Assessment of learning outcomes through an asynchronous on-line discussion board

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ABSTRACT: Asynchronous on-line discussion boards (AODBs) have become a standard pedagogical tool, and the use of learning outcomes has become normalised in much of higher education, yet little is known about using AODBs to assess learning outcomes. Hence, this article aims to assess the degree to which students demonstrate learning outcomes attainment through participation in an AODB. The research method implemented is built around a particular AODB instrument designed to teach and assess cross-disciplinary learning outcomes. Using a sample group of 30 computing students studying at a public university in the United Arab Emirates, this article demonstrates that a well-designed and structured AODB can be used to teach and assess important cross-disciplinary learning outcomes, and that discussions can be assessed in an efficient manner. By examining both student group and learning outcome scores, results indicate that students showed improvement in learning outcomes attainment across a semester. Given the recent growth in on-line learning, this study supports the need for more research into the use of AODBs as a method to teach and assess learning outcomes.

INTRODUCTION

Asynchronous on-line discussion boards (AODBs) have become a standard pedagogical tool for on-line and blended learning, and are now gaining traction in the traditional face-to-face classroom environment [1][2]. Correspondingly, learning outcomes have become standard nomenclature, while their integration into courses and programmes is now the norm [3]. Nonetheless, throughout the literature, there is limited understanding and consensus about why and how AODBs and their associated learning outcomes should be assessed.

The *why* question can be addressed with the understanding that if an activity is worth doing, is aligned with course learning outcomes, and requires a great deal of effort from students, then it needs to be assessed as both an incentive and reward for students. In terms of the *how* question, a common narrative in faculty development workshops is that AODBs generate a large amount of text that can be difficult to assess in an efficient manner [4], which is both reliable and valid [5]. Standard approaches to assessment of AODBs include criteria, such as timeliness of posts, depth and sophistication of posts and etiquette or ability to work well with other discussion participants, and points are awarded for each of the criteria to generate a somewhat efficient, reliable and valid assessment [6][7]. Of course, such approaches implemented with individual students over multiple discussions lead to a copious amount of reading and grading for instructors.

Learning outcomes are the foundation for any course or programme because they focus attention on what is learned rather than what is taught. The UK's Higher Education Academy describes learning outcomes as the skills and knowledge that a student should possess on successful completion of a course of study [8]. The Accreditation Board for Engineering and Technology (ABET), an international disciplinary accreditor in higher education, defines learning outcomes as what students are expected to know and be able to do by the time of graduation. These relate to the knowledge, skills and behaviours that students acquire as they progress through the programme [9]. ABET also defines assessment as one or more processes that identify, collect and prepare data to evaluate the attainment of student outcomes [9]. AODBs are one of many mechanisms that can be used to assess student attainment of learning outcomes.

The learning outcomes assessed in this research study are ones aligned with ABET's professional skills. These types of outcomes are also known as general education learning outcomes or 21st Century skills, and they include critical thinking, problem-solving, teamwork, information literacy and communication, amongst others. They cross disciplinary boundaries and are keys to successful employment [10][11]. While this study has been conducted in the discipline of computing, the findings are applicable to a wide audience since the learning outcomes cross disciplines. There has been considerable growth in the use of AODBs, yet there is still a limited understanding about ways in which they can be assessed - so this study makes a valuable contribution to knowledge in this area. The particular question addressed through this research is to what degree do students demonstrate learning outcomes attainment over time through participation in an AODB?

LITERATURE REVIEW

With AODBs, some of the most important questions to ask are why and how to integrate them into one's teaching. Key answers to these questions include that they increase interaction, are good for introverted or second language students, facilitate critical or higher order thinking, are recognised by students for their effectiveness, and that they can be graded. In terms of increased interaction, authors have found that AODBs can promote student participation [12]. Specifically, in a large study examining asynchronous learning networks researchers found that students reported being twice as likely to participate in, and put more thought into, on-line discussions than traditional face-to-face discussions [13]. More recently, Jacobi stressed the importance that structured, organised and prompted AODBs are necessary to promote meaningful engagement [6]. In a traditional discussion, it is easy for one or a small group of students to dominate the dialogue, whereas in an asynchronous environment everyone has an equal opportunity to contribute. In an AODB all students, including less confident students, have time to carefully reflect upon their response, consolidate and link ideas together and have their voices heard [14].

With second language students this reflective time plays an important role. Krashen, in his work on second language learners, proposed the monitor model in which learners monitor their output; that is, they may or may not communicate depending on circumstances [15]. When a learner over monitors their output, communication is halted and difficult. The reflective time available in an AODB mitigates this concern and allows the learner to participate effectively in the asynchronous discussion. While increases in discussion participation are important, an equally important issue is whether or not the discussions promote critical thinking.

Research has consistently shown that well-crafted AODBs can facilitate critical thinking or as the communities of inquiry model (COI) describes it, cognitive presence [4]. For example, in 2015, authors conducted an extensive review of the literature for eight existing models used to assess problem-solving in AODBs [16]. What they found was that while there were strengths and weaknesses to all of the models examined, AODB tasks needed to be well-designed if they are to promote critical thinking. They identified that techniques like scaffolding in terms of guiding questions and direct faculty interventions into discussion when students were getting off track were essential. This supported previous work that identified that scaffolding in the form of questioning led to higher quality posts and higher order thinking [17].

Other authors noted well-structured discussions with clear expectations for students were vital to *moving students to higher levels of understanding* [18]. An example of a well-structured discussion with clear expectations comes from Jacobi, where groups (seven to eight) of students were expected to post a 300-400 word response to a prompt by mid-discussion, and then follow up with a 150-200 word response to a post from a peer near the end of the discussion period [6]. Like other course tasks or activities that might be utilised, AODBs need to be well-crafted, with clear guidelines and expectations if they are to be worthwhile. When this is done, most students find AODBs more useful than traditional face-to-face discussions [6].

Though the use of AODBs is beneficial, anyone who has used them in a course, and then assessed them, realises that grading student posts can be challenging and very labour-intensive. Garrison et al noted this as they began to develop their COI model [4]. Nonetheless, in order for AODBs to be effective, students need to participate in them and the surest way to achieve this goal is to give them adequate weight in the course. Jacobi found that the AODBs were effective because all students participated as the discussions were worth 1/3 of the course grade [6]. This echoed the findings by Swan et al that stated AODBs need to be assessed and should count for a significant portion of the course grade [19].

The cross-disciplinary nature of the professional skills learning outcomes and their importance in the workplace makes them extremely important to university curricula [20]. However, one of the challenges with the professional skills is that they have long been seen as difficult to assess [21][22]. This is thought to be the case because they are non-technical skills like problem-solving and teamwork, ones which many faculty, especially in technical programmes, have very little knowledge or experience in assessing [23]. In addition, there are very few existing assessments that evaluate more than one professional skill at a time, thus making the process quite cumbersome [24].

THE CPSA

The computing professional skills assessment (CPSA) is a teaching and assessment tool developed for the purpose of effectively and efficiently assessing the professional skills as defined by ABET within the computing discipline. Part of the impetus towards creation of the CPSA was earlier research into the development and efficacy of the engineering professional skills assessment (EPSA) [25]. The EPSA was a face-to-face assessment instrument, where small groups of students participated in a 45-minute discussion about a complex, ill-structured and authentic engineering problem, thereby demonstrating differing levels of proficiency in the professional skills as defined by ABET's Engineering Accreditation Commission. Transcripts of the discussions were assessed by a group of faculty according to the criteria in the EPSA analytic rubric.

The initial iteration of the CPSA occurred in 2014 and was designed as an AODB rather than a face-to-face instrument because of the growing body of literature that showed the strengths and benefits of AODBs [1]. The primary benefit of the AODB is that the assessment runs over a 12-day period providing time for students to fully engage with the problem, and to develop and improve their skills. Numerous other benefits include development of critical thinking [2][14], increased participation rates when compared to face-to-face discussions [6][12], development of teamwork skills [26], and the suitability of asynchronous discussion for second language learners as lack of immediacy allows them needed time to better edit or monitor their output [15]. As the CPSA is very valuable as a tool for students to learn the professional skills, it is best described as a learning-oriented assessment.

The CPSA is a group-level learning and assessment instrument that allows students to demonstrate ability in the professional skills. Student groups attempt to solve a complex, ill-structured and authentic computing problem over a 12-day period collaborating on the AODB. The main components of the CPSA are:

1) a short computing-based scenario with accompanying discussion instructions and prompts;
2) a scoring rubric;
3) the method of implementation and assessment itself.

A scenario is a short 700-800 word article written about a relevant computing issue, where a solution is complex and multi-faceted with no obvious correct answer.

Scenario topics include, but are not limited to, cryptography, cyber-attacks, digital vulnerabilities and facial recognition. The scenarios are referenced with reputable news sources and academic journals, but are not intended to be all-encompassing theses on the topic; they are intended to be engaging discussion starters. The instructions that come with each scenario present the purpose, task, expectations and discussion prompts. The discussion prompts represent typical questions that would need to be addressed when solving a complex problem. The CPSA rubric is a criterion-referenced instrument that has been through numerous iterations to improve it and enhance its reliability and validity [5]. Currently, the CPSA rubric contains six sections, one for each of the six professional skills being assessed. The professional skills learning outcomes represented in the CPSA are:

- CPSA 1 - Students problem solve from a computing perspective;
- CPSA 2 - Students work together to accomplish a task;
- CPSA 3 - Students consider ethical, legal and security aspects;
- CPSA 4 - Students communicate professionally in writing;
- CPSA 5 - Students analyse the impacts of computing solutions within local and global contexts;
- CPSA 6 - Students interpret, represent and seek information.

For each of the professional skills the rubric includes assessment criteria, performance descriptors, and six possible levels of attainment: 0 - missing, 1 - emerging, 2 - developing, 3 - practicing, 4 - maturing, 5 - mastering. The levels of attainment are aligned with year of study, so that Master's students are expected to achieve a 5 - mastering, fourth year undergraduates a 4 - maturing, and so forth.

METHOD

Sample

The students that participated in this research were from three classes of a face-to-face, mandated computing course delivered in an ABET accredited computing programme at a gender-segregated, English-medium, public university in the UAE. All 65 students from the three classes gave consent to participate in the study with the proviso that their identity would remain confidential as per the approval granted by the institution's research ethics review board. For the purposes of this study, two groups were randomly selected from each class, so six groups had their discussion transcripts assessed. Each group was comprised of five randomly assigned students for a total of 30 students. These groups then worked together for the entire semester. All of the student participants were female Emiratis, native speakers of Arabic, and most were first generation university students aged between 19 and 25. The students were familiar with Blackboard, the medium for the AODB, as it is utilised to varying degrees in all courses.

Procedure

As the CPSA is a learning-oriented assessment, it is implemented normally two times in a semester and occasionally three times. The first run familiarises students with the process as they have never done this type of exercise previously. For this study, the CPSA was run three times as the authors were investigating the degree to which students' professional skills learning outcomes improved during the semester with three 12-day exercises on an AODB. Each implementation of the CPSA is a mandatory graded course component as this ensures full participation. Initially, students are given an introduction to the task, guidelines, expectations and assessment procedures, and then they are randomly assigned to groups of four to five on the Blackboard learning management system. The students start by carefully reading the scenario, and then over the following 12 days develop answers to the five prompts that are provided. There is no direct instructor involvement in any of the on-line discussions, though guidance on the process and detailed explanation of the prompts is provided during the first round. As Andresen noted, a faculty member's time is better served creating well-crafted AODB tasks with clear guidelines and expectations rather than getting directly involved with the discussions as they unfold [2]. Further, avoiding instructor involvement in the discussions prevents bias of the assessment.

At the end of the 12 days, the discussions are closed to students and the transcripts are collated and anonymised in preparation for assessment. The transcripts for each group are assessed by three faculty using the criteria present in the CPSA's analytic rubric. As there are six professional skills learning outcomes included in the CPSA rubric, student groups are assigned one score for each of the six learning outcomes by each of the assessors. Faculty collate the assigned scores and then meet to discuss any difference of greater than 1 for each of the learning outcome scores. Using the transcripts as evidence, faculty work together to reach a consensus on the scores and these are the final scores that are recorded for each of the groups.

RESULTS

Given that the CPSA was implemented three times in each class, the expected outcome is to see an improvement from the first to third instance of use. Because of this and to facilitate understanding of the data, overall group mean scores will be first shared followed by detailed scores for each group that includes the amount of improvement that occurred. To complete the results section, data is then examined from the perspective of the CPSA outcomes rather than student group mean scores.

Figure 1 illustrates the overall mean scores for each of the six student groups across both the first and third implementations of the CPSA, and it may be seen that in all cases the group mean scores increased from the first to third round. With a target mean score of 3.00, the figure shows that only group 1 achieved the target in the first round, and that only group 6 failed to attain the target in the third round. In the first round, scores ranged from 1.78 to 3.00, while they ranged from 2.83 to 4.67 in the final round. Data indicate that each group of students showed improvement from the beginning to the end of the CPSA task.

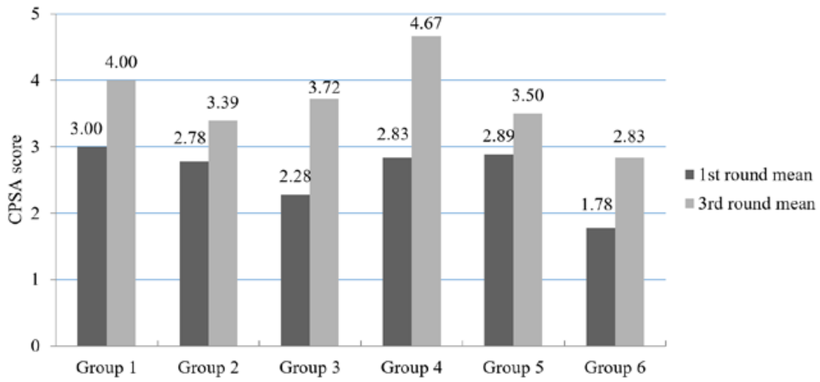

Figure 1: Group mean scores.

For the detailed scores of each CPSA outcome, Tables 1 to 6 display the mean scores for each group across all six CPSA outcomes in the first and third implementations, as well as the increase from the first to third rounds. For overall improvement, group 5 had a low of 0.61, while group 4 had the largest improvement with 1.84. Group 1 was the only group with mean scores above the target of 3.00 in both the first and third rounds, while group 6 was the only group with means scores below the 3.00 target in each round. Each round had a total of 36 data points or scored ratings, and of these 61.11% (22/36) were ≥ 3.00 target in the first round and 94.44% (34/36) were ≥ 3.00 target in the third round.

The lowest individual score of the first round was 1.00 (group 6, CPSA 6), and in contrast the highest was 3.67 (group 2, CPSA 6). The lowest individual mean score of the third round was 2.0 (group 6, CPSA 5), the highest was 5.00 (group 4, CPSA 1 - 4). In terms of % ≥ 3.00, group 6 had the poorest performance in the first round with only 16.67% of the scores attaining the 3.00 threshold, and groups 1, 4 and 5 all had the best performance in that 83.33% of scores were at or above the 3.00 threshold. For the third round of CPSA implementation, only groups 2 and 6 did not achieve 100% of the scores ≥ 3.00, and they both had a score of 83.33%. In terms of improvement from the first to third rounds, the range was 16.67% (groups 1, 2, 4 and 5) to 66.67% (groups 3 and 6). The results clearly demonstrate consistent improvement in professional skills attainment and meeting of the 3.00 target across the semester.

Table 1: Group 1 mean scores and increase.

Round	CPSA 1	CPSA 2	CPSA 3	CPSA 4	CPSA 5	CPSA 6	Mean	% ≥ 3.0
1	3.00	3.00	2.67	3.00	3.00	3.33	3.00	83.33
3	4.00	4.00	4.00	3.67	3.67	4.67	4.00	100
Increase	1.00	1.00	1.33	0.67	0.67	1.34	1.00	

Table 2: Group 2 mean scores and increase.

Round	CPSA 1	CPSA 2	CPSA 3	CPSA 4	CPSA 5	CPSA 6	Mean	% ≥ 3.0
1	3.00	1.67	3.33	3.33	1.67	3.67	2.78	66.67
3	3.67	3.67	3.67	3.67	2.00	3.67	3.39	83.33
Increase	0.67	2.00	0.34	0.34	0.33	0	0.61	

Table 3: Group 3 mean scores and increase.

Round	CPSA 1	CPSA 2	CPSA 3	CPSA 4	CPSA 5	CPSA 6	Mean	% ≥ 3.0
1	2.00	3.00	2.00	3.00	2.00	1.67	2.28	33.33
3	4.00	4.00	4.00	3.67	3.33	3.33	3.72	100
Increase	2.00	1.00	2.00	0.67	1.33	1.66	1.44	

Table 4: Group 4 mean scores and increase.

Round	CPSA 1	CPSA 2	CPSA 3	CPSA 4	CPSA 5	CPSA 6	Mean	% ≥ 3.0
1	3.00	2.00	3.00	3.00	3.00	3.00	2.83	83.33
3	5.00	5.00	5.00	5.00	4.00	4.00	4.67	100
Increase	2.00	3.00	2.00	2.00	1.00	1.00	1.84	

Table 5: Group 5 mean scores and increase.

Round	CPSA 1	CPSA 2	CPSA 3	CPSA 4	CPSA 5	CPSA 6	Mean	% ≥ 3.0
1	3.33	3.00	3.00	3.00	2.00	3.00	2.89	83.33
3	3.33	3.67	3.67	4.00	3.00	3.33	3.50	100
Increase	0	0.67	0.67	1.00	1.00	0.33	0.61	

Table 6: Group 6 mean scores and increase.

Round	CPSA 1	CPSA 2	CPSA 3	CPSA 4	CPSA 5	CPSA 6	Mean	% ≥ 3.0
1	1.67	2.00	1.67	3.00	1.33	1.00	1.78	16.67
3	3.00	3.00	3.00	3.00	2.00	3.00	2.83	83.33
Increase	1.33	1.00	1.33	0	0.67	2.00	1.05	

Figure 2 illustrates the mean CPSA scores for both rounds and again this shows a consistent improvement for each outcome. Results indicate that only with CPSA 4 - students communicate professionally in writing - were students achieving the target of 3.00 in the first round at 3.06, while by the third round all of the learning outcomes were at the expected level of 3.00. For five of the six learning outcomes, the range of scores in the third round was 3.67-3.89, and only CPSA 5 - students analyse the impacts of computing solutions within local and global contexts - was much lower at a 3.0.

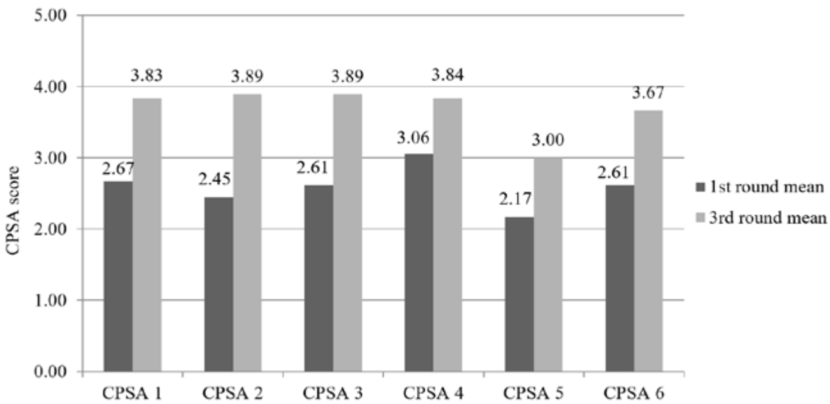

Figure 2: Learning outcome mean scores.

DISCUSSION

The two figures included in this study provide an overall snapshot of student groups and learning outcomes for the mean scores of all six professional skills learning outcomes. As would be expected, near the beginning of the semester most of the student groups had not attained the target score of 3.00 - practicing. By the end of the semester, all but one of the groups had. Similarly for learning outcomes, nearly all of the learning outcome targets were not achieved in round one, but all were achieved in the third round. This is sound evidence that the students' skills improved considerably over the course of the semester, emphasising the earlier noted efficacy of well-structured AODBs to promote critical thinking and learning [6][16][18].

Looking at the individual learning outcomes, the first one CPSA 1 - students' problem solve from a computing perspective - was a professional skill, where all of the student groups demonstrated or exceeded the targeted proficiency which was a score of at least 3.0. The improvement over the semester ranged from no improvement (group 5) to an increase of 2.00 for groups 3 and 4. Moreover, group 4 was rated at a 5.00 by the end of the semester showing mastery of this skill.

Though solving complex, ill-structured and authentic problems has appeared to often be a shortcoming of academic programmes [27], here this was not the case.

The second professional skill focuses on teamwork - students work together to accomplish a task. This is an important skill because collaborative problem solving is the type of problem solving in which professionals usually participate [28][29]. All of the student groups achieved the target of 3.00 by semester's end, and group 4 again was rated as a 5.00 - mastering. All six of the groups improved from the first round to the third, and group 4 also had the largest improvement from a 2.00 to the 5.00. Overall, the groups proved to be quite proficient with this learning outcome, which is an important finding given that in the computing industry, employees who can work effectively as a member of a team are more in demand from employers [10][30].

For the third individual learning outcome, CPSA 3 - students consider ethical, legal, and security aspects - all groups again attained the target of 3.00 by the end of the semester, and group 5 was rated a 5.00 - mastering. A 3.00 - practicing means that students achieved the outcome in the context of the problem and potential solutions. In the first round, only three of the 6 groups had achieved a 3.00, so there was substantial improvement shown across the semester.

Students communicate professionally in writing is the fourth professional skill that was examined. Given that students are English as a second language learners, this is an important learning outcome. All student groups met the target of 3.00 - practicing in the first round and as would be expected, again in the third round. Of particular interest is that there was very little improvement from the start of the semester until the end. The fact that targets were initially met supports the idea that AODBs are well-suited for second language learners. This is because the lack of immediacy allows them to better edit or monitor their responses [15].

The fifth professional skill - students analyse the impacts of computing solutions within local and global contexts - is clearly a component of problem solving and one that represents complex, ill-structured and authentic problems that are encountered in the workplace [29] by computing professionals [31]. Both groups 2 and 6 failed to meet the target of 3.00 by the end of the third round, so it appears as though the global aspect of computing problem solving is an issue that requires more curricular interventions.

Students interpret, represent and seek information is the final learning outcome that is designed to show that they are able to bring in external sources of data and information, and understand the data sources they have read. This is very much related to information literacy which aides problem solving. At completion of the third round, all of the student groups had achieved the target of 3.00 - practicing, and all but one of the groups improved from the initial round. This result is quite similar to an earlier study, where there was comprehensive improvement [32].

CONCLUSIONS

This research has shown that student participation in well-designed AODBs can facilitate learning outcomes attainment over the course of a semester. One must consider important features of a well-designed ADOB to include small discussion groups, providing clear instructions and guidance, giving unambiguous expectations for the length of posts and timing of posts, and providing specific questions for the students to address.

Though the professional skills learning outcomes are challenging to teach and assess, the CPSA method using the AODB has proven to be an effective approach to teach and assess these important learning outcomes. Framed within the constructivist learning principles that underpin group discussions facilitated by AODBs, this research has also shown the power of collaboration and working with peers to solve complex, ill-structured, authentic problems.

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