Customizing the EPSA Rubric to Cover Local Curriculum Content for Assessment of Engineering Professional Skills

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CONTEXT
The Accreditation Board for Engineering and Technology - Engineering Criteria 2000 (ABET EC-2000) identifies two areas of expertise, commonly distinguished as “hard engineering skills” and “soft engineering skills” with the latter also known as Engineering Professional Skills (EPS). EPS includes skills such as communication, teamwork, and ethical responsibility, and professionalism, awareness of the impact of engineering solutions on society, life-long learning and understanding of contemporary issues. The criteria of ABET EC-2000 have been widely adopted by many engineering programs as program outcome criteria. Recently a rubric has been developed to facilitate engineering professional skill assessment (EPSA) in the context of ABET EC-2000 criteria. However, any engineering program is likely to be strongly influenced by both the global and local situations faced by the country in which the engineering program is located. For instance, in a developing country like Indonesia, in addition to ABET EC-2000, the curriculum must simultaneously cover both the national (core) curriculum and the local (institutional) curriculum. (This requirement is stipulated by a Decree of the Minister of National Education of the Republic of Indonesia No. 232/U/2000 about Guidelines for Proposing of Higher Education Curriculum and Assessment of Student Learning). This necessitates a requirement for assessment that evaluates students’ understanding of both ABET EC-2000 and the national and local curricula.

PURPOSE
The purpose of this paper is to propose a customized EPSA rubric which is able to assess not only students’ understanding of ABET EC-2000 but also assess simultaneously their understanding of the global and local curriculum contents.

APPROACH
A customized EPSA rubric has been developed based on Curriculum 2012 of Department of Industrial Engineering, Universitas Atma Jaya Yogyakarta, Indonesia which is derived from the ABET EC-2000, Decree No. 232/U/2000 and institutional curriculum contents. In order to develop such a rubric that can cover all aspects of the assessment, a list of unique criteria based on global and local curriculum contents must be established first. This rubric is then complemented by the use of a series of locally relevant scenarios for the assessment.

RESULTS
The customized EPSA rubric has been used in a trial with five classes in the Department of Industrial Engineering, Universitas Atma Jaya Yogyakarta, Indonesia. The purpose of the trial was to evaluate our first attempt at a customized EPSA rubric. Initial analysis of the results indicates the modified rubric is appropriate both in assessment and for developing students’ understanding regarding the global and local curriculum contents. The trial has also identified issues to be investigated further before a second trial in 2017.

CONCLUSIONS
The customized EPSA rubric developed in this research, extends that of the original rubric beyond ABET EC-2000 requirements to include EPS requirements of the global and local curriculum contents. We envisage future developments of this rubric to be adopted as a formal assessment tool for engineering education accreditation processes.

KEYWORDS
ABET EC-2000, Curriculum, Engineering Professional Skills (EPS), Engineering Professional Skill Assessment (EPSA), Customized EPSA Rubric.

Introduction

According to the Accreditation Board for Engineering and Technology - Engineering Criteria 2000 (ABET EC-2000), there are two areas of expertise, commonly distinguished as “hard engineering skills” and “soft engineering skills”. Soft engineering skills are also known as Engineering Professional Skills (EPS). EPS includes skills such as communication, teamwork, and ethical responsibility, and professionalism, awareness of the impact of engineering solutions on society, life-long learning and understanding of contemporary issues. The criteria of ABET EC-2000 have been widely adopted by many engineering programs as program outcome criteria. Recently a rubric has been developed to facilitate engineering professional skill assessment (EPSA) in the context of ABET EC-2000 criteria. However, any engineering program is likely to be strongly influenced by both the global and local situations faced by the country in which the engineering program is located. For instance, in a developing country like Indonesia, in addition to ABET EC-2000, the curriculum must simultaneously cover both the national (core) curriculum and the local (institutional) curriculum. (The requirement to cover both the national and institutional curricula is stipulated by a Decree of the Minister of National Education of the Republic of Indonesia No. 232/U/2000 about Guidelines for Proposing of Higher Education Curriculum and Assessment of Student Learning). This necessitates a requirement for assessment which is able to evaluate students’ understanding of ABET EC-2000 as well as the national and local curricula.

EPS and EPSA Rubric

Assessment of hard engineering skills is commonly achieved through a series of written tests (perhaps including both pre-tests and post-tests). However, the main problem faced by the educators is to find an effective assessment method for EPS (McMartin, McKenna, & Youssefi, 2000). A literature review conducted as a part of this research has shown that faculty and administrators have used:

- qualitative methods such as questionnaires and interviews for gathering student opinions (Aglan & Ali, 1996; Yokomoto, Buchanan, & Ware, 1995).
- statistical analysis (Larpkiataworn, Muogboh, Besterfield-Sacre, Shuman, & Wolfe, 2003)
- comprehensive assessment program (McGourty, Sebastian, & Swart, 1998)
- mixed-method approach (Leydens, Moskal, & Pavelich, 2004)
- concept maps (Besterfield-Sacre, Gerchak, Lyons, Shuman, & Wolfe, 2004; Gerchak, Besterfield-Sacre, Shuman, & Wolfe, 2003; Turns, Atman, & Adams, 2000)
- attitudes assessment (Besterfield-Sacre, Atman, & Shuman, 1998)
- peer assessment (El-Mowafy, 2014; Falchikov & Goldfinch, 2000; Topping, 1998)

Unfortunately these assessment methods do not necessarily assess the real EPS of students because they may reflect an inaccurate perception of knowledge about a particular engineering concept. Furthermore, most of these assessment methods assess only one skill at a time (McCormack, Kranov, Beyerlein, Pedrow, & Schmeckpeper, 2013).

The method which is being studied in this research, the Engineering Professional Skill Assessment (EPSA) was very recently published by Schmeckpeper, Kranov et al. (2014) and may still need improvement. Research on the development of the EPSA was a 4-year project which was funded by the National Science Foundation (NSF). This project was started in 2011 and ended in 2015. The EPSA is used to assess students’ performance in responding to a given scenario using as criteria six learning outcomes from ABET (ABET Engineering Accreditation Commission, 2014; Kranov et al., 2011). This method is holistic, can assess multiple skills at a time and explores the students’ EPS assessment in depth.

The EPSA consists of a series of performance tasks including:

1) reading a 1-2 page scenario about a contemporary, interdisciplinary engineering problem intended to prompt discussion among a group of 5-6 students;
2) a 45-minute discussion period where students are asked to address a series of generic questions about the scenario;
3) an analytical rubric; and
4) a set of scenario-specific notes about what constitutes exemplary performance (Beyerlein et al., 2011; Kranov, Beyerlein, McCormack, Pedrow, & Schmeckpeper, 2013).

The EPSA assesses students' EPS with six standard ratings (0-missing, 1-emerging, 2-Developing, 3-Practicing, 4-Maturing, and 5-Mastering). This method and assessment tool can be used at course level in order to develop EPS and provide feedback, as well as at program level for data collection and inclusion in an accreditation report (McCormack, Beyerlein, Kranov, Pedrow, & Schmeckpeper, 2014). A particular advantage of EPSA is a customization possibility (Schmeckpeper, Kelley, & Beyerlein, 2014). There is thus an opportunity for enhancing and adapting EPSA to the particular conditions of engineering education in Indonesia.

Unique Criteria of Local Content

Indonesia has the fourth largest population in the world (252 million in 2014). In Indonesia there are currently 2,647 colleges in the form of academies, polytechnics, colleges, institutes, and universities. Of this total, only 212 are public universities, while private universities comprise the remaining 2,435. Most colleges provide engineering education.

Local content is a part of the curriculum structure. The existence of local content subjects is a form of education provision that is not centrally defined, in an effort to ensure the provision of education in each region which is relevant to the circumstances and needs of the region concerned. This is in line with efforts to improve the quality of national education so that the existence of local curriculum supports and complements the national curriculum. The scope of the local content can be in the form of the local language, local arts, skills and crafts area, customs, and knowledge of the various characteristic of the surrounding natural environment, as well as things that are considered necessary within the relevant location.

The learning process in the engineering school can be done in intra-curricular, curricular, and extra-curricular activities. However, there is a limited space available for inclusion of local contents as the curriculum must simultaneously cover all necessary aspects. In turn, this limits the amount of curriculum space for development of EPS. In the process of learning, these local contents can be integrated in all teaching and learning activities (Sofyan, 2006). There is flexibility in the design of local content since it can be determined independently by institution. That is why the local contents are also known as institutional contents.

Building a Customized EPSA Rubric

A customized EPSA rubric has been developed based on Curriculum 2012 of Department of Industrial Engineering, Universitas Atma Jaya Yogyakarta (IE UAJY), Indonesia which is derived from ABET EC-2000, Decree No. 232/U/2000 and Universitas Atma Jaya Yogyakarta curriculum contents. There are three criteria named as Main Criteria (MC), Supporting Criteria (SC) and Additional Criteria (AC). Main criteria is the criteria required by the national curriculum in the decree as general competencies that must be met by all engineering graduates. Supporting criteria refers to the competencies that must be met by appropriate engineering graduates within their engineering field. Additional criteria is the competencies that refer to the local conditions and needs, also known as local competencies. By adding additional criteria, the institution gives competitive advantages to its engineering graduates. The comparison of each criteria is shown in Table 1. Local content or institutional content is represented as Additional Criteria (AC).

Main Criteria (MC) consists of seven outcomes, Supporting Criteria (SC) consists of three outcomes and Additional Criteria consists of five outcomes. These outcomes are classified as hard engineering skills and soft engineering skills. After eliminating hard engineering skill outcomes, we are left with five outcomes which will be used in the customized rubric.

Table 1: Comparison of ABET EC-2000, Decree No. 232/U/2000 and IE UAJY (2012)

ABET EC-2000	DECREE OF MINISTER OF NATIONAL EDUCATION OF THE REPUBLIC OF INDONESIA No. 232/U/2000	IE UAJY Criteria (2012)
3d. Ability to Function on Multi-disciplinary Team		SC2. An ability to work effectively in a team either as a leader or member
3f. Understanding of Professional and Ethical Responsibility	2.3.2.c. Ability to act and behave ethically in working in his/her field of expertise in society;	SC3. An understanding of professional and ethical responsibility
3g. Ability to Communicate Effectively		MC7. An ability to communicate effectively
3h. Understanding of the Impact of Engineering Solutions in Global, Economic, Environmental, and Cultural/Societal Contexts	2.3.2.b. Ability to apply knowledge and skills in accordance with his/her expertise in the field of productive activities and service to the community with good attitudes and behaviour in society;	MC6. An ability to make decision to implement the results of problem solutions and demonstrate a deep understanding of its impact on the social, environmental, local and global context
3i. Recognition of and Ability to Engage in Life-Long Learning	2.3.2.d. Ability to engage in Life-Long Learning (up to date in the development of science, technology, and/or art in his/her field of expertise)	
3j. Knowledge of Contemporary Issues		
		AC1. Ability to be a technology-based entrepreneur in order to create new jobs

The final outcomes are then expanded to several specific areas as shown in Table 2.

Table 2: Professional skills aligned in the modified EPSA rubric

OUTCOME	SPECIFIC AREA CONSIDERED
MC6. An ability to make decisions to implement the results of problem solutions and demonstrate a deep understanding of its impact on the social, environmental, local and global context	Problem solving Impact/Context
MC7. An ability to communicate effectively	Verbally Non-verbally
SC2. An ability to work effectively in a team either as a leader or member	Leadership Participation

SC3. An understanding of professional and ethical responsibility	Stakeholder Perspective Problem Identification Ethical Considerations
AC1. An ability to be a technology-based entrepreneur in order to create new jobs	Creativity Technology Innovation

The EPSA rubric is an analytical rubric which is used to evaluate the students' discussion. We adopted the one-page version (March 2014) of the EPSA rubric published by Schmeckpeper, Kelley, & Beyerlein (2014) and replaced the five criteria related to learning outcomes of ABET with the new criteria which include the local content. Our modified rubric is provided in the Appendix.

Locally Relevant Scenarios

This new modified rubric is then complemented by the use of a series of locally relevant scenarios for the assessment. The scenarios are empowered by the use of a set of discussion questions that serve as a prompt to guide the discussion. EPSA scenarios are intended to cover real life experiences, related to the field of engineering that the students are studying, and are used to identify aspects, raise issues or otherwise enhance the understanding and learning experience of the engineering students. Because the scenario provides real-world examples of problems and solutions, challenges and strategies, the scenarios can be prepared based on the local situation faced by the stakeholders. Four locally relevant scenarios were designed for this research according to recent local issues in Indonesia. A list of the scenarios and aspects of their assessment can be seen in Table 3.

Table 3: List of locally relevant scenarios

Scenario No.	Title	General aspects of assessment	Locally relevant aspects of assessment
1	Adam Air	Problem identification Stakeholder identification and their interest Potential impact of proposed solution Ethical issues	Bribe issue based on political situation Local procedures for conflict of interest resolution versus international best practice
2	Low Cost Carrier	Problem identification Stakeholder identification and their interest Potential impact of proposed solution Ethical issues Problem solving	Local culture and customs view of the dilemma of safety versus cheap airfares
3	GO-JEK	Problem identification Stakeholder identification and their interest Potential impact of proposed solution Problem solving	Creating business opportunities and ideas based on local situation Local culture and customs view on transportation problem
4	National Car	Problem identification Stakeholder identification and their interest Potential impact of proposed solution Problem solving	Understanding political aspect of problem Conflict of interest among stakeholder based on business and national pride

Results and Discussions

The customized EPSA rubric has been used in a trial with five classes in the Department of Industrial Engineering, Universitas Atma Jaya Yogyakarta, Indonesia. The purpose of the trial was to evaluate our first attempt at a customized EPSA rubric. The trial (Table 4) was implemented in 3 different subjects, namely Technopreneurship (IND3852), Integrated System Design (IND4264) and Engineering Ethics (IND5172). The reason for the selection of these courses was because they are integrative courses which are taught in the two final years of the degree. By that stage students already have sufficient engineering knowledge to analyze engineering issues arising in these scenarios.

Table 4: Observed classes information

Code	SUBJECT	WEEK 1 (TRIAL RUN)			WEEK 2 (REAL RUN)			WEEK 3 (EVALUATION)
		Scenario No.	Number of Participants	Number of Groups	Scenario No.	Number of Participants	Number of Groups	Number of Participants
IND3852	Technopre-neurship	3	45	6	2	54	6	55
		3	62	6	2	42	6	53
IND4264	Integrated System Design	4	22	3	1	21	3	22
		1	18	3	4	24	3	21
IND5172	Engineering Ethics	1	42	6	4	34	5	38

193 students in the five classes were divided into teams, with one part of the team conducting a discussion based on given scenarios (representative of situations encountered in professional engineering) and the other part of the team using a modified EPSA rubric to assess the discussions. Each student was asked to be either a discussant or an assessor with the allocation to be arranged in class. The process took 3 weeks; the first week was used for a trial run, the second week was the actual assessment, and the third week was used for interviews and clarifications.

To evaluate the modified rubric, the students numerically rated their experiences in assessing students' discussion using the modified EPSA rubric. They were given a questionnaire which was divided into three parts. The first part was used to evaluate the given scenarios, the second part to evaluate the assessment rubric and the last part to evaluate the assessment process. Free format feedback at the end of questionnaires was also available to collect students' responses. Using a 5-point Likert Scale (with 5 being the ideal score) the mean of their observations (Table 5) were 3.42 / 5.00 for the scenarios, 3.38 / 5.00 for the rubric and 3.76 / 5.00 for the assessment process. That is, by and large the students thought the rubric was adequate but could be improved. Some of the feedback we received indicated that the rubric was too complicated and that students needed more time to practice both as participants and as an assessor. There is, of course, an inevitable tension between the ideal length of time to be spent on these assessments and that feasible within the other demands of the course. It was not possible to allocate more than 3 weeks for this activity since each class has it own schedule for what should be accomplished. Consequently, we recommend the redesign and simplification of the assessment rubric so it is easier to understand and implement in limited classroom time.

Table 5: The mean of student (self-assessed) experiences using the modified EPSA

CODE	SUBJECT	Part 1 (Scenario)	Part 2 (Rubric)	Part 3 (Assessment Process)
IND3852	Technopreneurship	3.47	3.32	3.48
		3.40	3.26	3.68

IND4264	Integrated System Design	3.68	3.73	4.07
		3.42	3.43	3.92
IND5172	Engineering Ethics	3.14	3.16	3.66
	AVERAGE	3.42	3.38	3.76

**Scale: (1) Strongly disagree, (2) Somewhat disagree, (3) Neither agree nor disagree, (4) Somewhat agree, (5) Strongly agree*

Meanwhile feedback from the Focus Groups (193 students were divided into 23 groups) also demonstrated similar results. Eighteen of the 23 groups declared that the major obstacles encountered during the process of discussion was the lack of time given. Furthermore 20 of the 23 groups expressed feedback that they easily understood the content of a given scenario but needed extra time to explore the scenario in more depth. Barriers identified during the assessment process were mainly due to logistical problems in the form of limited space in the classroom conditions causing noise disturbance from other discussion groups. However, 14 of the 23 groups agreed that the rubric assessment was too complicated.

A second finding (which was anticipated) was that students would complain about incomplete information in each scenario. The scenarios did not provide all the information needed because they dealt with "open-ended problems". The scenarios need to be brief to limit the number of pages so they can be read quickly. It's desirable that students learn how to make decisions with incomplete information. Inevitably, this makes some students feel uncomfortable with the conditions that exist in the scenario. Some students try to avoid making a firm decision. Students tend to expect a situation with all the data complete so that decision-making tends to be "algorithmic". By contrast, the information provided in the scenarios (including deliberate gaps) is intended to replicate situations which will be encountered by students in the real world following their graduation.

Conclusions

The customized EPSA rubric developed in this research extends that of the original rubric, beyond ABET EC-2000 requirements, to include EPS requirements of the global and local curriculum contents. Initial analysis of the results indicates the modified rubric is appropriate both in assessment and for developing students' understanding regarding the global and local curriculum contents. The trial has also identified issues to be investigated further before a second trial in 2017, with the most significant being shortening the rubric to fit within the limited classroom time available for this assessment.

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Appendix: The modified EPSA rubric*

	0 - Missing	1 - Emerging / 2 - Developing	3 - Practicing / 4 - Maturing	5 – Mastering
MC6. An ability to make decisions to implement the results of problem solutions and demonstrate a deep understanding of its impact on the social, environmental, local and global context				
	0 - Missing	1 - Emerging / 2 - Developing	3 - Practicing / 4 - Maturing	5 – Mastering
Problem solving	Students do not have any idea how to solve the problem	Students are able to come up with ideas of problem solving although these ideas are taken from the solutions that already exist.	Students are able to come up with ideas of problem solving. Although these ideas are taken from the solutions that already exist, they are able to make some adjustment and modification for the ideas.	Students are able to generate new ideas of problem solving and demonstrate how they choose the best solution from some alternative solutions.
Impact/Context	Students do not consider the impacts of potential solutions	Students start to consider the impact of their proposed solutions. Contexts considered may not be relevant. Students don't seem to understand the value or point of considering impacts of technical solutions or the contexts within which the solution is proposed.	Students consider how their proposed solutions impact major relevant contexts, and possibly re-think their understanding of the problem(s) themselves; justify possible solutions with reasonable accuracy. Impacts considered may be associated with relevant secondary problems.	Students clearly examine and weigh how their proposed solutions impact major relevant contexts, and justify possible solutions with reasonable accuracy. Impacts considered may be associated with relevant secondary problems, and display understanding of how different contexts can affect solution effectiveness.
MC7. An ability to communicate effectively				
	0 - Missing	1 - Emerging / 2 - Developing	3 - Practicing / 4 - Maturing	5 – Mastering
Verbally	Students do not demonstrate their ability in presenting their own ideas.	Students deliver their own ideas without considering other student's ideas.	Students demonstrate their ability to absorb, summarize and clarify other student's ideas. Most of the discussants give valuable input and attempt to clarify other's ideas.	Students invite and encourage participation of all discussion participants, build and clarify ideas together. Students build upon all ideas to come to a consensus.
Non-verbally	There is no evidence of using body language during discussion progress.	Some students may demonstrate their body language and gestures when they deliver their ideas, but it may not express their understanding of the problems raised in the scenario.	Students use body language, gestures and the tone and pitch of voice to emphasise their ideas. Students attempt to convince their colleagues to reach consensus.	Students demonstrate how to use body language, gestures and the tone and pitch of voice to emphasise their ideas effectively. It can be seen that students clearly work together to reach a consensus in order to clearly frame the problem and develop appropriate ways to solve the problem.
SC2. An ability to work effectively in a team either as a leader or member				
	0 - Missing	1 - Emerging / 2 - Developing	3 - Practicing / 4 - Maturing	5 – Mastering
Leadership	Students do not demonstrate their leadership ability in a team	Students begin to demonstrate their leadership ability in a team but have difficulty playing a role as a leader.	Students are generally successful in playing a role as a leader in a team.	Students demonstrate their leadership ability in a team, take control and lead all team members toward the main goals.
Participation	Students do not participate in a team	Students begin to participate a little in a team after getting encouragement from other team members.	Students participate actively in a team.	Students participate actively in a team while they also drive other team member's participation.
SC3. An understanding of professional and ethical responsibility				
	0 - Missing	1 - Emerging / 2 - Developing	3 - Practicing / 4 - Maturing	5 – Mastering
Stakeholder Perspective	Students do not identify stakeholders	Students identify few and/or most obvious stakeholders, perhaps stating their positions in a limited way and/or misrepresenting their positions	Students explain the perspectives of major stakeholders and convey these with reasonable accuracy	Students thoughtfully consider perspectives of diverse relevant stakeholders and articulate these with great clarity, accuracy and empathy
Problem Identification	Students do not identify the problem(s) in the scenario	Students begin to frame the problem, but have difficulty separating primary and secondary problems. If approaches to address the problem are advocated, they are quite general and may be naive.	Students are generally successful in distinguishing primary and secondary problems with reasonable accuracy and with justification. There is evidence that they have begun to formulate credible approaches to address the problems.	Students convincingly and accurately frame the problem and parse it into sub-problems, providing justification. They suggest detailed and viable approaches to resolve the problems.
Ethical Consideration	Students do not give any attention to ethical considerations	Students give passing attention to related ethical considerations. They may focus only on obvious health and safety considerations and/or fair use of funds involving primary stakeholders.	Students are sensitive to relevant ethical considerations and discuss them in the context of the problem(s). Students make linkages between ethical considerations and stakeholder interests. Students may identify ethical dilemmas and discuss possible trade-offs.	Students clearly articulate relevant ethical considerations and address these in discussing approaches to resolve the problem(s). Students make linkages between ethical considerations and stakeholder interests and incorporate them into their analysis and resolutions. Students may discuss ways to mediate dilemmas or suggest trade-offs.
AC1. An ability to be a technology-based entrepreneur in order to create new jobs				
	0 - Missing	1 - Emerging / 2 - Developing	3 - Practicing / 4 - Maturing	5 – Mastering
Creativity	Students do not demonstrate their creativity.	Students are able to modify an existing business idea into a new business idea.	Students are able to create a new business idea (think out of box).	Students are able to create a new business idea (think out of box) and formalize it into a business plan.
Technology Innovation	Students do not demonstrate their technology innovation ideas.	Students are able to master existing technology and use it to modify an existing business idea into a new business idea.	Students are able to master existing technology and use it to create a new business idea.	Students are able to develop a new technology innovation and use it to create a new business idea.

**adapted from the one-page version (March 2014) of the EPSA rubric published by Schmeckpeper, Kelley, & Beyerlein (2014).*