A new approach for assessing ABET's professional skills in computing

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ABSTRACT: In the fields of engineering and computing, the Accreditation Board for Engineering and Technology (ABET) education places much emphasis on professional skills, such as the ability to engage in lifelong learning and to function successfully on a multi-disciplinary team. The recently developed engineering professional skills assessment (EPSA) simultaneously measures ABET's non-technical skills for programme and course level assessment. The EPSA is a discussion-based performance task designed to elicit students' knowledge and application of professional skills. A research project is underway to adapt the method to the field of computing and develop the computing professional skills assessment (CPSA). The CPSA consists essentially of a scenario, a student discussion of the scenario and a rubric to grade the discussion. This article describes the work completed during the first year of the project and the results of the first complete iteration. The results demonstrate that the CPSA can successfully measure the professional skills.

INTRODUCTION

The engineering and computing disciplines worldwide recognise the importance of non-technical professional skills (which are also known by terms, such as transferable, 21st Century or soft skills) to graduates. University programmes have increasingly focused on these skills, which include teamwork, communication, critical thinking, and ethical and social considerations. However, these skills are considered very challenging to teach and assess [1].

The Accreditation Board for Engineering and Technology (ABET) education, the global leader in technical education accreditation, prescribes a number of student outcomes that students should attain by the time of graduation. Among them are six non-technical professional skills learning outcomes:

- Ability to function on multidisciplinary teams (outcome d);
- Understanding of professional and ethical responsibility (outcome f);
- Ability to communicate effectively (outcome g);
- Understanding of the impact of engineering solutions in global, economic, environmental and cultural/societal contexts (outcome h);
- Recognition of and ability to engage in life-long learning (outcome i);
- Knowledge of contemporary issues (outcome j) [2].

To address the persistent challenge of assessing these skills effectively, a method known as the engineering professional skills assessment (EPSA) was developed in Washington State University's College of Engineering by a team led by Ater Kranov [3]. The EPSA is the first and only direct method in the literature that can be used to assess all six ABET non-technical skills simultaneously. Assessment methods used up until now had typically measured each skill separately and distinctly from each other, and often evaluated the skills indirectly. Measuring the outcomes simultaneously increases the efficacy of the assessment, while direct measures are far more trustworthy. They are more trustworthy because they are concrete examples of student learning done through measures like capstone projects, responses on examinations, written work or simulations [4]. Indirect methods, such as self-rating scales are less trustworthy since they are merely proxies for student learning.

The EPSA consists essentially of a scenario, a student discussion of the scenario and a rubric for examining student responses. The scenario is designed such that the student discussion demonstrates the students' abilities in the six professional skills. The US National Science Foundation funded a rigorous five-year validity study of the EPSA method, which, at the time of this writing, is drawing to conclusion [5]. In 2014, Zayed University in the United Arab Emirates (UAE) embarked on a research project to adapt the engineering professional skills assessment (EPSA) to the field of computing and to the UAE. The ABET professional skills for computing (shown in Table 1) are somewhat

similar to those for engineering, but are dissimilar enough to require their own assessment tool. This project involves developing a rubric, creating appropriate scenarios suitable to the field of computing and the region and developing an implementation method. The primary task is the development of a valid and reliable rubric. The rubric, named the computing professional skills assessment (CPSA), is being developed from the EPSA. This article describes work conducted during the first year of the research project, which included creation of the scenarios, the first iteration of the CPSA rubric, adaptation of the method and results from the implementation.

The project is being conducted at Zayed University within the ABET accredited College of Technological Innovation (CTI). Zayed University is a UAE federal institution with campuses in Abu Dhabi and Dubai that primarily serves Emirati Nationals through a gender-segregated, English-medium environment. With a student population of approximately 9,000, nearly all of whom are undergraduate students, the University strives to deliver programmes matching international standards. CTI focusses on information technology (IT) education and seeks to produce graduates recognised by business, government and educational institutions in the UAE, the Gulf Region and the rest of the world, as having a sound, modern and comprehensive education in information technology. As part of this comprehensive education an emphasis is placed on ABET's professional skills.

ASSESSING THE PROFESSIONAL SKILLS

Since the 1997 launch of the Engineering Criteria 2000 (EC2000) document, ABET has placed much emphasis on the professional skills [6]. EC2000 firmly established a learning outcomes focus and stressed the importance of professional skills such as teamwork and communication, when previously the technical skills had dominated. ABET's Criterion 3 - Student Outcomes has the professional skills embedded, and Criterion 4 - Continuous Improvement emphasises that processes must be in place for the regular assessment and evaluation of the degree to which students are achieving the outcomes.

Unfortunately, existing assessment methods that are being applied to assess the ABET professional skills have limitations. For example, AlBahi et al utilised student internships to assess the professional skills [7], but a weakness with such a method is that when an employer serves as the evaluator, there is little control on the reliability or validity of their ratings. Using a more traditional assessment method, Lopez et al implemented a take-home written examination [8]. However, such a method is obviously inadequate in its ability to assess a professional skill like teamwork. A written paper can have students describe or reflect upon aspects of successful teamwork, but it cannot directly measure a student's proficiency as a member of a team. Portfolios have been used [9], but if they rely on student reflection, they are a form of indirect measurement.

Measurement instruments, such as those mentioned above evaluate each skill separately, distinct from one another. Disparate measurement tools not designed to complement one another and that rely on perceptions are inadequate for data-driven curriculum decision making. These constraints can be problematic for accurate and useful course and programme-level assessment of attainment of student learning outcomes because they: a) do not provide direct measures of student learning; and b) can make the assessment process resource intensive and cumbersome to implement. In addition, academic programmes face significant challenges in using such assessment data for meaningful curricular change focused on increasing student learning of core skills. To address the problem of assessing the professional skills among engineering students in the US, Ater Kranov et al developed the EPSA, which is the first direct method of assessing all six simultaneously [3].

DEVELOPMENT OF THE CPSA

One of the best ways to measure student performance is through the implementation of a performance assessment [10]. Students in a performance assessment display their knowledge and skills by participating in a process of creating a product [11]. The three typical components of a performance assessment are:

1. a task that elicits the performance;
2. the performance itself (activity or artefact);
3. a criterion-referenced instrument, such as a rubric, to measure the quality of the performance [5].

Performance assessments are designed to address the more difficult aspects of higher learning by asking students to grapple with authentic problems and are framed in the recognition that learning outcomes do not exist without interdependence between other learning outcomes. The EPSA is a performance assessment that consists essentially of a scenario, a student discussion of the scenario and a rubric to grade the discussion. The scenario is a brief description of a current issue, which is authentic, ill-structured and complex, and similar to issues often faced by engineering professionals in the work environment. The discussion of the scenario is conducted face-to-face among a group of about five students for 45 minutes and is recorded. The discussion transcript is analysed by raters using the rubric and scores are agreed upon.

In a 2013 pilot study of the EPSA approach, a scenario was created and four dimensions of the EPSA rubric were used to examine the feasibility of adapting the method to computing and the UAE [12]. While ABET's engineering and

computing professional skills outcomes are not the same, the pilot study showed the potential of the method and how it could be adapted for use in computing and with unique sets of students. Early in the pilot study, it was realised that running the group discussion in a 45-minute face-to-face session would not be suitable for these students. Further, it was likely that the method would be considerably enhanced by running it over an extended period of time. By giving students adequate time to read and reflect upon issues in the scenario, it would allow them to demonstrate their skills to the best of their ability and, thus, provide a more accurate assessment. Therefore, the discussion was conducted on a Blackboard discussion board for a period of 10 days. The 10-day period allowed students time to reflect on the issues in the scenario, the input of other students and time to craft their responses carefully. Because most students had not participated in a discussion board previously, the activity was scaffolded. The two main components of the scaffolding were a one-hour face-to-face group discussion and a semi-guided 10 day discussion board. These activities were immediately followed by the main 10-day discussion activity.

The development of the CPSA involves three major steps: a) scenario creation; b) rubric development; and c) rubric assessment and establishing of inter-rater reliability. Steps two and three are iterative and will run for the entire duration of this project. Additionally, the implementation method via the discussion boards as discussed above is being refined. Three scenarios were created based on current issues in IT. They were produced in accordance with guidelines provided with the EPSA [13]. Each scenario describes a current real world issue, which is complex with many facets. Credible news sources and academic articles were utilised as sources. The length is around 600-700 words and the level of difficulty was targeted to third year students at Zayed University. In particular, an emphasis was placed on the readability of the scenarios given that students are non-native speakers of English. The English language entrance requirement for the institution is an IELTS of 5.0, which corresponds with the abilities of modest users of the language [14]. Hence, the readability of the text was set to level 12 on the Flesch-Kincaid scale, which puts it within the students' abilities. Prompts to guide the discussions were also drafted to accompany the scenario, and were aligned with the ABET professional skills (see Ater Kranov et al for an example of a scenario [13]).

The first iteration of the CPSA rubric [13] was based directly on the EPSA rubric using almost the same wording in many parts. The reason was that the EPSA rubric was a proven valid and reliable instrument. That version addressed five ABET outcomes. This next iteration of the rubric addressed all six professional skills outcomes and wording in the rubric was changed following a round of rubric assessment and establishment of inter-rater reliability. Table 1 presents the outcomes assessed by the current rubric and the criterion within each of the CPSA sub-sections.

Table 1: Outcomes assessed and criteria.

ABET professional skills student learning outcomes for computing		Specific criterion considered in the CPSA
(b)	An ability to analyse a problem, and identify and define the computing requirements appropriate to its solution	• Problem analysis/solution identification • Stakeholder perspective
(d)	An ability to function effectively on teams to accomplish a common goal	• Task orientation • Discussion and consensus
(e)	An understanding of professional, ethical, legal, security and social issues and responsibilities	• Ethical considerations
(f)	An ability to communicate effectively with a range of audiences	• Grammar, punctuation, spelling • Vocabulary
(g)	An ability to analyse the local and global impact of computing on individuals, organisations and society	• Impact/context
(h)	Recognition of the need for and an ability to engage in continuing professional development	• Scrutinise information • Identify knowledge status

CONDUCTING THE ASSESSMENT

The current version of the CPSA was run, using a scenario on the topic of information privacy, with students studying a third year core course. The selected course investigates the role of IT in global and local contexts. The course learning outcomes include global awareness, technical communication, leadership, teamwork and critical thinking. As the learning outcomes aligned well with ABET outcomes, this was an ideal course for assessing professional skills, such as teamwork, global perspective, ethical and social awareness and communication. The participants were 29 native Arabic speaking women, in their early 20s, who had been studying in English throughout their baccalaureate degree. As they were third year students, their IELTS level was expected to be near to 6.0 - a competent user [14].

There are three distinct stages in the implementation of the CPSA and the initial two stages serve both as preparation for the assessment and also as excellent learning activities. The first stage is an instructor facilitated, face-to-face, small group discussion lasting one class period using one of the scenarios and prompts. This is used as a scaffolding exercise to make the students comfortable with the task and to become aware of the expectations for the next two stages. The second stage is conducted in a similar manner except that it is converted to an on-line, asynchronous, small group discussion, with limited instructor involvement. This discussion uses another one of the scenarios, lasts for about 10

days, and demands regular reading and postings from the students. At the start of this stage, students are given instructions on how to conduct an on-line discussion over a 10-day period. For the students, this is normally the first time that they have participated in this type of activity. During the on-line discussion, where there is poor participation or interaction or students are off track, the instructor enters into the discussion and provides guidance. The discussions are to be student led, so students are to generate responses and solutions. At the completion of this round, postings are anonymised and used as an in-class teaching resource demonstrating high and low quality responses. As an incentive for students to participate, the activity is assessed as a course requirement and grades are awarded to individuals. The final stage mirrors the second but, this time, there is no instructor intervention unless absolutely necessary. Again as an incentive for students to participate, the activity is assessed as a course requirement and grades are awarded to individuals for course grading purposes.

IMPLEMENTING THE CPSA RUBRIC

As the assessment of the skills is for programme assessment purposes, the students are assessed as groups and not individually. According to Holmes and Oakleaf, norming is crucial to the efficacy of a rubric and without such a process, deployment of a rubric may be a waste of time or severely limit its effectiveness [15]. Because of this, use of the CPSA rubric to assess student work involves a small team of assessors who participate in a norming process and continually work towards rater consensus.

A faculty rating session is started with a review of the rubric and a discussion of any issues that may have emerged. Raters are given a printed copy of the discussion board for each group. Raters, then, begin the process of assessing groups against the specific criteria and descriptors within the CPSA, and when complete, share the ratings. When results are shared, examples from the discussion text are used to support rater assertions directly. Where there is disagreement, further examples are presented and more discussions occur as raters work towards consensus. The approach taken follows the process described by the University of Hawaii Manoa's Assessment Office [16], where rater consensus is developed by having raters explain their evaluations through providing examples directly from the discussion text. In the case being described here, as the rubric is under development, complete rater agreement is not an expectation, nor is it required as the goal is a shared understanding for subsequent rubric improvement. Upon completion of the ratings discussion, scores from each of the raters are recorded, then, the mean is calculated (rounding is applied if necessary) to generate the overall score for each of the outcomes.

Though consensus-based, investigating the inter-rater reliability is important. Stemler posits that levels of agreement between raters should be 70% or greater [17], so this was the target for both the complete instrument and the individual outcomes. Inter-rater reliability was calculated through the simplest of methods - a simple count of cases receiving the same ratings divided by the total number of cases. Figure 1 demonstrates that the overall level of agreement was 75%, while the outcomes ranged from a low of 61% for (d) teamwork to a high of 83% for (f) communication, (g) local and global impact, and (h) professional development. These results show that the rubric does not meet the target for outcomes (d) teamwork and (e) ethics as both were below the 70% threshold. Further refinement of the rubric is required.

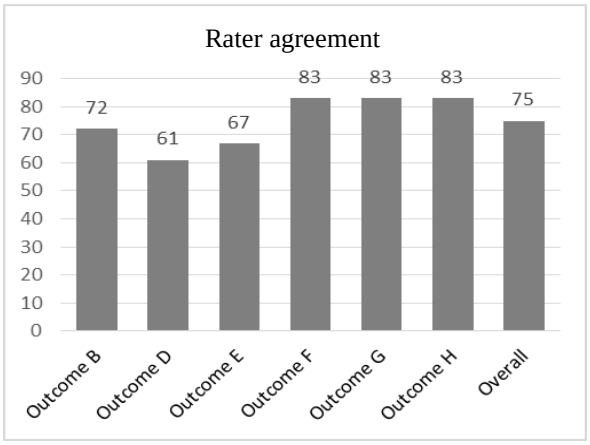

Figure 1: Inter-rater agreement.

RESULTS OF ASSESSMENT

Once results had been determined for each group, mean scores and % ≥ 3 was calculated for each of the outcomes. The target level of attainment was ≥ 3 on the six-point rubric, and the results indicate that overall the target was met 50% of the time (18/36) (see Table 2). The reason that three is the target level is because the associated rubric descriptors are aligned with expectations for students studying in a third year course. Disaggregated according to specific learning outcomes, (f) communication was the outcome for which the student groups performed best, reaching the target 83% of the time. Outcomes (d) teamwork and (e) ethics were the other two areas where students performed

well with 67% (4/6) groups achieving the target. Outcomes where students functioned inadequately (≤ 33% achieving the target) were (b) problem-solution, (g) local and global impact and (h) professional development. These results reveal that problem-solution, local and global impact and professional development are the outcomes that should be targeted for programme improvement. Communication is an obvious strength, while teamwork and ethics probably only require monitoring since the second group appeared especially weak.

Table 2: Student performance.

Group	B	D	E	F	G	H
1	2	2	3	2	2	1
2	1	1	1	3	1	1
3	2	3	4	3	3	3
4	2	3	3	3	3	2
5	4	4	3	3	2	2
6	3	3	2	3	2	1
Mean	2.33	2.67	2.67	2.83	2.17	1.67
% ≥ 3	33	67	67	83	33	17

DISCUSSION

The results of this trial demonstrate that the CPSA method can successfully measure the professional skills. While the sample size was small and the rubric is in the early stage of its development, the results indicate that this approach, which is the first of its kind in the field of computing, promises to be an effective way to measure the professional skills. The authors believe that this approach of conducting the discussion activity on-line for a 10-day period is a considerable enhancement over the EPSA, where the discussion activity lasted 45 minutes. The 10-day period allows time for the students to work on the problem and address the various aspects raised in the prompts. Asynchronous discussion boards seem ideally suited for second language learners, because they have the time to reflect upon and compose meaningful responses. Further, to address all the prompts in a meaningful manner students need to read more about the issue presented in the scenario by examining the references and searching for additional information. Again this aspect of the assessment is not possible in the face-to-face discussion.

The authors believe that the CPSA will also be an ideal approach to teaching professional skills and the results of the student survey showed that the students felt that it was a good learning experience. In particular, the tiered approach of a face-to-face meeting, followed by a 10-day guided discussion, then, a non-guided discussion, provided good learning. After the next round of CPSA refinement, the authors will look further into the teaching and learning benefits of this method.

CONCLUSIONS

Since the launch of EC2000 in 1997 [6], the importance of professional skills has been firmly established within the technical disciplines. Governments and higher education institutions alike have recognised that these are the skills that employers want and countries need in university graduates, if they are to contribute meaningfully to knowledge economies. Assessing the professional skills has been very challenging. However, the recent EPSA for engineering students has proved to be a successful approach. Now for computing/IT students, the CPSA is under development and promises to be a good method for use in teaching, as well as assessing these skills.

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