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Program Outcomes: The Core of Program Accreditation*

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Program outcomes, which are statements defining the knowledge, skills, and attitudes that students must acquire by the time they graduate, is at the core of accreditation processes. MÜDEK is a non-governmental organization that carries out outcome-based evaluation and accreditation of engineering programs of Turkey. A comparative account, in the light of eleven years of experience, of the first cycle program outcomes of MÜDEK is given.

Introduction

Accreditation of engineering programs is increasingly being recognized as a key instrument that enhances and improves the quality of engineering education and that contributes to mobility of engineers around the world. International organizations such as ENAEE (European Network for Accreditation of Engineering Education) [1] and IEA (International Engineering Alliance) [2] are moving towards setting global standards in accreditation criteria for engineering programs.

The trend that engineering program accreditation should be outcome-based [3] has been initiated by ABET [4] around 2000 and has now been accepted by almost all national accreditation agencies and by both ENAEE and IEA. This has elevated the program outcomes which are statements defining the knowledge, skills, and attitudes that students must have acquired by the time they graduate, to be the core of program accreditation practice in engineering. Such statements are built in the EUR-ACE Framework Standards [1, 5] that are used in accreditation practices of ENAEE and are formulated as Washington Accord Graduate Attributes [2] with the objective of

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serving as a common denominator for the engineering program accreditation activities of member countries of IEA. It is essential to recognize that the program outcomes used by a country's accreditation agency must on one hand observe the national (educational and professional) qualifications framework [6], if any, and must also be compatible with international standards of engineering educational outcomes, on the other. The former ensures that engineering graduates do not face obstacles in achieving professional qualifications inside the country and the latter ensures that they may attain worldwide mobility in carrying out their profession.

MÜDEK [7] is a non-governmental organization that started outcome-based evaluation and accreditation of four-year engineering programs, leading towards a Bachelor's degree, in Turkey in 2003. It became a member of ENAEE in 2006, was authorized by ENAEE to award EUR-ACE Label in 2009, and became a signatory of Washington Accord of the IEA in 2011. The rules and procedures used by MÜDEK in evaluating a program are detailed in MÜDEK's Directive on Policies and Procedures for Evaluation and Accreditation document [8]. The process starts with the institution submitting a self-evaluation report for programs that seek accreditation and involves a 3-day onsite visit to the institution carrying out these programs by a team of evaluators.

Program outcomes used by MÜDEK in 2003 were similar to outcomes "(a)-to-(k)" of ABET but have been revised in 2008 in order to:

I) incorporate accumulated experience gained by five years of program accreditation;

II) make them compatible with EUR-ACE Framework Standards and Washington Accord Graduate Attributes;

III) encompass National Higher-Education Qualifications Framework for engineering education.

This article gives a comparative account of the program outcomes criteria of MÜDEK focusing on their strengths and weaknesses apprehended in the light of eleven years of program accreditation practice in engineering. First we expound on the central role played by the criterion of program outcomes in the outcome-based accreditation processes. Then, based on [9], we summarize the main areas where engineering programs have difficulties in complying with the MÜDEK Program Outcomes criteria based on the findings by MÜDEK in its accreditation practice. The next section contains a summary and a brief comparison among the MÜDEK Program Outcomes, the relevant EUR-ACE Framework Standards, and Washington Accord Graduate Attributes. The last section presents results and conclusions.

Why Program Outcomes are so Central

The criterion of program outcomes that specifies the knowledge, skills, and attitudes that students must have acquired by the time they graduate is one of many other criteria that an engineering program is expected to comply with. This is a common situation in most outcome-based evaluation procedures that are adopted by accreditation agencies like ABET [4], Japan Accreditation Board for Engineering Education [10], German Accreditation Agency for Study Programs in Engineering, Informatics, Natural Sciences and Mathematics [11], Association for Engineering Education of Russia [12], and MÜDEK. For example, MÜDEK Accreditation Criteria used for evaluating four-year (first-cycle) engineering programs leading towards a Bachelor's degree have the ten components [7]:

Criterion 1. Students.

Criterion 2. Program Educational Objectives.

Criterion 3. Program Outcomes.

Criterion 4. Continuous Improvement.

Criterion 5. Curriculum.

Criterion 6. Faculty Members.

Criterion 7. Facilities.

Criterion 8. Institutional Support and Financial Resources.

Criterion 9. Organization and Decision-Making Processes.

Criterion 10. Discipline-Specific Criteria.

Among these criteria, 1 and 5-9 are input-based while criteria 2, 3, and (in some part) 10 are output-based. A combination of input and output based criteria is a common feature observed in the requirements of most accreditation agencies, such as listed above. Continuing with the MÜDEK example, Criterion 4 makes explicit that "Programs should provide evidence that they use the results obtained through their assessment and evaluation system for their continuous improvement. These improvement efforts must rest on solid data gathered systematically in all areas in need of development, primarily as related to Criteria 2 and 3." [7]. Programs usually need to gather such data from its alumni and their employers in case of Criterion 2 since program educational objectives are general statements defining the career goals and professional accomplishments that graduates are expected to achieve in 2-4 years after graduation. In case of Criteria 3 and 10, such data need to be obtained from student work and fresh graduates of the program. It is a common complaint of program administrators that it is difficult to reach the alumni and obtain feedback. Moreover, the employers or supervisors of past graduates of a program are quite uncooperative in providing feedback that can be so useful to a program administrator in measuring the degree of compliance with Criterion 2. It follows that, from the point of view of a program administrator, Criterion 3 is more amenable to collecting reliable data that may demonstrate compliance, because the source of data is much more reachable when it comes to assessing outcomes. This is also true from the perspective of the accreditation agency and its evaluators, not only because the data is more reliable but also because most source of data is in their reach as well. In case a sloppy administrator neglects collecting sufficient evidence for Criterion 3, the evaluator can easily ask the institution that a specific data is collected during the evaluation period. Thus, the relative ease of demonstrating compliance or noncompliance is the first reason why Program Outcomes is so central to program evaluation.

Statements that define educational and professional qualifications in engineering discipline are also, like those in Criterion 3, statements that specify the knowledge, skills, and attitudes of an individual. True, intended to be applicable in a different environment than academic, but nevertheless similar statements! National qualifications frameworks (NQF) have turned into key instruments for the restructuring and reforming of education, training, and qualifications systems in Europe during the last five years. In [6], NQF is described as "an instrument for the classification of qualifications according to a set of criteria for specified levels of learning achieved, which aims to integrate and coordinate national qualifications subsystems and improve the transparency, access, progression and quality of qualifications in relation to the labor market and civil society". Statements that define qualifications need to be as precise, easy-to-understand, unambiguous as possible, and therefore easy to implement, assess, and measure. The same is true in case of program outcomes. It is indeed our experience that engineering programs in Turkey are able to define and evaluate their program outcomes much easier than, say, their program educational objectives [9]. Ease of formulation and close ties with professional qualifications is the second reason why program outcomes are central in an accreditation process.

MÜDEK Experience of Compliance with Program Outcomes

According to MÜDEK, every engineering program to be evaluated must define their (intended) program outcomes so as to cover all knowledge, skills, and attitude components necessary to accomplish their program educational objectives, and to include the mandatory MÜDEK Outcomes given in Table 1. Programs must have an on-going assessment and evaluation process in place in order to periodically determine and document in how far these program outcomes are being achieved. Furthermore, programs are required to demonstrate (by providing evidence) that their students have achieved the program outcomes by the time they graduate.

Criterion 3 (Program Outcomes) related shortcomings most frequently observed during general evaluations of a total of 70 first cycle programs conducted during 2010-2011 and 2011-2012 evaluation periods are summarized in Table 2.

The first shortcoming listed in Table 2 is mainly observed in programs that are subjected to a cyclic general re-evaluation for the extension of their accreditation. The reason behind this is that such programs have failed to update their intended learning outcomes in parallel with the revisions made in MÜDEK evaluation criteria (in particular the program outcomes criteria) which took place at the end 2008 with a one year transition period given to institutions.

Second and third items in Table 2 are mostly observed in programs which are subject to a general evaluation for the first time. The main reason behind these two shortcomings is the lack of experience of programs in methods to be used for assessing achievement of program outcomes, particularly on methods directly based on student coursework. Furthermore, a lack of planned and coordinated effort in assessment of program outcomes and analysis of such assessment results also reflects as further shortcoming under Criterion 4 (Continuous improvement) in most programs.

Although not quantified here, these findings can be extended to all ten years of MÜDEK evaluated programs. It should also be noted that most programs also have difficulty of compliance with some new criteria incorporated in 2008, like 3.7, 3.10, and 3.11, but a shortcoming decision has been made for only a few programs. This is apparently because MÜDEK evaluators are more tolerant when they evaluate programs' compliance with newly incorporated criteria. On a positive note, most of the evaluated programs have no difficulty of compliance with the outcomes 3.1, 3.2, 3.4, and 3.5. A look at these criteria in Table 1 will show that it is relatively easier to collect evidence of compliance for these criteria from student works.

EUR-ACE Framework Standards, WA Graduate Attributes, and MÜDEK Program Outcomes

EUR-ACE Accreditation System is a decentralized accreditation system of educational programs as entry route to the engineering profession in Europe. The EUR-ACE Framework Standards, maintained by the ENAEE, provide the basis for awarding a common quality label, called EUR-ACE Label, to engineering programs after reviewing their accreditation procedure and does not substitute for national standards. EUR-ACE Accreditation System is currently implemented by nine agencies in Europe. ENAEE authorizes these agencies to add the EUR-ACE label to their accreditation. These are ASIIN (Germany), CTI (France), Engineering Council (UK), Engineers Ireland, Ordem dos Engenheiros (Portugal), AEER (Russia), MÜDEK (Turkey), ARACIS (Romania), and QUACING (Italy).

The EUR-ACE Framework Standards distinguish between First Cycle and Second Cycle degrees and specify 21 program outcomes for first cycle degrees and 23 for second cycle degrees,

Table 1. Program Outcomes stated in MÜDEK Criterion 3

Engineering programs must demonstrate that their graduates have acquired the following 11 outcomes:

1. Adequate knowledge in mathematics, science and engineering subjects pertaining to the relevant discipline; ability to use theoretical and applied information in these areas to model and solve engineering problems.
2. Ability to identify, formulate, and solve complex engineering problems; ability to select and apply proper analysis and modelling methods for this purpose.
3. Ability to design a complex system, process, device or product under realistic constraints and conditions, in such a way so as to meet the desired result; ability to apply modern design methods for this purpose. (Realistic constraints and conditions may include factors such as economic and environmental issues, sustainability, manufacturability, ethics, health, safety issues, and social and political issues according to the nature of the design.)
4. Ability to devise, select, and use modern techniques and tools needed for engineering practice; ability to employ information technologies effectively.
5. Ability to design and conduct experiments, gather data, analyse and interpret results for investigating engineering problems.
6. Ability to work efficiently in intra-disciplinary and multi-disciplinary teams; ability to work individually.
7. Ability to communicate effectively in Turkish, both orally and in writing; knowledge of a minimum of one foreign language.
8. Recognition of the need for lifelong learning; ability to access information, to follow developments in science and technology, and to continue to educate him/herself.
9. Awareness of professional and ethical responsibility.
10. Information about business life practices such as project management, risk management, and change management; awareness of entrepreneurship, innovation, and sustainable development.
11. Knowledge about contemporary issues and the global and societal effects of engineering practices on health, environment, and safety; awareness of the legal consequences of engineering solutions.

Table 2. Most frequently observed shortcomings concerning MÜDEK Criterion 3 Program Outcomes

Nature of Shortcoming	%
Intended program outcomes do not fully cover the mandatory MÜDEK outcomes	18
Insufficient assessment process is used for determining the extent of achievement of program outcomes by the students. (Usually only surveys or passing grades in courses are being used)	41
Insufficient evidence is provided to show that their students have achieved the program outcomes by the time they graduate	26
Lack of evidence demonstrating that the students have acquired the ability to design a complex system, process, device or product under realistic constraints and conditions, in such a way so as to meet the desired result; ability to apply modern design methods for this purpose	18
Lack of evidence demonstrating that the students have acquired the ability to work efficiently in intra-disciplinary and multi-disciplinary teams	10

grouped under the profiles: Knowledge and Understanding, Engineering Analysis, Engineering Design, Investigations, Engineering Practice, Transferable (personal) Skills. Although all six of the program outcomes apply to both first cycle and second cycle programs, there are important differences in the requirements at the two levels. These differences are particularly relevant to those learning activities that contribute directly to the program outcomes concerned with engineering applications. A full listing of the EUR-ACE Program Outcomes can be found at [1].

IEA consists of six international agreements governing mutual recognition of engineering educational qualifications and professional competence. Countries who wish to participate in any of these agreements, apply for membership, and if accepted become signatories to the agreement. The Washington Accord (WA), signed in 1989, is one of these agreements among agencies responsible for accrediting engineering degree programs. It recognizes the substantial equivalency of programs accredited by those agencies and recommends that graduates of programs accredited by any of the signatory agencies be recognized by the other agencies as having met the academic requirements for entry to the practice of engineering. Currently there are 15 signatories of WA represented in each country by the agency responsible for accreditation of bachelors or fist cycle engineering programs. These are Australia, Canada, Chinese Taipei, Hong Kong China, Ireland, Japan, Korea, Malaysia, New Zealand, Russia, Singapore, South Africa, Turkey, United Kingdom, and United States.

WA Graduate Attributes [2] provide a widely accepted common reference for accreditation agencies to describe the outcomes of substantially equivalent qualifications. There are twelve WA Graduate Attribute Profiles, which are Engineering Knowledge, Problem Analysis, Design/development of solutions, Investigation, Modern Tool Usage, The Engineer and Society, Environment and Sustainability, Ethics, Individual and Team work, Communication, Project Management and Finance, Lifelong learning.

Juxtaposing the four program outcomes of EUR-ACE First Cycle, EUR-ACE Second Cycle, MÜDEK, and WA Graduate Attributes, and use the six profiles of EUR-ACE as the basis, we can depict the chart in Figure 1 that makes a conceptual comparison. Thus, EUR-ACE Second Cycle program outcomes stand as the most demanding, followed by WA Graduate Attributes and MÜDEK Program Outcomes. EUR-ACE First Cycle program outcomes are the least demanding among the four. In "Knowledge and Understanding" profile, for example, there are slight differences between MÜDEK Program Outcomes and WA Graduate Attributes while both are substantially more demanding than EUR-ACE First Cycle program outcomes and less demanding than EUR-ACE Second Cycle program outcomes. In "Investigations" profile, MÜDEK Program Outcomes are slightly more demanding than WA Graduate Attributes. Currently, working groups from IEA and ENAEE are, in parallel, looking at the comparison between Graduate Attributes and EUR-ACE Framework Standards with the aim of reaching a consensus on substantial equivalencies among them. On a separate track, IEA has taken a decision that all WA signatories bring their program outcomes to a substantially equivalent level to WA Graduate Attributes by the year 2019.

Results and Discussion

Initiated by ABET around 2000, outcome-based evaluation has now been accepted by almost all national engineering educational accreditation agencies and by both ENAEE and IEA. The relative ease of demonstrating compliance or noncompliance, ease of formulation, and close ties with profes-

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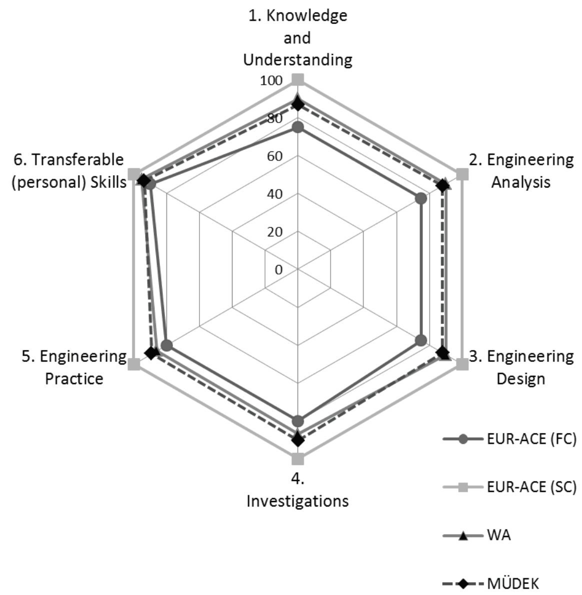
Fig. 1. A conceptual comparison



sional qualifications are reasons that make program outcomes the core of an outcome-based evaluation process.

Evaluation of a total of 70 first cycle programs by MÜDEK in the last two years is representative of shortcomings of the engineering programs in complying with program outcomes criteria. Almost half of evaluated programs have used an insufficient assessment process for determining the extent of achievement of program outcomes by the students. In almost one third of them intended program outcomes do not fully cover the mandatory MÜDEK Outcomes and have failed to provide sufficient evidence for MÜDEK Outcome 3.3 on complex system/process/device design. Some programs also had difficulty in complying with MÜDEK Outcome 3.6 on the ability to work efficiently in intra-disciplinary and multi-disciplinary teams.

When compared with regard to the level of strictness of standards, MÜDEK Program Outcomes are less demanding than EUR-ACE SC outcomes but more than EUR-ACE FC outcomes. At certain outcome profiles, it is also less demanding than WA Graduate Attributes, however, a revision for substantial equivalence is under way.

Outcome-based evaluation is only one method among a number of different program evaluation types, such as process- or goals-type methods [13], and it is not the perfect method. Program outcomes, if not clearly formulated and if are not amenable to collecting data, may not be assessable. It follows that they themselves need to be periodically assessed and revised. MÜDEK outcomes have been revised twice but it is already time for a third version, this time giving more thought to whether each MÜDEK Outcome is formulated so that each program administrator and every MÜDEK evaluator clearly understands the requirements for its implementation and can easily imagine how data can be collected as evidence of compliance for that outcome. More studies like [9] will provide many hints for implementing these features.

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