International Journal of Learning and Teaching

Volume 13, Issue 1, (2021) 13-31 www.ij-lt.eu

Assessing 'lifelong learning' through the capstone design project of BSc in EEE Programme

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Suggested Citation:
Bhuyan, M. H. (2021). Assessing 'lifelong learning' in the capstone design project for BSc in EEE Programme. *International Journal of Learning and Teaching. 13*(1), 13–31. https://doi.org/10.18844/ijlt.v13i1.5275

Received from September 10, 2020; revised from November 10, 2020; accepted from January 25, 2021;
Selection and peer review under responsibility of Prof. Dr. Jesus Garcia Laborda, University of Alcala, Spain

Abstract

Engineering education accreditation agencies have prepared a list of skills called programme outcomes (POs) or graduate attributes that a graduate must attain before his graduation from any engineering discipline. Of these POs, one of the important outcomes is lifelong learning. This skill is one of the most perplexing skills that graduates require in their professional careers. While most of these outcomes are measurable through the accustomed techniques, assessing lifelong learning is more challenging for faculty members and educators. Selecting a course to teach and assess lifelong learning is also a difficult job. The capstone design project (CDP) course may be an excellent means of transferring and strengthening the skills and proficiencies associated with lifelong learning. This paper explores how 'lifelong learning' as one of POs can be delivered, supervised, assessed and evaluated through the three CDP courses (EEE492, EEE494 and EEE496) integrated into the Bachelor of Science in Electrical and Electronic Engineering programme at Southeast University. Furthermore, this paper discusses about developing an appropriate assessment plan and rubrics to ascertain the achievement of these three courses in fulfilling this component of the accreditation. Evaluation data of the lifelong learning, assessed by the board of examiners during the final defence, is presented. Based on this, their achievements of the PO related to lifelong learning are discussed.

Keywords: Capstone design project, lifelong learning, OBE, PO assessment.

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1. Introduction

The Bachelor of Science in Electrical and Electronic Engineering (BSc in EEE) programme under the Department of Electrical and Electronic Engineering (EEE) in Southeast University (SEU) has been functioning since 15 November 2009 (Bhuyan & Khan, 2020). Already, more than 600 graduates have been produced by this department. The BSc in EEE programme had received accreditation from the Board of Accreditation for Engineering and Technical Education (BAETE) in July 2018 for 1 year (BAETE, 2019). After the expiration of that accreditation, the EEE department decided to go for the outcome-based accreditation in the next cycle. Since 1 July 2017, BAETE has changed its accreditation policy and adopted the OBE curriculum for the engineering programmes in Bangladesh to assess the graduate attributes while accrediting the concerned programmes (BAETE, 2017). As such, its academic committee designed and proposed an outcome-based curriculum (OBC); it was approved by the Curriculum Committee of the EEE department, Academic Council and the Syndicate of the University for its implementation from the Spring 2019 semester (EEE, 2020).

In this competitive world of education, getting a handsome number of students is a challenge. However, if a world-class quality engineering education can be provided, then it is not impossible to attract a good number of quality students for any engineering programme (Slade, 2017). If the student outcome or programme outcome (PO) can be achieved by ensuring an appropriate environment for the outcome-based education, curriculum, teaching–learning, assessment and accreditation, then it is possible to attract quality students for the engineering programmes because it is a holistic process to certify that the programme is offering quality engineering education to its students. BAETE adopted the OBE model to accredit any engineering programme since 1 July 2017 (BAETE, 2017). In its OBE manual, there are 12 POs. Of them, one of the essential POs is 'lifelong learning' (BAETE, 2017; 2018). The EEE department adopted all these 12 POs in the OBE-based undergraduate curriculum, where there are six mandatory credit 'capstone design project' (CDP) courses in its core course group to be offered in the three consecutive semesters of the fourth year with two credits in each semester. As per the curriculum committee meeting, the 'lifelong learning' outcome would be assessed in this course. This paper focuses on an assessment and evaluation of the 12th PO on lifelong learning through the 'CDP' course based on several performance indicators and rubrics set. These indicators are defined to quantify the fulfilment status of this PO. These data will be used as part of its reaccreditation process from 2021.

2. Literature review

Assessment and evaluation of POs is a significant part of any engineering programme evaluation to certify that the programme is operational in the right direction, sustainable in the long run, creates the necessary environment for quality engineering education and also thrives continuously to raise its excellence and standards in several aspects (Sikander, Aziz, Wasim, Hussain & Jahanzaib, 2017). In engineering education, OBE is recognised by the engineering programme accreditation agencies all over the world where various quality aspects can be evaluated through the OBE-based model (Buzzetto-More & Alade, 2006). The accreditation process helps to improve student learning by ensuring and refining the teaching–learning environment (Bhuyan, 2021). To assess the outcomes properly, various quantitative, qualitative, direct and/or indirect measurements are made (ABET, 2010). Without the assessment and evaluation, no one can certify that a particular programme of an institution of higher learning has fulfilled the minimum quality criteria and has demonstrated the least amount of physical and financial resources in its possession to provide quality education (Bhuyan & Tamir, 2020; Love & Cooper, 2004). Besides, there should have a policy in the programme for Continuous Quality Improvement (CQI) for further development and advancement of the programme (Sikander et al., 2017). The CQI process helps to develop the teaching–learning at the programme level (Alzubaidi, 2017).

The utmost imperative prerequisite of all accreditation bodies worldwide is to specify a cluster of skills and knowledge that they anticipate the graduates to attain at the point of their degree completion so that they are prepared for entering into the job market. Therefore, there must be some mechanisms in the OBE-based curriculum for assessing and evaluating those POs to be achieved. Lifelong learning is one of the vital POs set by the different accreditation bodies worldwide. It is defined as the voyage in which the people develop their knowledge, skills and attitude during their whole lives (Aspin & Chapman, 2001; Hojat, Veloski, Nasca, Erdmann & Gonnella, 2006). In the present world, employers demand that an individual should not only learn just through his/her formal education during their stay at the educational institutions but also during all stages of life and across all domains of learning (Billett & Choy, 2011). The researchers and educationists who support this standpoint explain that the central aim of tertiary education is to cultivate the pupils as lifelong learners (Candy, 1991).

Engineering educationists and researchers are trying to find the best possible means to teach lifelong learning skills for the students of an undergraduate engineering programme. However, they are yet to find the appropriate courses, assessment and evaluation schemes for this skill (Shuman, Besterfield-Sacre & McGourty, 2005). However, it is one of the important and mandatory POs that needs to be assessed by the engineering educators in Bangladesh for their students through any core courses of the programme as per the BAETE manual (2017). Lifelong learning has been defined in the BAETE manual as 'Recognise the need for and have the preparation and ability to engage in independent, lifelong learning in the broadest context of technological change' (Kishawy et al., 2014). The main difficulties in evaluating lifelong learning skills are 'the lack of consensus about definitions, the broad scope by which the outcome is assessed, and the nature of the outcome itself' (Shuman et al., 2005).

Lifelong learning skill is not supposed to be developed through classroom participation. This is more often settled in the minds of students through the other engagement outside the classroom. Therefore, the assessment and evaluation of such skills effectively are more challenging. Therefore, the real fact is that lifelong learning could extend for 30 or more years after the graduation of the students. Another real fact is that even though students may have attained the necessary lifelong learning skills, there is no assurance that the faculty members will be able to motivate the students enough to apply these skills in their professional field as performing engineers. As such, the prolonged behavioural transformation of growing as a lifelong learner, while working in the engineering profession, appears to be influenced by the abilities of the faculty members on inculcating attitudes toward acquiring the lifelong learning skills.

However, at present, the accrediting agencies around the globe mainly give partial attention to the lifelong learning skill because the industry people think that this skill is a part of the continuous professional development for the working engineers. They can develop it through their on-the-job training. Therefore, the main task of the engineering educators is to develop the attitude among the students towards lifelong learning while they are studying in the university before they enter into the professional fields of engineering.

According to Engineers Canada, continuous professional development is defined as 'the planned acquisition of knowledge, experience and skills and the development of personal qualities necessary for the execution of professional and technical duties throughout an engineer's professional life' (EC, 2020). Thus, faculty members must transfer their knowledge, skills and abilities among their students required for their future professional field. As per several regulatory bodies in Canada, there are six categories of continuous professional development that are identified. The graduates should know how to report, how to count and how to record their hours of continuous professional development. One such list has been taken from the Association of Professional Engineers of Yukon (APEY)'s website (APEY, 2020), which are as follows:

- Professional practice;

- Formal activities (including courses);
- Informal activities (including self-directed study and conferences);
- Participation (mentoring and service on technical societies);
- Presentations (at a technical conference);
- Contributions to knowledge (developing codes or standards and publishing an article).

It is very significant to underscore the need for understating the connotation and worth of lifelong learning skills for every undergraduate student studying any engineering programme. The engineering educators need to motivate their students rather than engage their students into a solitary prescribed model of being accustomed to the lifelong learning skills for their assessment purposes. However, engineering educators then may raise a valuable question that how they will assess their students that they have instilled in the mindset of their students that they have acquired and embraced an approach towards their learning that outspreads beyond the requirements of the curriculum, and as such it lasts for the rest of their life.

CDP course in the BSc in Electrical and Electronic Engineering programme is an excellent component for delivering, reinforcing and assessing lifelong learning skills and aptitudes. This paper will try to explain how 'lifelong learning' as a BAETE PO that can be assessed from the 'CDP' courses in the curriculum of the BSc in EEE programme, how to develop its contents and delivery method and how to define a metric for assessing and evaluating the students' approaches towards attaining the lifelong learning skills.

3. Objectives of the study

It is an important and challenging task to develop concepts and skills of undergraduate students in a CDP course. However, this course is one of the compulsory core courses for any undergraduate engineering students. Now in every engineering industrial sector, engineers need to deal with various issues that they may not have studied during their studies. So, they need to apply their lifelong learning skills to grasp the new knowledge rapidly and perform their assigned tasks properly. However, many faculty members have reported the difficulty of assessing and evaluating the teaching and learning level of this skill through any particular course. Several studies have been attempted to develop assessment and evaluation methods of this course in several engineering and non-engineering programmes (Rajak, Shrivastava & Shrivastava, 2019; Sikander et al., 2017), but a method for undergraduate electrical and electronic engineering programme is not still available in the literature. Therefore, the main objective of this research task is to discuss and explain a technique to measure and evaluate the course outcomes of the CDP course to be used to calculate the twelfth POs (i.e., lifelong learning) for the undergraduate students of the electrical and electronic engineering programme. The other purposes of this work are to:

i. Study various pieces of literature on the outcome assessment and evaluation process and formulate an evaluation plan for measuring the attainment of PO for 'lifelong learning' through the 'CDP' course supervised by the faculty members of the EEE department at the final year of the BSc in EEE programme.

ii. List out various indicators of lifelong learning.

iii. Identify various measurable performance indicators for this PO.

iv. Evaluate the level of achievement of each performance indicator.

v. Determine the strengths and weaknesses of the 'CDP' course and hence recommend appropriate remedial measures to be taken by the department chair or its academic committee.

4. Teaching and assessing methodology of lifelong learning

Core skills that are required for effective lifelong learning comprise self-directed and informal learning. It is very difficult to teach and assess this skill through any randomly selected course from the undergraduate engineering curriculum. Therefore, it is the first task to select a suitable course through which this skill can be delivered efficiently through several activities and can be assessed through a set of rubrics. To make the students commendable informal learners for their professional fields of engineering, the educators should focus on the procedures to frame as a set of this holistic skill that is not restricted to a definite issue of learning. Not only that, the educationists must pay distinct care to inspire the students to become self-directed and lifelong learners. Therefore, the EEE department of Southeast University, Dhaka, Bangladesh, has taken recent initiatives through its curriculum committee meeting at the permanent campus at Tejgaon of integrating lifelong learning into its CDP courses at the final year to address this issue.

The assessment and evaluation of the BSc in EEE programme started in January 2019, where a model was defined and used to measure the achievement of its POs through its curriculum committee meeting based on various direct and indirect measurements. Courses included in the programme were mapped to POs by examining individual course outcomes of each course. The first step was to examine the achievement of the learning outcomes of each course. Then, each PO was analysed individually based on data collected from the class test, assignment, midterm and final examinations' question-wise marks; feedback of the faculty members, existing students, alumni of the EEE department, intern students, parents and employers to quantify the level of accomplishment (Mehdi & Abou Naaj, 2013). The results produced by this model were not accurate as the same weight was given to all direct and indirect assessment tools contributing to the assessment of the same PO.

4.1. Curricular *initiatives*

In an engineering programme, lifelong learning must be integrated into a variety of courses. However, integrating assessments of lifelong learning must be in the CDP courses along with few other courses in the first, second and third year of study, and the students should be provided feedback continuously as and when discovered through a formative assessment (Kecskemety, Allenstein, Rhoads & Whitfiel, 2015). Therefore, it should be realised in more formal, organised and exhaustive techniques. CDP courses are one such example that may be assimilated into students' fourth year of study that permits for the formative assessment of students' lifelong learning abilities and must be addressed and emphasised properly. Through these courses, the students may get individualised formative feedback on lifelong learning issues (Patterson, Labun & Eikenaar, 2016).

One of the important focusing areas of the CDP course is to teach the students how to write research reports. This report writing skill is one of the core components of lifelong learning. The students got the opportunity to develop the writing skills through varieties of writings in their CDP proposal and final report, such as problem statement, design methodology, literature review, report organisation, model development, implementation processes, data collection process, result from analysis, discussion, future scopes etc. Besides, they need to prepare the PowerPoint slides at various stages of their works in progress, final poster etc. This process helps the graduating students to acquire problem-solving skills and critical thinking processes that are required for the engineers. When the students do the literature survey works, they are required to retrieve information through the literature survey and they need to find the flaws or drawbacks or any loopholes in those works and then identify the research problems to be solved. Then, they try to establish this through their research proposal by writing it over and over again after getting feedback from the supervisor or the board of examiners. After completing their works, they need to discuss, write, present and defend their works before the board of examiner finally and prove or validate their results by comparing with the results of other researchers. This is a kind of self-assessment via written reflections (Plouff & Morrow, 2011; Santelli, Besterfield-Sacre, Shuman & Siewiorek, 2010). Through these writing

practices, the students get the opportunities to learn and practice assessing the information gaps and then filling those gaps as much as possible. Therefore, their documentation of this course, like capstone project proposal, final report or presentation slides can provide a written document to assess the attainment of the lifelong learning skill by the individual student. Therefore, lifelong learning skills must be taught effectively through these writing practices in CDP courses.

There are three parts of the CDP course, such as EEE492 CDP I, EEE494 CDP II and EEE496 CDP III. All of these courses are offered in three consecutive semesters of the final or fourth year. In the first semester of the final year, EEE492 CDP I course is offered to all the registered students. They are taught how to retrieve research information from the literature and how to write the reflection note. Then, they are supplied several relevant research papers to find the research gaps and write their reflection on them and submit it as an assignment to be assessed by the supervisor. This may be a tool for the faculty members to assess the students' lifelong learning abilities that can be mapped to the programme outcome 12 (PO12) and assist as a formative assessment for the students of the BSc in EEE degree programme.

The engineering accreditation bodies have identified the requirements for continuous professional development that there are several steps of attaining lifelong learning skills. Of them, the first two steps are to reflect on the engineer's present form of knowledge and then identify the places where this would be required. One of the most important lifelong learning skill-attainment criteria is self-reflection, i.e., the students need to discern what information they are to secure to fill up the knowledge gaps to solve their problems. But to attain the skills, it is required to provide a lot of time and effort from the supervisors and the students (Prus & Johnson, 1994).

Another aspect of the CDP course is that the EEE offers this course to the students who are in the final year. These three courses need to take in three consecutive semesters of the final year, i.e., over 1 year as BAETE manual (BAETE, 2019). Then, the registered students are grouped, but not more than three students in a group. Each group is assigned a dedicated faculty member as the supervisor for the entire duration of their project works. Therefore, the faculty member can assess each student very closely. Besides, this course is research-intensive. So, it is easy to get writing reflections several times and hence to assess and evaluate.

Since lifelong learning skills require that the students must be proficient in a broad spectrum of professional skills the supervisor can observe the student's attitude towards the course, group members, individual and group tasks etc. Besides, the supervisor may give them some modern tools for use in their project works and can assess how fast the students grasping the knowledge of those tools, how effectively they can use those tools and how many complex problems they can solve.

4.2. Co-curricular initiatives

It has already been suggested in the literature that the engineering educationists should not only depend on curricular activities to support the lifelong learning skills, but also they will devise some methods or processes through which students get sufficient opportunities to develop those skills and thus they will be able to shift their attitudes towards lifelong learning. To make this effective for the students, the EEE department has introduced EEE Club and IEEE Student Branch for expanding co-curricular activities so the students can get the opportunity to develop their individual and professional development, including lifelong learning. All the students of the EEE department need to be a member of the EEE Club and IEEE Student Branch from the first semester of their study. The students learn individual, teamwork and leadership skills that will help them in their professional field. Thus, they can become efficient as time, crisis and change managers.

The EEE Club and IEEE Student Branch organise varieties of lecture series on non-curricular courses, workshops, seminars and training programmes that are envisioned to familiarise students with the fundamental concepts to support their academic and professional knowledge and skills. They also learn the necessity of these co-curricular initiatives taken by the department. They not only acquire

individual teamwork, and leadership skills, but also acquire professionalism, ethics and equity, and lifelong learning. Through such activities, they can become aware of health and sustainability issues, positive and robust mindset, the delightfulness of engineering identities etc. They can also assess, analyse and evaluate their knowledge, technical skills and other soft skills. Thus, they can be made committed to lifelong learning. There are no direct assessment tools or mechanisms. However, there should be some formative feedback mechanism through which the attainment of lifelong learning skills can be measured.

4.3. Metrics for assessment

In parallel to the development in the EEE programme curriculum and taking initiatives for extracurricular as well as co-curricular actives, there must be some metrics for measuring the students' capability whether they are becoming self-directed learners from the other informal means of education which can help them to become the lifelong learners. If the propensity of the students can be directed towards lifelong learning then when they will likely no longer be enrolled in their formal education and begin their engineering profession they can easily convert themselves as lifelong learners. As a result, measuring students' motivation to be self-directed learners is vital, and hence, in assessing and evaluating their capability to become lifelong learners in the future. In the accreditation guidelines, lifelong learning is emphasised in all types of engineering education. As such, the tools necessary for measuring students' attitudes towards this skillset should be developed properly. Guglielmino's (1977) Self-directed Learning Readiness Scale metric had been tested and used in a variety of situations to determine propensity for self-directed learning. This survey used a 5-point Likert scale of agreement intended to stimulate assertiveness towards lifelong learning, and it may be accommodated to ascertain the success of the BSc in EEE programme. Since this paper is advocating for CDP course to determine the attainment level of lifelong learning, therefore, from the research information retrieval skills, this can be measured by posing some questions relevant to this task. The metrics should detect whether the eagerness of the students' self-directed learning readiness upsurges with time during their studies.

4.4. Sample

The sample of 25 students used in the study was chosen from the pool of undergraduate students enrolled in the CDP course offered in the Spring 2020 semester only of the academic year 2020 at the EEE department of Southeast University. Data were collected from the rubric-based assessment tool of the CDP course offered in the final three semesters of the EEE department for one cohort of students. It is to be mentioned that the EEE department of SEU started the OBE curriculum implementation from the Spring 2019 semester with the freshers admitted in that particular semester. But we have converted the assessment model of the old curricula to gain experiences of evaluating the students' course and POs attainment based on rubric-based assessment tools for the CDP course. We have used data from the CDP courses, EEE492, EEE494 and EEE496, offered in Spring, Summer and Fall 2019 semesters, respectively.

4.5. Course outcome

A course outcome is a list of skills, competencies and/or attitudes a successful student will develop at the endpoint of a particular course. There may be further higher-level course outcomes during the entire programme, but the CDP course is a culminating course in the undergraduate EEE programme (Kasilingam, Nithiyananthan & Mani, 2017). The understanding of many courses can be reflected through the CDP course. This is a mandatory course in the final year through which most of POs can be assessed. Therefore, the course outcomes of the CDP course should be prepared and its assessment schemes should be done in such a manner to develop a deep level of understanding of this course that can be attained by the learners. In the CDP course, the faculty members teach the students in both

theory and laboratory classes. To prepare the course outcomes, we followed the SMART principles and the following standard formula for each COs as much as possible:

Action verb + Condition + Standard

Then, we wrote the following ten course outcomes for the computer programming course:

[CO1] cIdentify an electrical and electronic engineering problem that is complex and propose a solution by systematically writing proper planning within some given constraints.
[CO2] Analyse the problem, review the relevant pieces of literature and articles to have necessary technical information, propose a methodology for the works and investigate the available resources for designing the complete system and its sub-systems.
[CO3] Implement the designed system within the budgetary and time constraints using technical knowledge and skills, tools and techniques or any modern tools.
[CO4] Simulate the system using any modern tools and find the experimental results as well as analyse and compare the results acquired to meet the expected specifications.
[CO5] Estimate the impact of electrical and electronic engineering solutions in a global, economic, environmental and sustainability, health, safety and societal context.
[CO6] Identify the ethical issues that may arise during the design stages of the system.
[CO7] Function in a team as a group member or team leader.
[CO8] Communicate with all members to complete the project in time, and be able to write technical reports, present the works in oral and poster formats.
[CO9] Recognise the importance of engaging in lifelong learning.
[CO10] Manage and control the financial issues of the CDPs.

At the EEE department of SEU, course delivery is conducted face-to-face inside the classes, with the Moodle e-Learning system and Google classroom technique being used as a complementary learning management system, although the latter two techniques are yet to be fully implemented. Course syllabi are distributed to the students at the very first day of the class of each semester where all lecture and examination schedules, required text and reference books are mentioned, assessment plans are specified clearly (i.e., which questions of class tests, midterm and final examinations, assignment topics, course projects etc. will be counted for CO assessment), CO–PO mappings are also shown.

4.6. Programme outcomes

The BSc in EEE programme offered at SEU has four major areas of concentration, viz. power and energy, electronics, communication and computer. The BSc degree in EEE requires that students earn the degree with anyone area as his/her major and another one area as his/her minor with minimum degree requirements of 153 credits. Its curricula follow the guidelines set by the UGC, Bangladesh (Bhuyan & Khan, 2018; UGC, 2018) and BAETE, Bangladesh. The curricula have been designed by the academic and curriculum committee comprising five external academic and industry members and also taking the opinions of local and regional requirements from the Industry Advisory Panel comprising 10 external industry expert members and one alumni member. There are 12 POs of this programme as suggested by the BAETE. Graduates are expected to be able to achieve these 12 qualities at the instant of their degree completion (BAETE, 2017). Of them, the twelfth PO is related to lifelong learning so that the graduates can recognise the need for and have the preparation and ability to engage in independent, lifelong learning in the broadest context of technological change.

4.7. CO–PO mapping and performance assessment

Key performance indicators (KPIs) are measurable quantities that every student must meet to justify the attainment of the outcome in several courses of the programme where he/she is studying (ABET, 2010). These parameters indicate what performance the learners are expected to establish in themselves right after the completion of their programme. For each PO listed above related to the BSc in EEE programme, the expected knowledge, skills and attitude required to achieve that outcome were listed to define various performance indicating parameters for the BSc in EEE programme. Related specific teaching domains with levels, teaching–learning strategies and assessment tools of a particular course are identified and listed in Table 1 with the PO mapped to each CO of this particular course. To provide students with the necessary knowledge of the capstone project, various levels of the cognitive domain in the teaching–learning strategies are followed in this course. It has been observed that this technique is more realistic than that in the traditional technique of teaching–learning strategies (Bhuyan, 2014; Bhuyan & Khan, 2014; Bhuyan et al., 2014). The measurement of the attainment level of each CO and PO is carried out by using one or more components of the rubric-based assessment tools (Table 1). The assessment tool, criteria and time-frame are shown in Table 2.

Table 1. CO–PO mapping, teaching domain, teaching–learning strategy and assessment tools of the computer programming course

Course outcome	PO	Teaching domain and level	Teaching–learning strategy	Assessment tools
[CO1] Identify an electrical and electronic engineering problem that is complex and propose a solution by systematically writing proper planning within some given constraints	PO2	Cognitive/Apply	Discussion on the project proposal, question and answer (QA) session	Project proposal form
[CO2] Analyse the problem, review the relevant pieces of literature and articles to have necessary technical information, propose a methodology for the works, and investigate the available resources for designing the complete system and its sub-systems	PO4	Cognitive/Analyse	Discussion on Chapters 1 & 2, question and answer (QA) session	Chapters 1 & 2 of the report
[CO3] Implement the designed system within the budgetary and time constraints using technical knowledge and skills, tools and techniques or any modern tools	PO3	Psychomotor/ Naturalisation	Discussion on demonstrated project work QA session	Demonstrated project + Chapters 3 & 4 of the report
[CO4] Simulate the system using any modern tools and find the experimental results as well as analyse and compare the results acquired to meet the expected specifications	PO5	Psychomotor/ Naturalisation	Discussion on Chapters 3 & 4, QA session	Chapters 3 & 4 of the report
[CO5] Estimate the impact of electrical and electronic engineering solutions in a global, economic, environmental, and sustainability, health, safety and societal context	PO6, PO7	Affective/ Characterisation	Discussion on Chapter 5, question and answer session	Chapter 5 of the report
[CO6] Identify the ethical issues that may arise during the design stages of the system	PO8	Affective/Valuing		

[CO7] Function in a team as a group member or team leader	PO9	Affective/Valuing	Weekly Meeting and Group Discussion	FGD
[CO8] Communicate with all members to complete the project in time, and be able to write technical reports, present the works in oral and poster formats	PO10	Affective/ Organisation		FGD Final Report PowerPoint Slide, Poster
[CO9] Recognise the importance of engaging in lifelong learning	PO12	Affective/ Naturalisation		FGD
[CO10] Manage and control financial issues of the capstone design projects	PO11	Affective/ Naturalisation	Discussion on Chapter 5, QA session	Chapter 5 of the report

Table 2. Assessment criteria and tools to evaluate student performance on lifelong learning skills for PO12

Course outcome	Assessment criteria	Assessment tools	Time frame
[CO9] Recognise the importance of engaging in lifelong learning	Assessment of Future Scopes of the Project	CDP_RUB_14 for a Section in Chapter 6 of Final Report	End of Semester

Table 3. Assessment plan of capstone design project course

Assessment tool	Scale level	Full marks	Key performance indicators				
			KPI_LLL9.1	KPI_LLL9.2	KPI_LLL9.3	KPI_LLL9.4	KPI_LLL9.5
Rubric	Excellent	5	Personal interests and goals	Information literacy	Taking the responsibility for learning	Critical thinking	Personal development
	Very Good	4					
	Average	3					
	Poor	2					
	Very Poor	1					

A performance scale is also developed based on the percentage of scores obtained in each CO contributed from different direct assessment tools discussed in Table 2. This is shown in Table 3 as per the policy of Southeast University across all the departments (Bhuyan & Khan, 2018).

Initially, the CO achievement target has been set to 50%; that means 50% of students of the cohort of this course should be at the satisfactory or above level. However, at a satisfactory level, the numerical scale is also 50%. Therefore, setting 50% as the threshold level is justified.

Table 4. Performance scale based on the percentage of marks obtained

Performance level	Numerical scale
Excellent	80% and above
Very Good	70%–79%
Good	60%–69%
Satisfactory	50%–59%
Developing	40%–49%
Unsatisfactory	Below 40%

CDP_RUB_14: Rubric for Assessment of Life-Long Learning from Capstone Design Project Report
Target Course and Program Outcome: CO9 and PO12

Southeast University

Serial #		Capstone Design Project Title	Semester:
Poster ID			

Project Member's Name and ID #			
	1.		
	2.		
	3.		

Key Performance Indicator (KPI)	Very Poor (1)	Poor (2)	Average (3)	Very Good (4)	Excellent (5)	Marks (5)		
						1	2	3
KPI_LLL9.1 Personal Interests and Goals	*Student has no personal interests upon his/her professional field of study and relevant industries*	*Student has little personal interests upon his/her professional field of study and relevant industries*	*Student has average personal interests upon his/her professional field of study and relevant industries*	*Student has personal interests upon his/her professional field of study but lacks some knowledge on relevant industries*	*Student has personal interests upon his/her professional field of study and in-depth knowledge of relevant industries and actively participates in his/her professional capacity*			
KPI_LLL9.2 Information Literacy	*Student has no knowledge about the literature collections and review of journal and conference papers and thesis reports; unclear regarding proper citation format*	*Student has little knowledge about the literature collections and review of journal and conference papers and thesis reports; unclear regarding proper citation format*	*Student has little knowledge about the literature collections and review of journal and conference papers and thesis reports and can extract information without any inferences; a little idea regarding proper citation format*	*Student has sound knowledge about the literature collections and review of journal and conference papers and thesis reports and can extract information with little inferences; clear regarding proper citation format*	*Student is aware of the breadth and depth of a research topic; synthesizes and integrates information from a variety of sources; formulates a clear and precise personal point of view but citing in proper format; find a problem to be solved; and is able to clearly communicate ideas to others. Student understands and recognizes the concept of intellectual property, can defend if challenged.*			
KPI_LLL9.3 Taking the Responsibility for Learning	*Student is unable to effectively formulate a research question; unaware how to search for the literature that would be useful in formulating a convincing problem statement*	*Student is unable to effectively formulate a research question; aware how to search for the literature but isn't useful in formulating a convincing problem statement*	*Student is able to formulate a research question; aware how to search for the literature but isn't useful in formulating a convincing research question and/or problem statement*	*Student is able to formulate an effective research question; aware how to search for the literature but isn't useful in formulating a convincing research problem statement*	*Student is able to formulate an effective research question; aware how to search for the literature that is useful in formulating a convincing research problem statement*			
KPI_LLL9.4 Critical Thinking	*Student is unable to think and analyze critically his/her research works; unable to find innovative and complex engineering problem and its solution*	*Student is unable to think and analyze critically his/her research works; able how to find a complex engineering problem and its solution but it is not so innovative and unique*	*Student is able to think and analyze critically his/her research works; able how to find a complex engineering problem and its solution but it is not so innovative and unique*	*Student is able to think and analyze critically his/her research works; able how to find a complex engineering problem and its solution but it is less innovative but not so unique*	*Student is able to think and analyze critically his/her research works; able to find innovative and unique complex engineering problem and its unique solution*			

(a)

Key Performance Indicator (KPI)	Very Poor (1)	Poor (2)	Average (3)	Very Good (4)	Excellent (5)	Marks (5)		
						1	2	3
KPI_LLL9.5 Personal Development	*Student is unable to perform any corrections to his/her research report, PowerPoint, and poster presentation suggested by the examiners/supervisor within the deadline accurately by applying own judgement and maintaining the specified formats/styles*	*Student is able to perform the corrections to his/her research report, PowerPoint, and poster presentation suggested by the examiners/supervisor within the deadline but there remains many errors and can't apply own judgement and can't maintain the specified formats/styles*	*Student is able to perform a few corrections to his/her research report, PowerPoint, and poster presentation suggested by the examiners/supervisor within the deadline but there remains a huge errors and can't apply own judgement but can maintain the specified formats/styles*	*Student is able to perform most of the corrections to his/her research report, PowerPoint, and poster presentation suggested by the examiners/supervisor within the deadline but there remains a few errors and can't apply own judgement but can maintain the specified formats/styles*	*Student is able to perform the corrections to his/her research report, PowerPoint, and poster presentation suggested by the examiners/supervisor within the deadline without any errors and can apply own judgement by maintaining the specified formats/styles*			
Comments of the Supervisor:				**Assessed by (Name, Sign & Date)**	**Total (Out of 25)**			

(b)

Figure 1. Rubric for assessment of lifelong learning through the capstone design project course: (a) first page and (b) second page

4.8. PO assessment

To measure the accomplishment levels of various POs, each course outcome is assigned to at least one PO each out of 12 POs set for the entire programme of the BSc in EEE programme at SEU. The level of attainment for each PO is computed as follows:

i. Each CO contributes equally to each PO for this particular course.
ii. From Table 1, we see that CO9 will help to achieve PO12.
iii. The percentage of scores is calculated and is assigned to the PO contribution by each student.
iv. The percentage of students in CO9 is computed and this is the same for PO12 as well.
v. The PO is considered achieved if the percentage of students in the 'Excellent', 'Very Good', 'Good' and 'Satisfactory' categories is within 50% score. This is roughly equivalent to 50% of the students scoring grade C+ (50%) and above.

The PO is considered achieved if it scores a total value greater than or equal to 50%; an unachieved PO is defined with a score of less than 50%. POs with a level of achievement between 50% and 59% are considered to be marginally attained, and those with a total score of achievement between 60% and 69% need further improvements in knowledge and skills. Besides, the PO with a level of achievement between 40% and 49% is considered to be a developing stage and may require additional care for the attainment of COs and POs.

CDP is assessed and evaluated through a rubric. There are 14 rubrics to evaluate ten course outcomes (CO1–CO10) of the CDP course. One of the rubrics, named 'CDP_RUB_14: Rubric for Assessment of Lifelong Learning from Capstone Design Project Report,' is shown in Figure 1. This is used to assess the course outcome number nine (CO9), which is mapped to PO number 12 (PO12), i.e., 'lifelong learning' of the BSc in EEE programme. Later, we show that this rubric is useful in determining the achievement of 'lifelong learning' of a programme.

To assess the lifelong learning skills achieved by the students, marks are given on a Likert scale of 1–5 as shown in Figure 1. Then, the supervisor puts marks for each KPI of the rubric in the rightmost columns for each student of his/her research group comprising students' numbers not more than three. Then, the total of all KPIs is counted out of 25. In the Results and Discussion section, we discuss the achievement level of lifelong learning skills of the students through the CDP courses.

5. Results and discussion

5.1. Course and PO evaluation

Table 5 gives a summary of the level of attainment of the course and hence the PO. It shows that the required skills and attitudes that are required to develop by the CDP students through the five KPIs for lifelong learning of CO9 of CDP courses (KPI_LLL9.1-5) through which CO9 of CDP course and hence a part of PO12 has been achieved above the satisfaction level by more than 50% of this cohort of students of the CDP course. It is also perceived that all the students of the CDP course took part in the process completely.

Table 5. Course and programme level assessment and attainment table for the lifelong learning skills

	PO >>		**PO12 (Lifelong Learning)**						
	CO >>		**CO9**						
	Tools >>		**KPI_LLL9.1**	**KPI_LLL9.2**	**KPI_LLL9.3**	**KPI_LLL9.4**	**KPI_LLL9.5**	**Total**	**In %**
SL #	Student ID #	Student Name	5	5	5	5	5	25	100.0%
1	ID 1	Name 1	5	5	5	3	5	23	92.0%
2	ID 2	Name 2	5	5	5	3	5	23	92.0%

3	ID 3	Name 3	4	4	3	3	3	17	68.0%
4	ID 4	Name 4	3	3	3	2	3	14	56.0%
5	ID 5	Name 5	5	4	4	3	4	20	80.0%
6	ID 6	Name 6	5	4	3	3	4	19	76.0%
7	ID 7	Name 7	5	5	5	4	5	24	96.0%
8	ID 8	Name 8	5	5	5	4	5	24	96.0%
9	ID 9	Name 9	4	4	4	3	3	18	72.0%
10	ID 10	Name 10	4	4	3	3	3	17	68.0%
11	ID 11	Name 11	4	4	4	3	3	18	72.0%
12	ID 12	Name 12	4	4	3	3	3	17	68.0%
13	ID 13	Name 13	4	4	3	3	3	17	68.0%
14	ID 14	Name 14	4	5	4	3	3	19	76.0%
15	ID 15	Name 15	4	5	4	3	3	19	76.0%
16	ID 16	Name 16	3	2	2	2	2	11	44.0%
17	ID 17	Name 17	3	2	2	2	2	11	44.0%
18	ID 18	Name 18	3	2	3	2	3	13	52.0%
19	ID 19	Name 19	3	2	3	2	3	13	52.0%
20	ID 20	Name 20	4	4	4	3	4	19	76.0%
21	ID 21	Name 21	4	4	4	3	4	19	76.0%
22	ID 22	Name 22	3	2	3	2	3	13	52.0%
23	ID 23	Name 23	3	2	3	2	3	13	52.0%
24	ID 24	Name 24	4	5	4	3	4	20	80.0%
25	ID 25	Name 25	4	5	4	3	4	20	80.0%

Legends for Tools: KPI_LLL9.1 = the first Key Performance Indicator for the Lifelong Learning for the Course Outcome 9 (CO9) of the CDP course, KPI_LLL9.2 = the second Key Performance Indicator for the Lifelong Learning for the CO9 of the CDP course, KPI_LLL9.3 = the third Key Performance Indicator for the Lifelong Learning for the CO9 of the CDP course, etc.; ID 1 = Identification Number of Student No 1 in the class, Name 1 = Name of Student No 1 in the class (Real IDs and Names are not disclosed here).

Table 6. Number of students achieving the performance levels for the CO9 of the Capstone Design Project course and hence the programme outcome 12 (PO12) of the EEE department at SEU

	Excellent	Very Good	Good	Satisfactory	Developing	Unsatisfactory
CO9	7	7	4	5	2	0

Table 7. Percentage of students achieving the performance levels for the CO9 of the Capstone Design Project course and hence the PO12 of the EEE department at SEU

	Excellent	Very Good	Good	Satisfactory	Developing	Unsatisfactory
CO9	28%	28%	16%	20%	8%	0%

In Tables 6 and 7, the number and percentage of the students achieving the performance levels for CO9 of the CDP course is shown, and hence a part of the PO12 of the BSc in EEE programme at SEU has also been presented. From these tables, it is seen that out of the 25 students of this cohort, 23 students, who comprise 92% of the total students of this cohort, could achieve the benchmark of the satisfactory level. However, the threshold value of 50% is well below this value.

However, from Table 8, we get information only on the average score of CO9, but not on the individual KPI scores. Therefore, in Table 8, we showed the number of students achieving the average and above levels in each KPI for measuring the CO9 of the CDP course. This shows that the KPI_LLL9.1 on personal interests and goals are achieved by all the students as assessed by the Board of Examiners and Supervisors of different CDP groups of a particular semester. Since the students have already studied a 4-year BSc in EEE programme, therefore all of them are supposed to develop their personals interests and goals by this time. Thus, the contribution to PO12 has been achieved by all of the students and thus an aggregated total achievement of 100% of the first KPI as shown in Table 9.

If we look at the KPI_LLL9.2 on information literacy, we see that 19 students could achieve it which is 76% of the total students of this particular cohort of a semester. However, this is above the benchmark level of 50%.

If we investigate further Tables 8 and 9, we find the KPI_LLL9.3 on taking the responsibility for learning. We observe that 23 students could achieve it, which is 92% of the total students of this particular cohort of a semester. The reason is that most of the graduating students become matured enough to take responsibility on their shoulders for learning by themselves.

If we move down on Tables 8 and 9, we find the KPI_LLL9.4 on critical thinking. We discern that 18 students could achieve it, which is 72% of the total students of this particular cohort. The reason is that most of the graduating students lack in developing critical thinking skills. We also see that the majority of the students (64%) have achieved an average level of critical thinking skills. This is a concern for the programme.

If we go down on Tables 8 and 9, we find the KPI_LLL9.5 on personal development. We recognise that 23 students were able to achieve it, which is 92% of the total students of this particular cohort. The reason is that most of the graduating students are now matured and they understand their personal development issues. However, a major portion of the students (in this case, 52%) achievement is at the average level, which is a concern for the programme.

Table 8. Number of students achieving average and above levels in each key performance indicator for measuring the CO9 of the CDP course and hence the PO12 of the EEE department at SEU

	Excellent (5)	Very Good (4)	Average (3)	Poor (2)	Very Poor (1)
KPI_LLL9.1	6	12	7	0	0
KPI_LLL9.2	8	10	1	6	0
KPI_LLL9.3	4	9	10	2	0
KPI_LLL9.4	0	2	16	7	0
KPI_LLL9.5	4	6	13	2	0

Table 9. Percentage of students achieving average and above levels in each key performance indicator for measuring the CO9 of the CDP course and hence the PO12 of the EEE department at SEU

	Excellent (5)	Very Good (4)	Average (3)	Poor (2)	Very Poor (1)
KPI_LLL9.1	24.0%	48.0%	28.0%	0.0%	0.0%
KPI_LLL9.2	32.0%	40.0%	4.0%	24.0%	0.0%
KPI_LLL9.3	16.0%	36.0%	40.0%	8.0%	0.0%
KPI_LLL9.4	0.0%	8.0%	64.0%	28.0%	0.0%
KPI_LLL9.5	16.0%	24.0%	52.0%	8.0%	0.0%

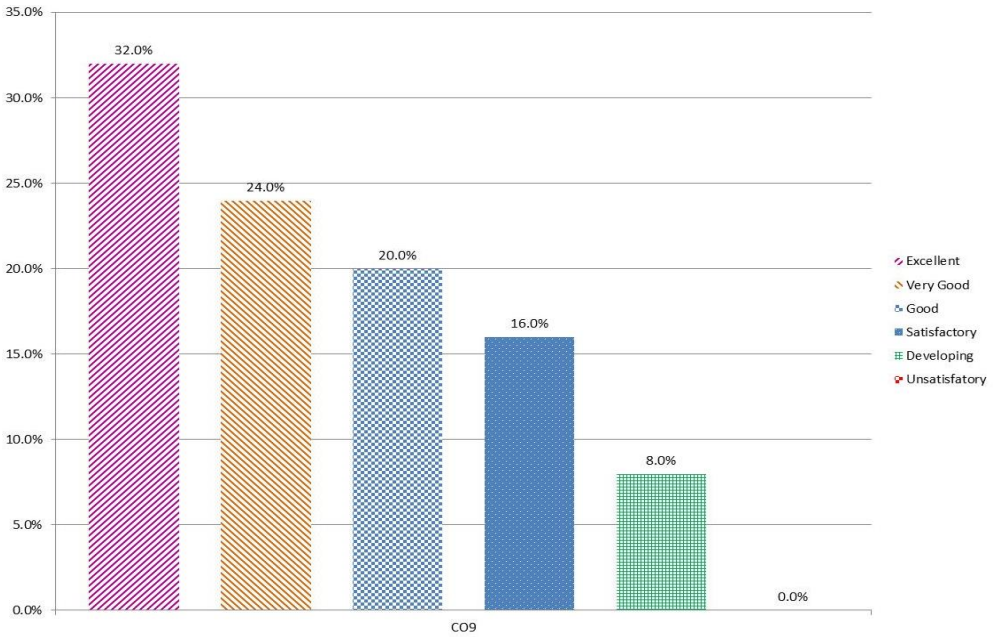

Figure 2. Evaluation matrix of CO9 mapped to PO12

Based on the results obtained from Tables 7 and 9, two different graphical illustrations have been shown in Figures 2 and 3. Since the benchmark of achievement has been set as 50% for this course, it is seen that most of the students (92%) could achieve CO9 and hence could contribute to their PO12 from this course. However, since this is the culminating project, therefore, it needs much care and refinement in the teaching–learning strategy, delivery and evaluation processes, as well as appropriate rubric setting, so that all the students of this CDP course can achieve this CO9 on lifelong learning and hence a part of PO12 on the same.

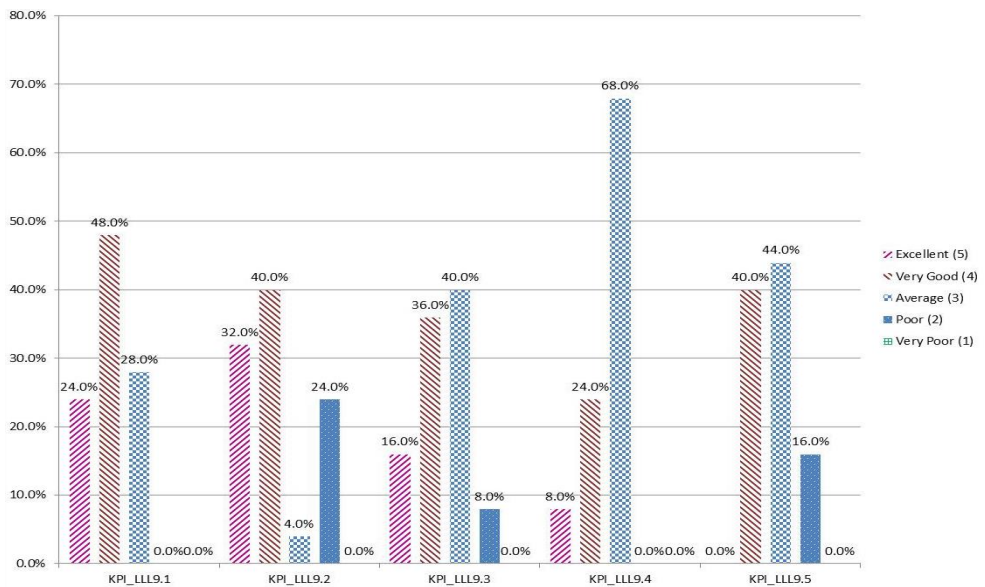

Figure 3. Evaluation matrix of key performance indicators of lifelong learning for PO12

5.2. Recommendations for improvement through PO evaluation

To improve the level of attainment of CO9 and hence PO12 partially, the EEE department has developed a set of possible remedial actions. One or more remedial action(s) may be applied to the CDP course. Actions can be one or more of the following:

a. Engaging students with more literature reviews.
b. Assigning students with more experimental or simulation works in the laboratory.
c. Arranging a research meeting with the CDP course students regularly every week.
d. Engaging students with more group works that are relevant to achieving CO9.
e. Identifying the areas or scopes of improvement and as such dedicating more time for lecture classes to the areas where improvements are needed.
f. Suggesting in the design works and its reviews.
g. Using a different teaching–learning strategy, especially to address non-attainment of CO9, psychomotor and affective domains are recommended to be applied.
h. Replacing the course supervisor with one who has the industry experience and commitment to supervising and evaluating the outcome of the CDP students.
i. Emphasising the works to be accomplished by the students independently or in a group.

The EEE department has required several concerned faculty members to document all the activities to be performed to progress the attainment of COs/POs and to submit at the end of the following offering semester a report indicating whether there have been any significant improvements on the achievement levels of COs/POs as a result of their engagements.

6. Conclusion

Lifelong learning is an imperative segment of engineering professionals for the development of their careers. However, not all graduates of the various engineering programmes ultimately become professional engineers. A significant number of graduates of the various engineering programmes work outside of the engineering profession without having any formal supervision and measurement of their commitment to and engagement in lifelong learning. The educationalists anticipate that all the engineering graduates should have the abilities and attitudes essential to convert themselves to be lifelong learners. Faculty members of the undergraduate engineering programmes teach their undergraduate students how to develop and exercise lifelong learning and instil the values of that to implement a persistent and vigorous instrument for transfer and valuation. CDP courses like EEE492, EEE494 and EEE496, in conjunction with the creative and insightful co-curricular activity designs like a seminar, webinar, poster presentation, project showcase, workshops on research methodology, research proposal writing, thesis paper writing, formatting and styles of research papers, idea contest etc. opens the doors of opportunities for the undergraduate engineering students and creates significant impacts upon them.

However, CDP courses model a basis for lifelong learning and it is continuous and self-directed. The faculty members require developing and applying an adjusted scale as a metric to have a means of assessing and evaluating the skills and attitudes among the final-year engineering students in both short and long terms.

This paper describes a method that has been applied to collect, compile and evaluate the 12th POs on lifelong learning achieved by the students of the CDP courses offered by the EEE department. The assessment data and its subsequent evaluation process are used for applying the re-accreditation of its BSc in EEE programme through the OBE curriculum and teaching–learning process. This method used several rubrics to assess ten COs of the CDP course and hence its contribution to POs. After the end of the semester, the supervisors of the CDP course has to submit a detailed report to the department chairman for further incorporation of it to the POs at the programme level with the

contributions from the COs obtained from the other faculty members. For this purpose, a database is also developed. Faculty members have also submitted the recommendations and analysis to the department suggesting a few improvement plans to help the department chairman to decide which action(s) need to be taken through its OBE Activity Committee. From the assessment of the CDP course, we observed that out of 10 COs, one CO (number 9) is related to lifelong learning and that is why it is mapped to PO12 of the PO. However, the recommendations for corrective measures suggested by the supervisors may be implemented before offering this course in the next semester so that the next cohort of all the students can achieve the CO relevant to lifelong learning.

Implementing a new method to measure the achievement of POs for any academic programme helps the institution to categorise the challenging parts and adopt the applicable corrective measures. The method termed in this paper is very broad; it may be made functional to any course of any engineering programme requiring or seeking the OBE-based accreditation with measurable course outcomes. Since data collection and analysis were carried out manually, it requires a substantial aggregate of time from the faculty members. In the future, it is recommended to use a software tool to expedite the whole process of assessing and evaluating any CO and PO of the BSc in EEE programme very easily. The lifelong learning outcome assessed and evaluated from the CDP courses will help to implement a part of the OBE process successfully in the EEE department of Southeast University.

List of Abbreviations

BAETE	Board of Accreditation for Engineering and Technical Education
CDP	Capstone design project
CO	Course outcome
EEE	Electrical and Electronic Engineering Programme
LLL	Lifelong learning
OBE	Outcome-based education
PO	Programme outcome
SEU	Southeast University

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