

A Workshop on New Trend of Implementing the Engineering Faculty Improvement Workshop in Taiwan: A Multi-institutional perspective

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Abstract

Although the outcome-based approach of Abet EC 2000 is widely used in the United States as a tool to enhance learning and teaching processes, and to assure quality improvement, it is a brand-new phenomenon in the engineering education of Taiwan. It is an increasing concern that the traditional lecture-based instruction is failing to fulfill the needs of development of active learning skills of engineering students in Taiwan. Through a careful literature review, this paper first summarizes the crucial events in engineering education that led to the formation, implementing, and assessing of a team-based faculty development workshop. These will provide possible implications for improving teaching and learning effectiveness of engineering education in Taiwan.

Secondly, five successful attributes of the workshop were found: 1. Administrative support by Ministry of Education reinforced faculty rewards and incentives; 2. Disciplinary related teammates are arranged to encourage collaborative learning during group interactions; 3. Involvement of multi-disciplinary team facilitators from both engineering and education field; 4. On-going tutoring before the workshop, during the pre-workshop and the group discussions; and 5. The topics of the workshop were tailored to the needs of 82 faculty from 24 institutions.

Thirdly, the main results of assessing of effectiveness of the workshop are presented in the following five aspects: 1. Which topics/areas did attendees feel the most practical? 2. What knowledge and skills did they learn from the workshop? 3. What was the most difficult part during the process of learning this outcome-based approach? Analysis of data showed, with the implementation of teamwork strategies, participants' attitude toward group learning revealed significant changes. Moreover, familiarity with areas outside their discipline becomes necessary. Engineering faculty must become reasonably knowledgeable in writing, pedagogy, team dynamics, societal and global concerns, and professional ethics.

Finally, future directions for designing a faculty development model to assure faculty involvement and to assure quality of accreditation processes are addressed at the end of this paper. It is crucial to apply results to maintain a systematic process of continuous improvement of program and to establish accreditation criteria to evaluate the effectiveness of institutions in Taiwan. With the partnerships of the interdisciplinary researchers, we wish to demonstrate how our focus on a faculty development program may result in an improved educational environment for engineering education in Taiwan.

I. Introduction

1. Inconsistency between university curriculum and industry demand

Due to the industrial evolution in Taiwan, disappearing of traditional industry and more weighted on high-tech industry, there is inconsistency between the university's cultivation on sophisticated-trained engineers and demands of high-tech industry. With the advent of consumer-based economies, promoting outcome-based education and fostering technological entrepreneurship are increasingly important. In order to remain competitive, the guidelines for evaluation of engineering programs can help to pinpoint the direction of curriculum evolution.

Furthermore, a misplacement of educational resources would also have long-term impact on Taiwan's competitiveness. However, it is troublesome that fresh engineers cultivated by universities can not fit the needs of the industry. Hence, the importance of university-industry cooperation is a dilemma which has needed attention for many years. It is essential that schools need to have a consistent and systematic procedure to document students' achievements, and ways to evaluate the implemented curricula.

In order to reduce the gap between industry and university, the engineering education should be assessed effectively in the curriculum, teaching and learning such that qualified graduates are supplied to the industry with the knowledge and skills needed.

2. Perceived problems with exam-oriented education in Taiwan

One of the major perceived problems of "examination-oriented education" in Taiwan is that students are always put in a passive position: compelled to learn for the purpose of dealing with examinations. This can lead to students having good skills in answering examination questions but a lower capability for dealing with problems in practice and for teamwork. [1].

Traditional education for engineering students focuses on the classroom indoctrination of domain knowledge. Most problems given to students in class are well defined, with only one correct solution. Under current engineering training, students are asked to solve these "textbook" problems, which generally are simple, formulated in particular forms and have standardized approaches and answers. In industry, however, engineers often face complicated problems with no immediate and absolute answers. Hence, engineering graduates often find that techniques they have learned in college are not practical for solving industrial problems.

Examination-oriented education effectively turns assessment into a tool for these kinds of competition. Schools tend to focus on how to help students pass the selective examinations and how to increase promotion rates. Teachers tend to pay closest attention to the "best" students, those that have the best prospects of entering university, while tending to neglect the students with lower test achievement. As a consequence, schools use the test scores as the primary indicator for evaluating students [2].

Consequently, teachers tend to pay closer attention to drill knowledge instead of training students' skills, attitudes and other non-cognitive attributes. Schools only concentrate on the subjects and knowledge that must be examined in the national standardized examination.

Students are trained particularly to tackle difficult questions, in artificial situations. A comprehensive assessment process has three advantages. To students, a solid and systematic feedback loop has the following advantages: 1. It not only will be able to show students' achievements, but will also specifically point out the shortcomings of students' learning difficulties. 2. Students will not be 'labeled' or ranked, but rather are evaluated according to whether the curriculum has successfully achieved its objective.

Furthermore, in the current competitive environment, it is important for most institutions to assess students' interdisciplinary learning outcomes. It is a big challenge for universities to utilize their curriculum to instill essential basic engineering theories and knowledge in students, teaching them techniques to solve real world problems, and most importantly, it should develop life-long learning habits in the students, together with communications skills, and cultivate good ethics and perception of their profession. In addition, since a greater scale of international partnership will be predictable flowing increasing globalization, engineering ethics is recognized as a new and significant topic.

3. Institutions' urgent need to identify school characteristics and future development

Due to the rapid growth in the number of colleges in Taiwan in recent years, which has caused a transition from a selective to a mass education, the danger of lowering education quality has appeared. Even though there are on-going institutional assessments in Taiwan, the results seem to be not very satisfactory because of the lack of systematic and objective process. Currently, every field takes assessment or accreditation independently and there is no common language between one field and the others. Every field's accreditation represents certain level of quality in its field, but there is no unity level of accreditation quality guaranteed. Furthermore, the results cannot be utilized to maintain a close contact with international engineering accreditation. Meanwhile, because the goal of the assessment is to improve the quality of teaching and research, so the evaluators of assessment should be chosen with great care [3].

Under the ABET EC 2000, the general direction and future development of each university may be pinpointed. The accreditation process allows flexibility for schools to pursue excellence in the cultivation of their students and provide suggestions for improvements based on evaluation comments. The programs or schools will not be ranked and instead they are evaluated according to how successfully they have achieved their individual missions.

A glimpse at the perceived problems in the past and in the future trend of development of engineering education in Taiwan shows the vital role that a systematic assessment process is necessary for further improve the quality of engineering education. On one hand, ABET EC 2000 encourages the programs to establish a continuous self-assessment process to demonstrate its achievements; on the other hand, through objective reviews by professionals within the field, the findings may provide guidelines to improve the curriculum design and to guarantee an effective engineering education.

II. Literature Review

1. Rationale of EC 2000

Due to the huge difference among engineering programs, EC2000 is based on two factors to do performance assessment, whether the program been assessed having observable and specific objectives for their course content and whether it shows continuing improvement. Mainly, this internationally well known accredited criterion, EC2000, is considered as an outcome-based accreditation. It's guidelines for universities to find their own characteristics and directions.

In a traditional way of teaching, once a topic has been delivered and an exam has been given, it is essentially complete [4]. However, in the outcome-based approach, a teacher will look at specific objectives, strategies, and learning outcomes which improving students' learning by these feedbacks.

Over the past several years, Journal of Engineering Education has published many useful studies that have presented functional groups, decision-making, and teaming skills as important pedagogical tools for engineering faculty to integrate into their curriculum. There were two primary challenges facing the faculty development programs. First, there was the traditional reluctance of engineering faculty to participate in professional development in regard to teaching and learning. Secondly, evidence suggested that well below 10% of the engineering faculty within the coalition sponsored by National Science Foundation in the United States had participated in any faculty development activities, and far fewer were using nontraditional instructional methods such as cooperative learning or portfolio [5]. Thus, we placed great emphasis on teamwork strategies. Emphasis was placed on participants' ability to operate in open-ended, collaborative learning situations.

2. Cognitive Style and Cultural Values of Engineering Students

Nonetheless, engineers typically have a cognitive style known as field independence [6]. Engineers preferred problems that were structured and predictable, whereas activities with unpredictable responses (e.g. group discussion) are neither structured nor predictable. The students preferred to read about the techniques, read about examples, and then pass a written test.

Results from a study investigating cultural differences in students' self-regulation also produced evidence that students work to maintain their level of effort for academic tasks [7]. These students found that Chinese and Japanese parents or teachers have a lower tolerance for errors; and when they occur, they seldom ignore them. Also, belief about effort, ability, and achievement has far-reaching consequences for learning. In Asia, the emphasis on effort and the relative disregard for innate abilities are derived from Confucian tradition. Differences among individuals in innate abilities were recognized, but more important was the degree to which a person was willing to maximize these abilities through hard work.

Furthermore, cultural values can play a pronounced role in the group dynamics of cooperative learning activities on faculty development. Most engineering students have been rewarded for being competitive, getting the right answers, and receiving higher grades than most of their classmates. It is not surprising that when students pursue relative ability or extrinsic goals, learning is viewed as a means to an end. A sense of accomplishment is derived from outperforming others, avoiding negative ability judgment, and receiving external rewards, regardless of the learning involved. Students with such goals are concerned about how others will evaluate them because external evaluation will determine how they compare to others or if they receive rewards. Such concerns have negative effects on task choice and persistence. Therefore, learning cooperative skills may be difficult for engineering students. Jordan and Le Matais [8] suggested that students who have done well in the traditional curriculum have learned to:

- (1) Perform individually for grades by the teacher,
- (2) Individually take tests; and
- (3) Individually deliver reports.

However, in courses where teaming performance becomes part of the evaluation process, the student must master an entirely different set of abilities that demonstrate knowledge by:

- (1). Helping team members and cooperating in a group;
- (2). Helping to plan;
- (3). Pacing and scheduling projects;
- (4). Getting peer and teacher feedback on work; and
- (5). Teaching classmates.

The shift from the traditional system of education to cooperative learning may redefine what a good student does, thus threatening and raising the anxiety of traditionally good students. The highly competitive nature of most problem solvers also hinders teamwork ability. College students receive little training on how to work as a team, and since they have only been in a simulated environment, they will not realize that most of the projects in industry require group efforts. That is the main reason why employers are concerned that although these new engineers may have good technical skills, they may lack other knowledge skills necessary for success. For instance, life-long learning habits in the students, communications skills, and the cultivation of good ethics and perception toward their profession are all important.

3. Cooperative learning: theoretical bases and implementation issues

Jordan and Le Matais described four general theoretical perspectives that explain the beneficial effects of cooperative learning on performance [8]. One perspective involves *motivation*, and the second is the *social cohesion* perspective, while the third and fourth perspectives are the *cognitive-developmental* perspectives. Further, they found that providing group rewards and holding students individually accountable for learning are key influences on cooperative learning performance successes. Group rewards can be both extrinsic (e.g., course grades), and intrinsic (e.g., feeling of achievement or cohesiveness through working together effectively). Both group cohesiveness and role inter-dependence are examples of some of the many motivational and emotional effects of implementing cooperating learning that transcend academic achievement.

According to constructivist theories of learning, knowledge must be actively constructed by the learner for learning to occur. Positive peer interaction in cooperative groups such as cognitive elaboration, multiple perspectives, as well as giving and receiving help may coordinate with adaptive teacher instruction to work in structured groups where group members are positively interdependent.

In addition, Jordan and Le Matais [8] favored a supportive classroom environment that allows learners to take risks in their learning in an atmosphere which invites cooperation and

shared ownership. This can be achieved when learners are given the opportunity to develop strategies in working together. Through planned systematic social skill and cooperative learning activities, a gradual 're-culturing' of classroom environment will occur.

III. Faculty development workshop for assessment methodology

1. Purposes of assessment methodology faculty development workshop

The purpose of this faculty development workshop is to provide administrators, curriculum and accreditation committee members, as well as key faculty with an understanding of outcome-driven assessment, together with what is involved in establishing an assessment program in an educational environment. It results the advancement of education through trans-disciplinary cooperation and cross-institutional networking. The workshop highlights the school-wide progress and experiences in engineering education; it is also a platform for creating mutually beneficial collaborative efforts through team learning. In addition to being an occasion for discussing the development of engineering education, this faculty development represents an opportunity for fruitful encounters between various backgrounds. Each of the participants is encouraged to develop meaningful social contacts and personal enrichment among our multi-disciplinary colleagues. However, implementing a comprehensive assessment process for 82 faculties from 24 institutions presents a big challenge. McGourty (2001) identified the following four strategies to support faculty involvement of this kind:

- (1) Initiate a structured process to involve faculty and staff in the ongoing planning, development, and monitoring of the program;
- (2) Offer "just-in-time" educational sessions to develop faculty knowledge and skills in assessment;
- (3) Create an assessment toolbox providing administrators and faculty with templates that can be used both in and outside the classroom; and
- (4) Review and modify major institutional practices to ensure that they are aligned with educational objectives and outcomes.

Based on those four strategies listed on above, the following outline describes the topics designed for this workshop:

- (1) Learn how to develop a comprehensive outcome-based assessment plan:

- Procedures of identifying, reviewing and modifying the desirable educational objectives, learning outcomes, and performance criteria for a course, as well as for a program under the EC 2000 framework.
- Identify the possible barriers to implementing the plan.

(2) Learn how to create a student outcome assessment planning matrix:

- An initial assessment planning strategy should include the following issues:
- What characteristics, skills, knowledge, attitudes, and values will the student exhibit so you can tell if they have achieved the desired outcome?
- What assessment methods can you use to gather evidence on performance criteria?
- What assessment tools will be used and what data will be collected and measured?
- Based on the data, what actions can be taken to improve the quality of a program?

(3) Learn how to choose the right assessment tools for the right courses:

- Pros and cons of various qualitative and quantitative methods
- How to implement cautiously with these assessment methods (i.e. without driving teachers and students crazy!)

(4) Learn how to implement and assess a portfolio:

- How to implement a portfolio within the instruction?
- How is the portfolio going to be assessed?
- -How are the results going to be used to improve the curriculum?

IV. Findings

The rationale for the workshop was in the mission of educating engineers to be competitive globally. Unlike past lecture-based setting, this workshop involved 82 faculty, administrators, and professionals from 24 engineering institutions and industry around the country working in partnership. A faculty development team was organized to involve the engineering faculty and could be sustained with both internal and external incentives. The main results from assessing the effectiveness of this workshop will be presented in the following four aspects:

1. What was the most difficult aspect during the process of learning EC 2000?
2. What were the most rewarding aspects you have learned from the workshop?
3. What were successful factors of this workshop based on empirical research?

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4. What were the concerns of participants in regard to implementing an outcome-based approach in Taiwan?

The following findings are quantitative and qualitative results that we synthesized from the evaluation sheets and interviews:

Quantitative Results

1. What was the most difficult aspect of EC2000 assessment method?

Description:	Frequency
How to develop measurable learning outcomes	10
How to apply EC2000 to improve current teaching model	8
How to implement portfolios	6
Too many materials to learn	3
Unable to comprehend the glossary of assessment tools	3
How to design curriculum mapping	2
Language barriers	2
Need more time to practice the skills learned	2
Lack of Chinese demonstration kits of program example (to practice EC2000 by)	1
May encounter difficulties in gaining consensus among the faculty	1
Feel uncertain about actual effectiveness of EC2000	1

Figure1: Attendee’s Difficulties in Learning EC 2000 criteria

The greater difficulties reported by engineering faculty are the vagueness of definition of EC 2000 [9]. Coincidentally, the finding of this study confirmed the research done by Besterfield-Sacre et al [10] that the lack of specificity of these outcomes creates two problems for these new-comers. The first problem is the selection of a measurable component to represent the nature of understanding associated with the non-technical natures of A-k outcomes.

The major problem for outcome-based approach for course planning and learning assessment is the expression of the outcome in terms of components that are measurable for use in instructional setting. Since most teachers feel that the assessment process and developing measure learning outcomes are more difficult, these topics will be the first priority topic for future development programs.

2. What were the most rewarding aspects you have learned from the workshop?

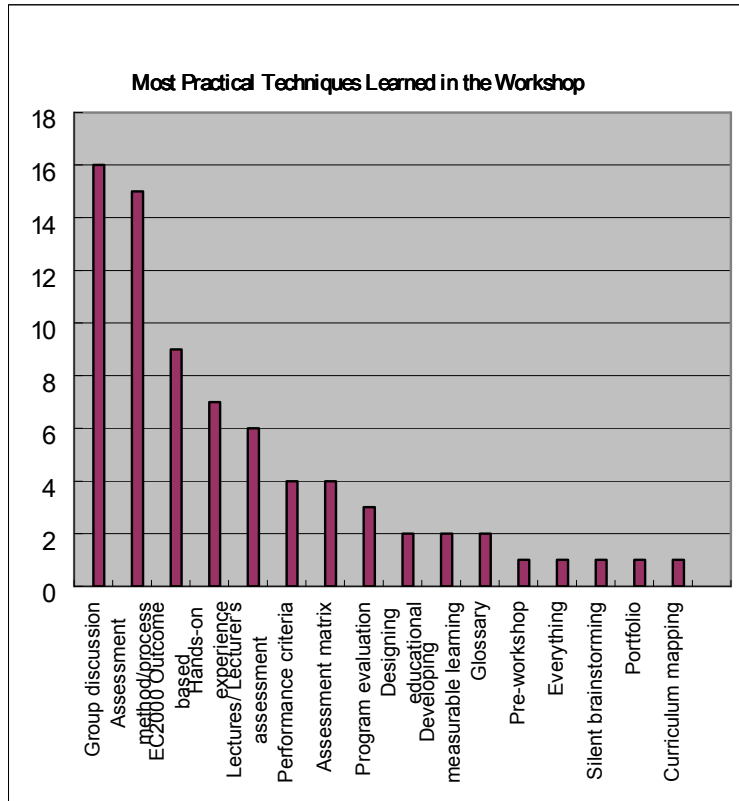


Figure2: The most rewarding aspects participants have learned from the workshop

In this workshop, participants not only actively participated in group activities, but grasped the rare chance to network with others in multi-disciplinary fields. Most participants indicated that learning how to identify and select assessment tools to be was very difficult. But it is encouraging that based on the evaluation results; this is also one of the most rewarding aspects they have learned from the interacting process. A possible explanation may lie in the fact that, after only two days in the workshop, those participants were still at the beginning stage of their knowledge and skills regarding to ABET EC 2000 and outcome-based education. They have little experience concerning outcome-based approach and therefore are overwhelmed with becoming knowledgeable in curriculum planning and design, which is very challenging. The most rewarding lessons these participants have learned can be summarized as follows:

- (1) Importance of teamwork
- (2) The difficulty of reaching consensus
- (3) How to align objective, outcome, assessment tools.

- (4) The definitions and procedures of outcome-based approach
- (5) How to design a curriculum mapping that will ensure the achievement of these objectives and desirable learning outcomes.
- (6) The development of learning objectives and of an assessment plan for these objectives.

Qualitative Results

3. What are successful factors of this workshop based on empirical research?

Analysis of data showed that, with the implementation of teamwork strategies, participants showed very positive attitudes toward group learning. Specifically, there were five successful factors of this workshop:

(1) Administrative support by the Ministry of Education

This workshop emphasized the positive effect of government activism in support of pedagogical renewal and reform. This approach was based on collaborative efforts by the Ministry of Education, administrators, faculty and educational researchers. The workshop aimed at incorporating the internally driven assessment (e.g. pedagogical improvement) with externally driven assessment (accreditation) to reinforce faculty rewards and incentives.

(2) Disciplinary relevant teammates were arranged to encourage collaborative learning

The workshop proved to be very useful for both the faculty and administrators who have the responsibility for improving the effectiveness of their programs. The discussion groups are formed by groups of five participants, and the interaction between participants from different institutions resulted in the networking among faculty. The goal for this workshop is to help faculty become empowered as individuals by contributing to and learning from collaborative efforts [11]. The interaction will also encourage participants to present their team reports to the class in order to learn to share their results and comments to the class.

(3). Involvement of multi-disciplinary team facilitators

An interdisciplinary facilitator team was organized to improve the ability of engineering faculty to work on as a team, which is an innovative way to facilitate engineering faculty's continuous development in Taiwan. The group of three facilitators was made up of two faculty members from mechanical engineering, and one from education. Since

cooperative learning emphasizes peer learning and active participation, the facilitators with engineer background can assist participants with technical materials, whereas the facilitator with background in education may bring in the empirical research and pedagogical knowledge to design a collaborative learning community for multi-disciplinary engineering faculty across campus.

(4). On-going tutoring before the workshop and during group discussions

A tutor or more knowledgeable peer would be present and approachable in a context openly supportive of questioning. When learners do not have to worry about normative evaluation and are encouraged to work for the sake of mastery and intrinsic enjoyment, they are much more likely to ask for assistance when they face difficult tasks [12].

(5). Topics of the workshop was tailored to the needs of 82 faculties from 24 institutions.

The interdisciplinary collaboration of this workshop goes beyond just having professors from another field of study. The course content was specifically integrated with engineers' cognitive style [13], and teamwork training aimed at encouraging these participants to learn differently than in a traditional lecture-based workshop setting.

4. What were the concerns of participants in regards to implementing the outcome-based approach in Taiwan?

Due to the rapid increased in numbers of colleges in recent years, which indicates the turning point of the education system from a selective to a mass education, teachers are concerned that there appeared is the danger of lowering education quality. Some teachers are concerned with how long the improving effect of outcome-based approach will take. Their anxiety come from the fact that the process of outcome-based assessment emphasizes the ongoing evaluation system of continuous improvement, but most colleges for the persuasively observable objective, may set up a rather high ratio of completion or courses for students to pass. There is a long-term history of problems in implementing norm-criteria, where the ratio of completion is based on the entire percentages of students' population of each individual institution, not by an absolute standard. For this reason, the improvement by taking this criterion may cause bad competitions among colleges.

The second concern that they indicated was the fact that, even though the traditional

passive instruction was failing to fulfill the needs of development of active learning skills of engineering students in Taiwan, there is still resistance of engineering faculty to adopt a highly interactive instruction, a brand new pedagogical skills in the classroom. The participants believed that few engineering faculty would choose to add faculty development activities without incentives comparable to the ones already in place for disciplinary research [5]. The implementation of accreditation will add a great extra load to faculty's already overcrowded schedules. Therefore, efforts to create intrinsic motivation are difficult to achieve in a large population. However, it is our goal that if a small group of highly motivated faculties across institutions are involved in accreditation activities, more will follow to improve their own teaching, and eventually served as mentors to other interested colleagues.

V. Conclusions and implications

This workshop involved 82 faculty, administrators, and professionals from 24 engineering institutions and industry around the country, working in partnership with each other. Four topics of the workshop were synthesized to highlight the systematic quality assurance assessment process of the workshop: 1. Learning how to develop a comprehensive outcome-based lesson plan; 2. Learning how to create an assessment planning matrix; 3. Learning how to choose the right assessment tools for the right courses; and 4. Learning how to implement and assess a portfolio within the instruction as well as the institution.

Despite the general insecurity these participants felt when first confronting the challenge of learning the outcome-based approach, these participants' willingness to participate will promise to explore yet new directions. Participants wish to acquire more knowledge, whether face-to-face or in written form. With greater learning motivation than we have expected, these participants are not only eager to learn more about ABET EC2000, but also look forward to learning more. We are sure that this will develop long-lasting relationships for cross-institutional collaboration on engineering education. It also reminds us that in helping one another along the journey, these teachers find the strengths and purposes for their own growth.

Based on the finding of implementing the workshop, this study concludes that faculty consensus and dialogue is crucial if successful implementation is going to follow. Through such ice-breaking activity, all the constituents can finally begin to see the common objectives

and outcomes across various disciplines in the near future. This is actually a crucial first step toward curriculum mapping and coherence (Rogers, 2003). If the universities could respond appropriately to the needs of constituents and build partnerships with them, not only would the interaction between education system and the public be strengthened, but also the nature of continuous improvement assessment would be genuinely implemented. Therefore, the techniques of collaborative learning skills can continue to be integrated to create a better awareness of communication and teamwork issues than in the traditional lecture-based workshop.

Finally, the findings of this study suggest two directions for future research:

(1) To apply the lessons learned from this workshop to investigate the feasibility and effectiveness of outcome-based approach to engineering programs in Taiwan. For instance, further study may be conducted to find out whether the workshop has continuous impact on the attendees' use of team-based approach, their willingness to practice their courses in an outcome-based format, and their willingness to participate in faculty development workshops in the near future.

(2) To establish an accreditation criteria by which programs are evaluated for the effectiveness of curricula and ongoing improvement of the program. For a society which is moving rapidly towards globalization, ABET assessment process is an effective system to connect with international engineering education. Furthermore, the implementation of international accreditation will facilitate the mobility of engineers in the global market.

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