serve the student outcomes set forth by ABET [11]. An analysis of learning outcomes of an electrical engineering curriculum offered at a university of technology in South Africa was presented by Meda and Swart to determine if academics are structuring them in a way that promotes student learning [12].

Alshehri described the means and methods adopted by the Faculty of Engineering, Rabigh Branch, King Abdulaziz University for developing and assessing the generic competencies defined by the ABET Engineering Accreditation Commission for student outcomes 3 and 5 [13]. A mathematical model was developed by Faisal et al to determine the students' attainment of course learning outcomes and student outcomes in higher education institutions [14].

A comparative analysis was performed by Ayadat et al between the direct assessment results and those of indirect assessments to analyse students learning outcomes [15]. Also, a comprehensive rubric scoring system was developed by Chowdhury et al to assess and grade the senior design course of the civil engineering programme at Prince Mohammad Bin Fahd University in Saudi Arabia [16].

In this current article, the authors' contributions to these studies include:

- 1) the ABET student outcomes assessment process of the historically ABET-accredited EEET programme at HBCC is described in detail by presenting the best practices of the EEET Department;
- 2) it is anticipated that this article may be useful as a case study for academic institutions who are aspiring to accredit their associate degree programmes by the Engineering Technology Accreditation Commission (ETAC) of ABET.

EEET ASSOCIATE DEGREE PROGRAMME

Hafr Al Batin Community College (HBCC) was established to meet the skilled and technical manpower needs of the Eastern Province of the Kingdom of Saudi Arabia. In this section, the historically ABET-accredited Electrical and Electronics Engineering Technology (EEET) programme at HBCC is discussed. There is presently one track in the EEET programme; namely, Instrumentation Engineering Technology [17].

Instrumentation Engineering Technology Track

The Instrumentation Engineering Technology (IET) track was proposed and developed according to a memorandum of understanding (MoU) between HBCC and Saudi Aramco in order to prepare the EEET graduates for electrical inspection jobs at Saudi Aramco. The EEET Department has adopted the industry job requirements and competencies as a basis for the development of the new EEET programme at HBCC, in line with the MoU. The IET track of the EEET programme at HBCC is designed to have a competitive edge over the existing similarly named programmes in Saudi Arabia. The IET track is operational since the spring semester of 2016-2017 academic year. The IET track requires 23 courses, which together constitute 67 credit hours. The general and core requirements of the IET track are discussed below [17].

General Requirements

The general courses and free elective course of the IET track are shown in Tables 1 and 2, respectively. The 11 general courses constitute 31 credit hours. Currently, the free elective course for the general requirements of the IET track is Computer Applications I (OA 101), which is offered by the Computer Science and Engineering Technology Department at Hafr Al Batin Community College. However, the other three departments of HBCC including the EEET Department may choose to propose an elective course.

Table 1: General courses of the IET track of the EEET programme at HBCC.

Code	Title	Semester
ENGL 161	English Composition I	1st
IAS 100	Islamic Ideology	1st
MET 106	Computer Aided Drafting	1st
MATH 151	Applied Calculus	1st
PHYS 151	Principles of Physics	1st
EEET 110	Introduction to Electricity and Electronics	2nd
ENGL 171	English Composition II	2nd
IAS 110	Objective Writing	2nd
CSET 121	Introduction to Computer Programming	2nd
MET 101	Industrial Safety	2nd
XXX xxx	Free Elective	2nd

Table 2: Free elective course of the IET track of the EEET programme at HBCC.

Code	Title	Semester
OA 101	Computer Applications I	2nd

Core Requirements

The core courses and technical elective courses of the IET track are shown in Table 3 and Table 4, respectively.

Table 3: Core courses of the IET track of the EEET programme at HBCC.

Code	Title	Semester
EEET 214	Electric Circuits	3rd
EEET 210	Electronics	3rd
EEET 231	Instrumentation and Measurements I	3rd
EEET 211	Digital Electronics	3rd
EEET 212	Industrial Electronics	3rd
EEET 232	Instrumentation & Measurements II	4th
EEET 239	Industrial Instrumentation	4th
EEET 2xx	Elective	4th
EEET 234	Instrumentation Engineering	4th
EEET 237	Programmable Logic Controller	4th
EEET 291	Applied Project	4th
EEET 299	Summer Training	Summer

Table 4: Technical elective courses of the IET track of the EEET programme at HBCC.

Code	Title	Semester
EEET 238	Microprocessor Interfacing	4th
EEET 241	Microcontroller Applications	4th
EEET 245	Industrial Control	4th

The 12 core courses constitute 36 credit hours. As per the degree plan, the prerequisites for EEET 291 and EEET 299 courses are the completion of 40 and 50 credit hours, respectively, and/or the EEET Department's approval [17].

The history of enrolled and graduated students for the past five years in the IET track of the EEET programme at HBCC is shown in Table 5. Note that some of the early graduates of the IET track were transfer students. The EEET Department has a credit transfer policy in place to facilitate the transfer case students.

Table 5: History of enrolled and graduated students for the past five years in the IET track of the EEET programme at HBCC.

Academic year	Number of new and transfer students enrolled	Number of graduated students
2016-2017	18	-
2017-2018	50	4
2018-2019	21	28
2019-2020	14	24
2020-2021	15	11

ABET STUDENT OUTCOMES ASSESSMENT PROCESS

The EEET Department at HBCC has adopted the same five student outcomes (SOs) as specified in the 2021-2022 ABET ETAC criteria for accrediting engineering technology associate degree programmes, which also allows the programmes to include more than five student outcomes if needed [18]. The programme educational objectives (PEOs) of the EEET programme are designed to prepare the graduates for:

- PEO (1): Successful career in the field of EEET;
- PEO (2): Pursuing professional development through self-learning or advanced degrees;
- PEO (3): Contributing members of society.

The mapping of ABET student outcomes to the programme educational objectives of the EEET programme at HBCC is shown in Table 6.

Table 6: Mapping of ABET student outcomes to the programme educational objectives of the EEET programme at HBCC.

Student outcomes	PEO (1)	PEO (2)	PEO (3)
SO (1)	✓		
SO (2)			
SO (3)	✓	✓	
SO (4)	✓		
SO (5)	✓		✓

The mapping of ABET student outcomes to the core courses of the IET track of the EEET programme at HBCC is shown in Table 7. This has been carried out by only those faculty members who have taught the courses before in the EEET Department. Presently, only EEET 241 is being offered as the technical elective course by the EEET Department at HBCC. Therefore, only this particular technical elective course features in the mapping table shown in Table 7.

Table 7: Mapping of ABET student outcomes to the core courses of the IET track of the EEET programme at HBCC.

Code	SO (1)	SO (2)	SO (3)	SO (4)	SO (5)
EEET 214	✓			✓	
EEET 210	✓	✓	✓	✓	✓
EEET 231	✓	✓		✓	
EEET 211	✓	✓		✓	
EEET 212	✓	✓	✓	✓	
EEET 232	✓		✓	✓	
EEET 239	✓		✓	✓	
EEET 241	✓				✓
EEET 234	✓	✓	✓	✓	
EEET 237	✓			✓	✓
EEET 291	✓	✓	✓	✓	✓
EEET 299			✓	✓	✓

It is worth noting that all the mapping tables in this section have gone through rigorous discussions in the EEET Department ABET committee meetings before approvals. Enormous amount of care was taken by the EEET Department to ensure that the mapping shown in Table 7 is adequate enough to measure the ABET student outcomes and is not densely populated.

The ABET student outcomes assessment cycle of the IET track of the EEET programme at HBCC is shown in Figure 1.

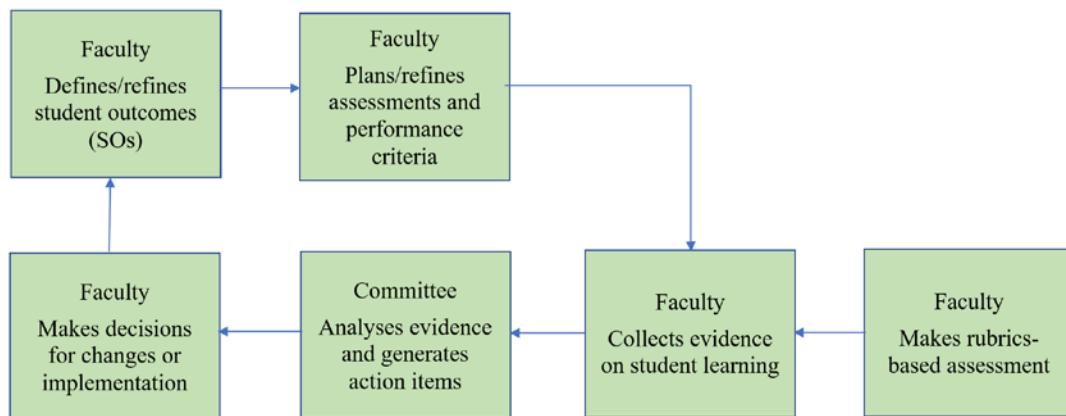


Figure 1: ABET student outcomes assessment cycle of the IET track of the EEET programme at HBCC.

The course learning outcomes assessment cycle of the IET track of the EEET programme at HBCC is shown in Figure 2.

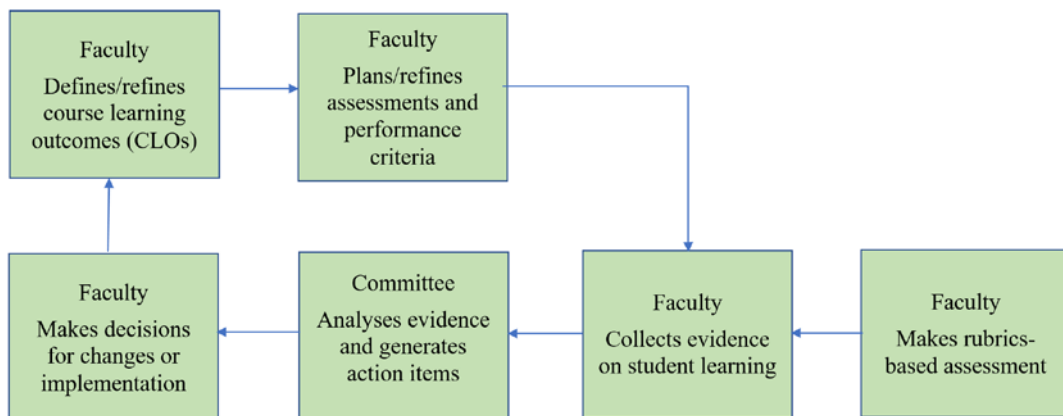


Figure 2: Course learning outcomes assessment cycle of the IET track of the EEET programme at HBCC.

The faculty members of the EEET Department define/refine the student outcomes that gauge the movement of graduates towards the PEOs. With student outcomes defined, the faculty again is the main body who defines performance criteria and implements the educational practices to collect relevant objective evidence on student learning.

Depending on the assessment strategies, the EEET Department ABET committee analyses the evidence and generates action items accordingly for closure. If there were action items from the last review cycle, decisions must be made to improve the curriculum or to refine the existing student outcomes.

Note that the CLO assessment cycle goes through a similar exercise as the ABET SO assessment cycle described above. It deals directly with the student learning experience. Students at this level may not know the student outcomes or even the PEOs, but the learning experiences they have in class are directly linked to the skill set that is intended to be developed at this stage. Therefore, assessment at this level is critical to the long-lasting success of the programme.

For each course, the responsible faculty defines/refines course learning outcomes that students should master by the end of the semester. Once evidence on student learning is collected, the responsible faculty will analyse data for any action items. The suggested action items will then be reviewed for appropriateness and will be implemented during the next regular offering of the course. This is the most time-consuming level of assessment, not only because of the amount of data needing collection, but also in the time spent on compilation and the data analysis.

The ABET student outcomes assessment plans of the IET track at HBCC for the academic year 2019-2020 (semesters 191, 192 and 193) and the academic year 2020-2021 (semesters 201, 202 and 203) are shown in Table 8. These assessment plans will enable the EEET programme to collect the data for evaluation from two graduating cohorts of students. Such an extensive exercise will ensure a robust continuous improvement of the programme.

Table 8: Assessment plans for ABET student outcomes of the IET track of the EEET programme at HBCC for the academic year 2019-2021.

Student outcomes	191	192	193	201	202	203
SO (1)	✓			✓		
SO (2)	✓	✓		✓	✓	
SO (3)		✓	✓		✓	✓
SO (4)	✓			✓		
SO (5)		✓	✓		✓	✓

The ABET student outcomes assessment plans of the IET track at HBCC for semesters 191, 192 and 193 are shown in Tables 9 to 11, respectively. The courses listed in each of these tables are the regular courses offered during that particular semester. If there are any out-of-plan courses being offered during a semester as per student need, then those out-of-plan courses will not be assessed as per the EEET Department policy.

As an example, one can notice that EEET 210 course maps to all student outcomes SO (1) - SO (5) as shown in Table 7. However, data collected from EEET 210 course during semester 191 will be used to assess only student outcomes SO (1), SO (2) and SO (4) as agreed in the EEET Department ABET committee meetings. Such a practice is necessary to reduce faculty time as the faculty members are occupied with teaching load and Departmental committee activities.

Table 9: Assessment of ABET student outcomes of the IET track of the EEET programme at HBCC for semester 191.

Code	SO (1)	SO (2)	SO (3)	SO (4)	SO (5)
EEET 214	✓			✓	
EEET 210	✓	✓		✓	
EEET 231	✓	✓		✓	
EEET 211	✓	✓		✓	
EEET 212	✓	✓		✓	

Table 10: Assessment of ABET student outcomes of the IET track of the EEET programme at HBCC for semester 192.

Code	SO (1)	SO (2)	SO (3)	SO (4)	SO (5)
EEET 232			✓		
EEET 239			✓		
EEET 241					✓
EEET 234		✓	✓		
EEET 237					✓
EEET 291		✓	✓		✓

During the summer semesters most of the faculty members are on vacation. Therefore, the ABET student outcomes targeted by the summer training course as shown in Table 11 are evaluated during the following subsequent semester in coordination by the respective summer training advisors. For example, the summer training course in semester 193 from the academic year 2019-2020 is evaluated in semester 201 from the academic year 2020-2021 as per the EEET Department policy.

Table 11: Assessment of ABET student outcomes of the IET track of the EEET programme at HBCC for semester 193.

Code	SO (1)	SO (2)	SO (3)	SO (4)	SO (5)
EEET 299			✓		✓

Various assessment tools shown in Table 12 are used by the respective faculty members for the direct and indirect evaluation of ABET student outcomes of the IET track of the EEET programme at HBCC. For all EEET courses as listed in Table 7, except EEET 291 and EEET 299, assessment instruments, such as homework, quizzes, major examinations 1 and 2, final examination, laboratory reports, midterm laboratory examination and final laboratory examination are used by the respective faculty members teaching the courses for the direct evaluation of respective ABET student outcomes as mapped in Table 9 and Table 10. For EEET 291 - Applied Project course, assessment instruments, such as progress report, final report, demonstration and presentation are used for the direct evaluation of respective ABET student outcomes as mapped in Table 10. For EEET 299 - Summer Training course, assessment instruments, such as weekly reports, mid-progress report, final report, company evaluation and presentation are used for the direct evaluation of respective ABET student outcomes as mapped in Table 11.

Table 12: Classification of assessment tools for the assessment of ABET student outcomes of the IET track of the EEET programme at HBCC.

Assessment tool	Assessment type	Assessment instrument	Schedule
Rubrics-based assessment of ABET student outcomes	Direct	Homework, quizzes, major examinations 1 and 2, final examination, laboratory reports, midterm laboratory examination, final laboratory examination, applied project reports, applied project demonstration and presentation, summer training reports and company evaluation, summer training presentation	Semester
Student course exit survey	Indirect	Survey questionnaire	Semester
Employer survey	Indirect	Survey questionnaire	Annual
Alumni survey	Indirect	Survey questionnaire	Annual
Graduating student exit survey	Indirect	Survey questionnaire	Annual
Summer training self-evaluation survey	Indirect	Survey questionnaire	Annual

The direct assessment of ABET student outcomes of the IET track of the EEET programme at HBCC for the academic year 2019-2020 is shown in Table 13. The data presented in this table comes from the rubrics-based assessment of ABET student outcomes by the respective faculty members teaching the courses as presented in Table 12. As can be seen from Table 13, the ABET student outcomes of the IET track of the EEET programme at the HBCC are found to be at the proficient level of 3 for most of the courses for the academic year 2019-2020. The other three performance levels are excellent, apprentice and novice which correspond to 4, 2 and 1, respectively. The faculty achieved the target goal of 2.4, which corresponds to 60% for the academic year 2019-2020 as demonstrated in Table 13. Therefore, there were no action plans required for any of the course offerings in the subsequent academic year 2020-2021.

Table 13: Assessment of ABET student outcomes of the IET track of the EEET programme at HBCC for the academic year 2019-2020.

Code	SO (1)	SO (2)	SO (3)	SO (4)	SO (5)	Is any action plan required?
EEET 214	3.08			3.52		None
EEET 210	3.4	3.15		3.93		None
EEET 231	3.98	3.54		4		None
EEET 211	3.64	3.45		3.82		None
EEET 212	3.6	3.57		3.88		None
EEET 232			3.43			None
EEET 239			4			None
EEET 241					3.85	None
EEET 234		3.58	2.96			None
EEET 237					3.6	None
EEET 291		3.36	3.36		3.36	None
EEET 299			3.35		3.38	None

The percentage attainment of ABET student outcomes of the IET track of the EEET programme at HBCC for the academic year 2019-2020 corresponding to Table 13 is shown in Figure 3. As can be seen from this figure, the percentage attainment of ABET student outcomes in all the core courses of the IET track of the EEET programme at HBCC is above the target goal of 60% for the academic year 2019-2020.

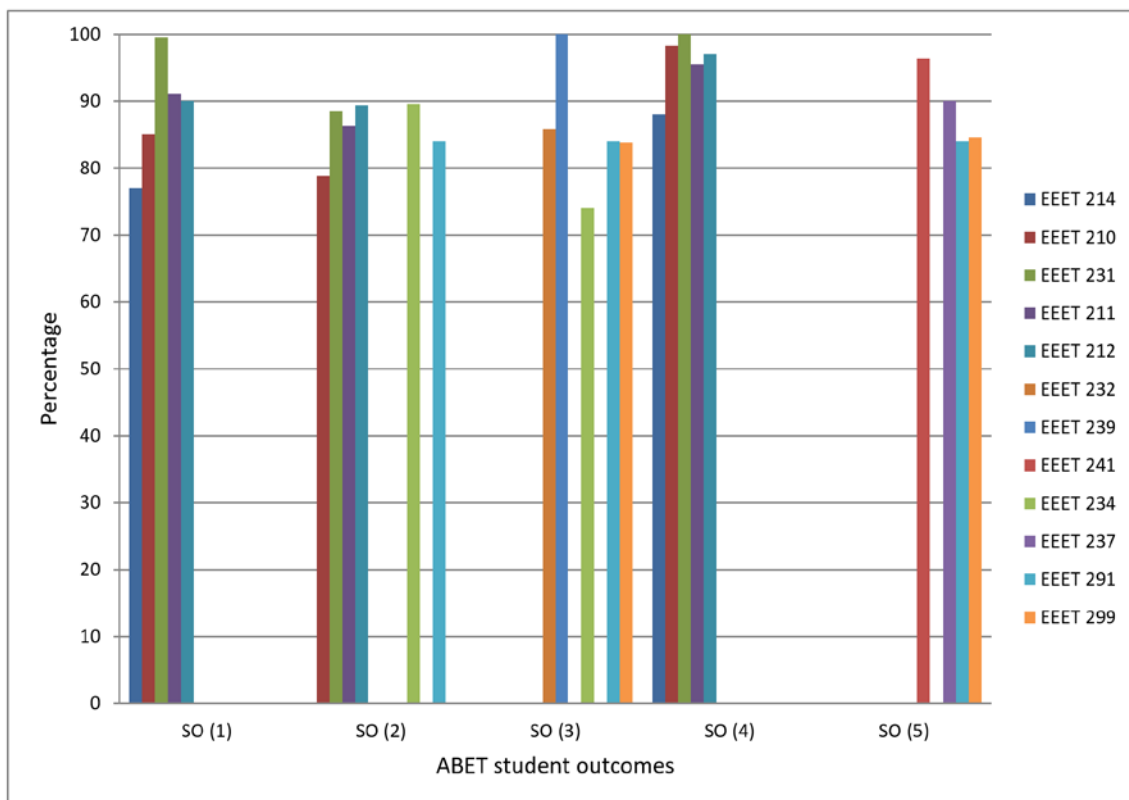


Figure 3: Percentage attainment of ABET student outcomes of the IET track of the EEET programme at HBCC for the academic year 2019-2020.

Note that the authors refer to the 2021-2022 ABET ETAC criteria for accrediting engineering technology programmes in this article. As per the General Criterion 5 - Curriculum of the ETAC of ABET, the discipline-specific content of the curriculum must represent at least one-third of the total credit hours for the curriculum, but no more than two-thirds of the total credit hours for the curriculum [18]. The discipline-specific content credit hours in the EEET programme at HBCC are shown in Table 14. As can be seen from this table, the EEET programme at HBCC, which is seeking ABET accreditation satisfies the discipline-specific content part-A of the General Criterion 5 - Curriculum of the ETAC of ABET [18].

Table 14: Discipline-specific content credit hours of the IET track of the EEET programme at HBCC.

Programme	Total CH	1/3rd of the total CH	2/3rd of the total CH	Core CH
EEET	67	22.33	44.67	36

The students' data collection and assessment have been carried out via the Blackboard learning management system during the Covid-19 pandemic. It has been a challenge for the faculty members and students to switch from the traditional classroom teaching to on-line teaching via Blackboard as hardly any of the faculty members were used to delivering on-line courses. It was a new kind of experience for the faculty and students.

The University conducted on-line workshops for the faculty and students in order to facilitate the teaching and learning activities via Blackboard. With the sufficient usage of Blackboard and supporting on-line workshops, the faculty and students gained adequate amount of expertise needed to carry out their respective teaching and learning activities.

During the peak hours many issues were reported by both the faculty and students, such as poor connectivity, poor voice quality, poor video quality, etc. The Information Technology Department at the University tried to resolve most of the reported issues as much as possible. The Blackboard settings were standardised for major and final examinations assessments for all the courses as prescribed by the University's Academic Affairs Department. In this way, students' complaints were minimal with regard to the manner in which major and final examinations were conducted via Blackboard. Moreover, all the faculty members were required to submit daily reports to their respective department coordinators as prescribed by the University's Academic Affairs Department. In this way, the faculty members were given an opportunity to officially report on a daily basis any problems faced with teaching and learning activities during the Covid-19 pandemic.

The percentage of required credit hours for general and core requirements of the IET track of the EEET programme at HBCC is shown in Figure 4.

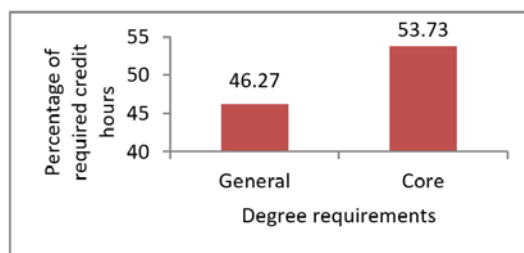


Figure 4: Percentage of required credit hours of the IET track.

CONCLUSIONS

The direct assessment process of ABET student outcomes of the IET track of the EEET programme at HBCC for the academic year 2019-2020 is described in this article. The percentage attainment of ABET student outcomes as obtained by employing the direct assessment process in all the core courses of the IET track of the EEET programme at HBCC is above the target goal of 60% for the academic year 2019-2020.

The EEET programme at HBCC, which is seeking ABET accreditation is shown to satisfy the discipline-specific content part-A of the General Criterion 5 - Curriculum of the ETAC of ABET.

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BIOGRAPHIES



Mohammed Mujahid Ulla Faiz received his diploma from M.N. Technical Institute, Bengaluru, India, in 1999, and his BE degree from Visveswaraiah Technological University, Belgaum, India, in 2003, both in electronics and communication engineering. He received his MS degree in electrical engineering from King Fahd University of Petroleum and Minerals (KFUPM), Dhahran, Saudi Arabia, in 2010. Mr Faiz is a recipient of the Best Paper Award at the *12th IEEE International Multi-Conference on Systems, Signals and Devices*, Mahdia, Tunisia, in March 2015. He is currently a Lecturer in the Electrical and Electronics Engineering Technology (EEET) Department at Hafr Al Batin Community College of the University of Hafr Al Batin, Hafr Al Batin, in Saudi Arabia. He is also currently serving as the programme coordinator, summer training coordinator and ABET coordinator of the EEET Department. His research interests include DSP, adaptive filtering and its applications

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Mubarak Saad Almutairi received his BS degree in systems engineering from King Fahd University of Petroleum and Minerals (KFUPM), Dhahran, Saudi Arabia, in 1997. He received his MS degree in industrial and systems engineering from the University of Florida, Gainesville, FL, USA, in 2003. He received his PhD degree in systems design engineering from the University of Waterloo, Waterloo, ON, Canada, in 2007. From 1997 to 2000, he was an industrial engineer with the Saudi Arabian Oil Company (Saudi Aramco). Dr Almutairi served as a member of the KFUPM board from 2011-2015, and since 2015, has been a member of the University of Hafr Al Batin board. He is currently an Associate Professor in the Computer Science and Engineering Department at the College of Computer Science and Engineering of the University of Hafr Al Batin, Hafr Al Batin, Saudi Arabia, and is serving as Dean of Hafr Al Batin Community College at this University. Dr Almutairi's

research interests include decision analysis, expert systems, risk assessment, information security, fuzzy logic and mobile government applications. He is a member of the IEEE (USA), senior member of the IIE (USA), ASNT (USA), ASEE (USA) and SCE (Saudi Arabia). Dr Almutairi is a recipient of three research grants in the field of ITC. He has edited two books and published 22 journal, conference papers and book chapters, and is also the recipient of the 2007 Distinguished Teaching Award at the University of Waterloo.