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Exploiting Digital Learning Management System (LMS) Capabilities for Effective Program Assessment of Competency-based Education

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Background: Effective programmatic assessment (PA) is essential for accreditation of professional degree programs leading to licensure. Accreditation organizations for Higher Education Institution (HEI) programs such as the ABET may stipulate student outcomes. Programs seeking accreditation from ABET must present clear proof of a rigorous process that uses student work products to assess student outcomes attained. The value of PA results offers entry points for institutions and/or departments to initiate discussions on the status of student learning and to make informed decisions on program improvements. The concept of PA is well described in the literature; however, studies on implementing and operationalizing a consistent assessment approach using a Learning Management System (LMS) across courses of an academic program are lacking. Best practices on program assessment recommend that numerical scores of student performance should be linked to learning objectives. Few engineering faculties received formal grading training. They tend to rely on historical grading practices, personal experiences as students, or grade student work with a rubric that is disconnected from the learning objectives. Such traditional grading practices tend to mask the various aspects of student learning and therefore lacks the capacity to capture the full breadth of competency-based education. Globally, a high percentage of colleges and universities use a LMS to better manage teaching and learning activities. Despite the significant financial investment in LMS, faculty have not fully exploited its data capture, analytics and visualization capabilities and therefore its utility in support of effective program assessment is mostly underutilized.

Objective: This paper seeks to add to the ongoing discussion on effective strategies that improve assessment of student learning in competency-based education. We present a case study to show the data collecting, data analytics and visualization capabilities of the Canvas ™ LMS for student outcomes on communications for engineering management and engineering technology programs. In doing so, we address two questions that guided this investigation namely: a) what are the best practices to formulate student assignments given student outcomes for ETAC programs, and b) how to devise and setup up standard rubrics in a LMS for unbiased scoring of student work products.

KEYWORDS: Geospatial Literacy, ETAC, ABET, Assessment, Evaluation, Continuous Improvement, Rubric Assessment, Student Learning Outcomes, Engineering Technology.

1. Introduction

Engineering and engineering technology (ET) programs at Higher Education Institutions (HEIs) value accreditation status because it encourages confidence among students that the educational experience offered by the institution meets high standards of excellence, enhances their employment opportunities, provides access to federal grants and scholarships, and satisfies the academic requirements for access to professional licensure [1]. Accreditation status is not only recognized for quality education and services to students but also to build confidence among the public in the value of the program an institution has to offer. Accreditation organizations such as ABET expects programs to define and assess student learning outcomes. Student outcomes describe the knowledge, skills, and behaviors that students will acquire as they progress through a program of study [2].

The assessment process of judging the quality and extent of student achievement should be well designed in order to yield meaningful results as input for the continuous improvement of a program. Any competent assessment process is time consuming as it involves designing assessment instruments like exams and homework, collecting student work, grading student assignment, analysis, and evaluation of student work. Fortunately, learning management systems (LMS) such as Canvas hosts digital tools that can remove the tedium and time-consumption from program assessment [3] and, together with a robust assessment process, has the potential to ensure high fidelity evaluation of student performance.

LMS technology by itself does not guarantee effective outcomes assessment. Canvas provides digital tools for messaging, creating a grade book, scoring student work by rubric, and other aspects associated with teaching and learning. However, despite financial investment in LMS, a substantial percentage of faculty members and instructors have not fully exploited its capabilities and therefore its utility in support of effective program assessment is mostly underutilized [4, 5].

The most important dataset for assessing and evaluating a student outcome (SO) is student grades. Student grades are translated as numerical scores based on judgements of student work against a set of standards or criteria [6; 7]. However, grading practices by faculty and instructors vary widely across courses and even among course sections of a single program having different instructors. Such varying grading styles may be fashioned by institutional norms, personal whim or grading on a curve to induce student satisfaction ratings in hopes of reinforcing promotion and/or tenure or job security [8]. These practices compromise the data on student competence and seriously mask student learning and teaching inefficiencies [9; 10; 11 and references therein]. Students deserve to be treated fairly and therefore the grading system employed should aim to be consistent across a program. Rubrics provide a mechanism to standardize grading so that student scores reflect student performance objectively [7]. A rubric articulates specific student skills and expectations on a categorical scale. Modern LMS's support the implementation of grading rubrics for scoring student performances.

The purpose of this paper is to demonstrate our efforts to automate student outcomes assessment using the Canvas LMS. Criterion-based assessment (CBA) is described as the process of evaluating student achievement against a set of criteria without reference to the achievement of others [12; 6]. Given that our established assessment program has already passed review by the Engineering Technology Accreditation Commission (ETAC) of ABET, the previous assessment cycles involved traditional data collection methods and analysis. We therefore explore the capabilities of Canvas to improve the quality of assessment data and visualization of student performance results. **Section 2** provides a brief overview of Canvas' architecture and how the technology can be used to enhance assessment of student achievement for insight on a program's continuous improvement. We show an example of automatic data collection, simple data analytics, and visualization on student performance. We also show the limitations on performance evaluation when the judgement of student work is disconnected from assessment of student outcomes. **Section 3** describes the CBA approach and shows the measurable performance of student development on student outcomes for a 4-yr degree program. We emphasize the importance of using rubrics in order to obtain high fidelity data as input for realistic evaluation of student outcomes. We propose an example rubric on communications skills for programs accredited by ETAC of ABET. **Section 4** offers a summary and concluding remarks for future work.

2. Canvas Hierarchical Structure and Assessment Architecture:

Canvas has a hierarchical structure that facilitates outcomes assessment at various levels of an institute. **Figure 1** illustrates its four-tiered structure. This structure dictates the level and administrative control at which outcomes are created and assessed [e.g., 3]. The top level is where institutional outcomes (i.e., rankings, graduation rates, capacity, faculty effectiveness, student retention, and student success etc.) are assessed. Institute assessment data are collected at all levels across this hierarchical structure. The next level down is the college level that connects all of the programs within a college. Below the college level is the program level that connects all of the courses within a degree program. Achievement data can be collected at this level where the programmatic outcomes are created and assessed. At the course level is where faculty and instructors perform activities like scheduling and arranging instructional materials (i.e., learning videos, links to online software, lecture notes etc.), creating assignments (i.e., quizzes, reports, exams), messaging, creating a grade book for scoring student work, and other aspects associated with teaching. Faculty and instructors are given direct access at the course level to interact with students through two main tools namely *Inbox* and *SpeedGrader*. The *Inbox* tool is for messaging to communicate with the entire class, an individual student, or a group of students. The *SpeedGrader* tool allows the instructor to view, annotate submitted student work, and grade student assignment submittals in one place. Canvas' *SpeedGrader* tool allows an instructor/grader to score student work products with an option to use a rubric. As mentioned earlier, a rubric can reduce grading bias. Student scores are the most important dataset in the workflow process in support of assessing and evaluating student outcomes.

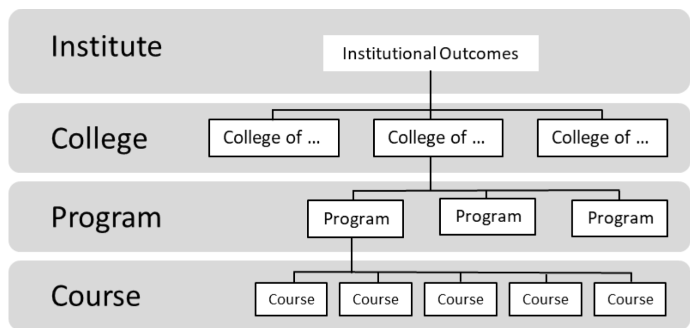

Figure 1: Canvas hierarchy. Instructor access is limited to the course level. Access above the course level requires administrative privileges.

Student outcomes include the knowledge, skills, abilities, and habits of mind that students have developed during their learning experiences through a program of study [13]. While program outcomes are broad descriptions of competencies that graduates will possess [14], course outcomes are specific to a class and describe what will be taught and tested during that semester. Course outcomes are typically assessed and evaluated through in-class activities such as oral presentations, quizzes, and exams. The process of assessing learning outcomes involves identifying, collecting, and analyzing specific student work and then evaluating the results as they relate to student outcomes [2]. Judgements of student performance are quantified by numerical scores which typically are converted to letter grades.

Referring to Figure 1, the level at which an outcome is placed is where the achievement score is recorded. An outcome created at one level can be used by any connected group below that level but is unattainable for the levels above. Access privileges are controlled by the institute's administrators. Program level access can be given to program directors but instructor access is restricted to the course level [3].

2.2.2 Automatic Data Collection and Visualization

Canvas offers tools akin to computer-based testing (CBT) for designing assignments and tests, automatic scoring, and analytics on student performance. Types of questions include Multiple Choice, Drag & Drop, Matching, True or False, and simulations among others [e.g,.15 and references therein]. A great advantage of Canvas' CBT-like system is that grade assignments are dispassionate toward students. However, setting up CBT-type student assignments require a significant amount of upfront work to create large databases of questions with their corresponding correct responses and associate distractors. Furthermore, the *Assignment* tool in Canvas allows instructors to design assignments that have a variety of question types. The assignment tool also offers the option to scramble questions randomly when students attempt a quiz-type assignment.

But more than just an automated grading system that shows grades instantly, Canvas provides instructor feedback options. Specifically, *SpeedGrader's* annotation feature (much like Microsoft Word's comment feature to highlight, strike out, and insert text, write free-form comments, and draw free-form shapes on a document) offers opportunity for instructor feedback that engineering facility may be accustomed to. In addition, Canvas offers basic data analytics and visualization tools as the following example illustrates.

Figure 2 shows an example of data visualization of student performance on a pop quiz in a circuits course of the Electrical and Computer Engineering Technology (ECET) program. In this example, student performances are depicted in a bar chart. The graphic shows that 30% (6 respondents) answered correctly, while 13 students selected incorrect responses. One student left the answer field blank. These results indicate that 70% of students cannot solve a technical problem related to circuits. The visual impact is strong showing that 50% of the students chose -6 volt compared to the other distractor of +6 volt. Which response is more wrong?

During the review of the assignment, students readily identified their folly when the instructor pointed out the differences between standard and non-standard circuit conditions. But more intrusively: *what information can this question reveal about student learning?* While this assignment aimed to test students' understanding of the properties and characteristics of an operational amplifier (the triangle object in the diagram) in circuits, the scores do not provide sufficient information to identify the levels of learning. What are the levels of performance of the 13 students in terms of near mastery (50% correct) or below mastery – say a 30% correct effort?

What can the scores infer about students' ability to differentiate between passive and active circuits? The results as displayed (Figure 2) do not provide sufficient feedback to suggest what remedial action to recommend. This example illustrates how the severed link between the student score and what skill this assignment is meant to assess mystifies student learning. Grading with a rubric that is detached from the learning objectives generally fails to inform what a student knows or can do, nor how student learning could be improved [9].

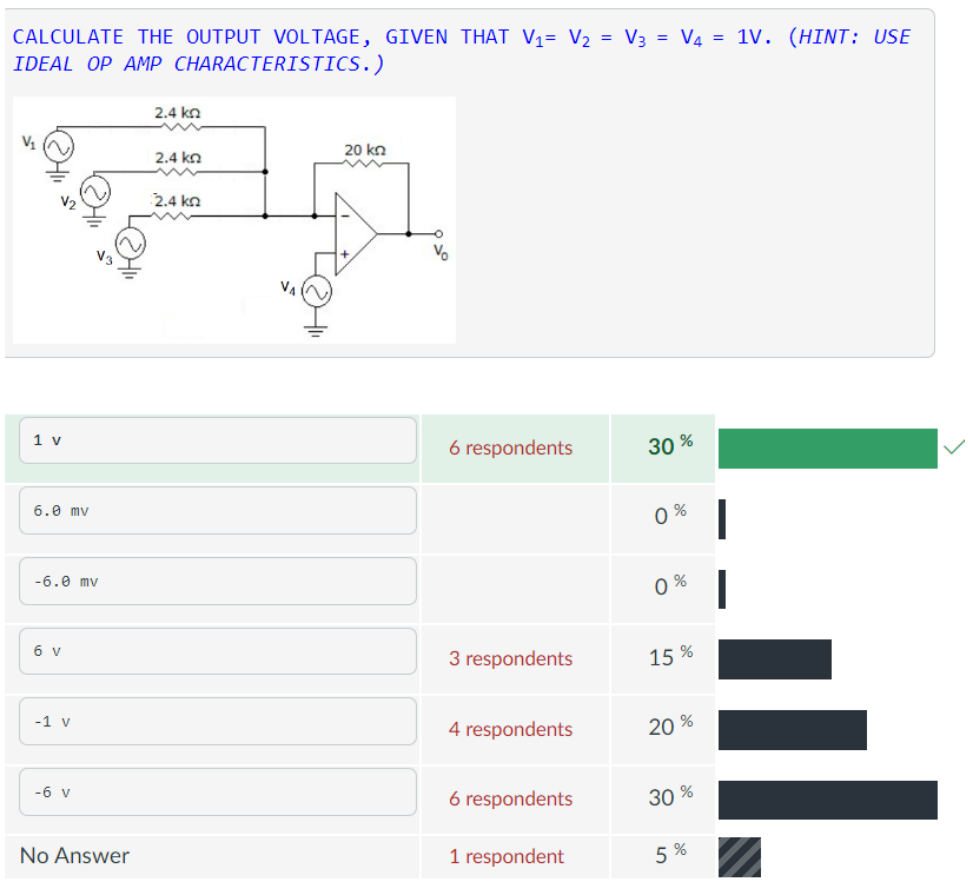

Figure 2: Canvas analytics and visualization on student performance

3. Criterion-Based Assessment Supported by Canvas

Criterion-based assessment (CBA) is the process of evaluating the learning of students against a set of criteria without reference to the achievement of others [12]. Criteria describe skills and attributes that students should be able to demonstrate as learning outcomes. Although students perform assignments and activities at different levels of competency over the course of a study program, the quality of their work is marked by a performance indicator (PI) which is quantified on a categorical scale. The benefits of CBA include its transparency so that a grade can be traced to a specific performance. The ETAC of ABET specifies criteria on skills required by the industry and many ET programs adopt them verbatim as their student outcomes (SO's).

ETAC of ABET Criterion 3 states that student outcomes for ET baccalaureate degree programs under the general criteria include:

> **SO-1**: an ability to apply knowledge, techniques, skills and modern tools of mathematics, science, engineering, and technology (STEM) to solve broadly defined engineering problems appropriate to the discipline
>
> **SO-2**: an ability to design systems, components, or processes meeting specified needs for broadly-defined engineering problems appropriate to the discipline
>
> **SO-3**: an ability to apply written, oral, and graphical communication in broadly-defined technical and non-technical environments; and an ability to identify and use appropriate technical literature
>
> **SO-4**: an ability to conduct standard tests, measurements, and experiments and to analyze and interpret the results to improve processes.
>
> **SO-5**: an ability to function effectively as a member as well as a leader on technical teams.

These criteria appear simple and straightforward but they describe a wide range of skills. For example SO-1 describes competence on the body of knowledge (BOK), correct application of techniques or methods, and use of appropriate tools of STEM to solve discipline-specific problems. Competency in any of the five (5) student outcomes is developed gradually in a program through introductory lectures, experiential learning in laboratory sessions, followed up and reinforced in mid-level courses and finally mastery level skills that are taught at the highest course levels of the program.

Table 1 presents a generalized assessment plan for any four year ET program. Here we deconstruct each of the five SO's into objectively measurable performance criteria or tasks. A scoring rubric, assigned to each sub-criterion, will be developed and used in evaluating a student's achievement of each learning outcome. Course learning outcomes are described in the course syllabi of a program. The assessment plan comprises a formative assessment to inform student development and teaching effectiveness proactively while a summative assessment provides feedback on the strength of the program's ability to attain student outcomes in compliance with the accrediting agency's standards.

Formative assessment should be done during the early part of student development. Formative assessment provides input/feedback to instructors and program administrators on where in the program learning or teaching deficiencies exists and how best to scaffold the learning for a positive effect on student achievement [e.g., 16 and references therein]. Most programs focus on summative assessment which takes place at the end of the learning program. Data for summative assessment of student outcomes is generally taken from student work performed in a capstone course, a final exam, or other instrument of a terminal course.

Table 1: Generalized Assessment Matrix for typical 4-yr ET programs (adapted from [3])

	Intro Course	Methods Apply	Intermediate Concepts	Laboratory/ Experience	Advanced Concepts	Capstone/ Practicum
SO-1: Competence in Discipline						
a) Displays knowledge of key concepts	Intro		Reinforce		Reinforce	Mastery/Assessed
b) Demonstrate Disciplinary Methods		Intro	Reinforce	Reinforce	Reinforce	Mastery/Assessed
c) Skill with Discipline Tools/Instruments		Intro	Reinforce	Reinforce		Mastery/Assessed
SO-2: Design Thinking						
a) Technical Merit of Design	Intro		Reinforce	Reinforce	Reinforce	Mastery/Assesse
b) User needs met	Intro		Reinforce		Reinforce	Mastery/Assessed
SO-3: Communication						
a) Oral Communication/Public Speaking	Intro		Reinforce	Experience		Mastery/Assessed
b) Written Communication	Intro	Experience	Reinforce	Experience	Reinforce	Mastery/Assessed
c) Graphical Communication	Intro	Experience	Reinforce	Experience	Reinforce	Mastery/Assessed
SO-4: Quantitative Reasoning						
a) Method of Analysis	Intro	Reinforce	Reinforce		Reinforce	Mastery/Assessed
b) Interpretation of Results	Intro	Reinforce	Reinforce		Reinforce	Mastery/Assessed
SO-5: Diversity/Teamwork						
a) Work habits/Reliability	Intro			Reinforce		Mastery/Assessed
b) Leadership Skills		Intro	Experience		Reinforce	Mastery/Assessed
c) Collaboration		Intro	Experience		Reinforce	Mastery/Assessed
d) Attitude		Intro	Experience	Reinforce		Mastery/Assessed
	100-200 level courses		300-level		400-level courses	
	Formative Assessment				Summative Assessment	

3.1 Grades, Grading Practices & Data Collection

Grades are the most widely used method for ranking students' academic performance and signal if the program achieved its stated educational objectives and goals. Traditional grading methods attaches a numerical or letter grade to represent the extent to which a student has met an individual faculty member's requirements and expectations for a particular student assignment. Generic labels for student achievement are letter grades "A" through "F" where an "A" denotes *superior* performance. An "A" signals that the student demonstrates excellent judgment and high degree of independent thinking. The letter grade of "B+" denotes *excellent* performance and a "B" denotes *very good* performance. A "C+" denotes *good* performance while a "C" denotes *acceptable* performance that predicts success at the next higher course level. A "D" denotes *minimal* competence but also signals insufficient preparation for the next higher-level learning of the same subject.

Studies found that grading practices among faculty and instructors at colleges and universities vary widely [e.g., 11 and references therein] even within programs having many courses and where sections of the same course are assigned to different instructors. Their varied grading practices may be shaped by institutional norms or they rely on their personal experiences as students. Such variable grading practices may be attributed to several motivations or factors. Adjunct instructors may be tempted to award higher grades than their full-time counterparts in order to keep students happier or for fear of being replaced if students complain about low grades. Others may rely on inflated appraisal on their teaching effectiveness [17] by awarding students higher grades than they deserve. However, such practices mask student learning and teaching inefficiencies [10]. Students deserve to be treated equally and therefore the grading system that informs criterion-based performance should aim to be consistent across a program.

Traditional grading practices and assigning of numerical or letter grades to student work offer only limited insights on student learning. It does not reveal how the students have developed mastery of the subject, nor the levels of skills in analytics or interpretation of results [9]. Traditional grading or numerical scoring of a student assignment is generally performed without connections to a rubric that is designed to assess student learning [9; 11]. An assessment tool, such as an exam question or a laboratory exercise, must be related to a specific learning outcome if it is to inform student thinking and problem-solving skills.

Most HEI's have invested in an LMS, such as Canvas, to support teaching and learning activities as well as ease the burdens and labor intensive tasks related to program assessment. However, reports indicate that academic staff may not fully exploit its capabilities [11] but only operate on basic functions of uploading course materials, syllabi, and provide portals for student work submission. Despite having access to an LMS faculty and instructors may oftentimes fall back into old habits of grading subjectively without guidance from a rubric that is tied directly to student outcomes. Underutilized functionality of the Canvas LMS can significantly limit its capability to digitally capture good quality assessment data for analysis to inform learning, teaching, and program improvements.

3.2 Performance Indicators for Direct Assessment of Student Outcomes

Rubric development is a three-step process starting with identifying the performance criteria, then establish performance levels, followed by a description of the performance at that level. As pointed out earlier, the assignment example shown in Figure 3 was devised without considering connectivity to the five SOs as described above. Therefore, it fails to capture all of the competencies outlined in SO-1 or any of the other SOs, thus illustrating that a single isolated result, devoid of a CBA-guided rubric, cannot offer universal inference on the learning.

Consider a different problem; a skill set that is common to engineering management (EM) and ET professionals namely Geographic Information System (GIS). GIS has become an important tool in land development and engineering/construction management [18]. Constant advances in digital technologies like computing and big data engineering require re-tooling a college program's skills development so that graduates can be more productive and meet the industry needs [19]. Most EM and ET programs teach a course on GIS or its application. *What are the specific performance tasks to assess SO-1 assuming the assessment instruments (exams, homework etc.) are developed for a GIS course of a specific ET discipline?*

As pointed out in Table 1, three performance tasks can be ascribed to the SO-1 assessment. The first performance task is to demonstrate the applications of GIS. The first performance indictor, ***PI-1.1***, may stipulate that students demonstrate understanding of the quality and uses of the different data types allowed in GIS. The second performance indicator relates to operations and/or methods. GIS operations on raster (imagery) and vector data (coordinates) are generally not interchangeable. Therefore, ***PI-1.2*** may stipulate that students demonstrate appropriate GIS operations given a specific data type. The third performance task for SO-1 relates to the use of tools in STEM. Accordingly, the indicator ***PI-1.3*** may stipulate that students demonstrate the correct approach on data analysis and visualization (i.e., projection, scale, etc.) to produce the best solution for the GIS problem. The descriptions for each performance level should use an action verb, which is measurable, and clearly states the desired quality level. This example aims to demonstrates that simply using LMS, without exploiting its capabilities on a rigorous assessment approach, does not in itself guarantee that analysis and evaluation of test scores lead to effective and comprehensive assessment of student learning outcomes. LMS capabilities in concert with a robust CBA process can ease the tedium of traditional analogue program assessment workflows and, at the same time, yield effective and comprehensive assessment of student learning outcomes through automatic data collection and visualization

The next step in developing a rubric is to assign a direct measure of the outcomes for each performance task [9; 2]. Formative assessment can use a 5-point Likert scale starting with the performance level designated “no evidence” =0, “below mastery” = 1, “near mastery” = 2, “master” = 3, and the highest performance level as “exceed mastery” = 4. For the GIS example, we can define the performance level ***PI-1.2*** for “exceeds mastery” as students being be able to combine different data formats using the Spatial Analyst tool without errors to analyze messy GIS data. Of course, a summative assessment will not include the “no evidence” category.

Industry places a high value on soft skills for engineering graduates [20]. Communication, in particular, is important for organizational behavior, strategic decision making, and supervising all factors of project management. Communication skills are vital for EM and ET graduates who will interact with diverse groups of professionals, technicians, contractors, and general workers. Seminal reports, based on recommendations by educators, professionals, scientists, and in collaboration with students, have called for undergraduate curricula to engage students more in communication as a professional. Unfortunately, not much research is available on helping students effectively communicate to a variety of audiences from professionals to the general public [21]. This study highlights a few key elements of professional communication that students should be able to master. In an effort to expand the tools available for assessment of communication skills, this study performed an initial validation of a rubric for student outcomes 3; Communication.

Table 2 shows a rubric on communication for each of the three key performance criteria. PI’s for oral communication include *Diction*, *Modulation and Gestures*, *Timing* of major parts of the speech in relation to the total allotted time. The fourth PI for this performance criterion is judgment on succinct *Introduction* of the problem/topic and the summary statements in the *Concluding* remarks that comprehensively highlight the main results.

Four PI’s for written communications include checks on *Grammar & Spelling*, *Punctuation*, *Format and Components*, and *Logic*. The third PI, *Format,* denotes completeness of the written document with distinct and separate parts of the report including references, and correct style of citations. The fourth performance criterion is judgement on the *Logical* sequencing of the thoughts presented in the report.

PI’s for *graphical communication* include application of *Cartographic Principles* when making freehand field sketches, Computer Aided Drafting (CAD), or GIS graphics. Judgements are on aspects like cartographic balance, shape, distortions, relevant detail given the scale and (physical) paper size. *Annotations* should be well placed, legible, and complete. The PI for *Completeness and Accuracy* describes the ability to include title blocks correctly without missing relevant information, data that is accurate, and the format of the map or graphic that conforms to industry standard.

Constructing rubrics in Canvas can be confusing because of the differences in terminologies. What ABET describes as a criterion is called an outcome group in Canvas. The term performance criterion or task as used in the literature on education is termed an outcome in Canvas. Performance levels are preset in the standard Canvas rubric. As stated above, SO-3 has three major performance criteria namely, oral communication, written communications, and graphical communications. For each performance criterion we describe the PIs for scoring student work.

Visualization of student performance is accessible through the Learning Mastery Gradebook (LMG). Canvas' graphical output displays a banner with tabs labelled students and the various student outcomes that are related to the student assignment. As stated before, the assignment grades are related to the student outcomes via a rubric. Information on any of the labelled tabs enables a graphical output while hovering the mouse over the tab.

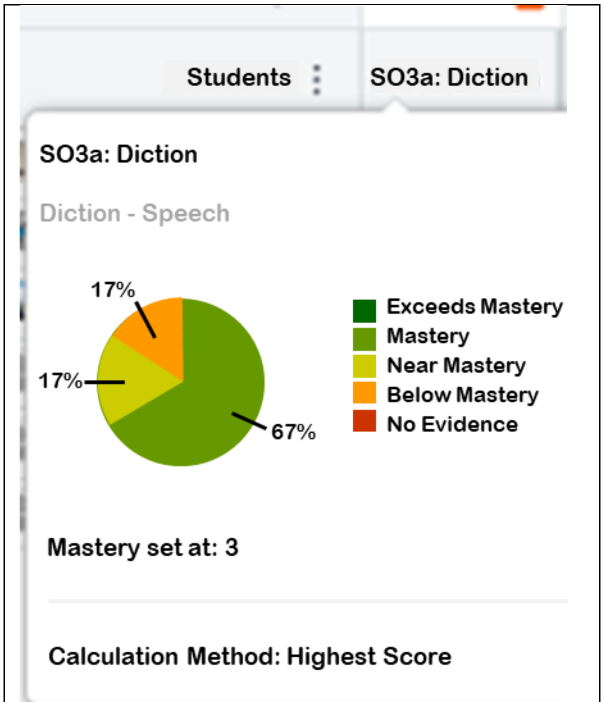

Figure 3: Visualization in LMG

The graphic in **Figure 3** is not printable from Canvas but only visible by hovering the mouse over the outcome label SO3a: Diction – as in this case. This data visualization feature is only visible after enabling LMG via the *Settings* link. The graphic is informative. The result shown in Figure 3 is very useful as it informs that 67% of the class demonstrated mastery in diction, 17% performed at the near mastery level, while the remaining 17% of students performed below mastery level.

The output shown in Figure 3 is more insightful than the example output in Figure 2 because the former shows the relationship of the student work to the student outcomes. The output shown in Figure 3 provides valuable insights for formative assessment and provides a perspective on what aspects of the learning requires remedial action. However, the graphics from this module is not exportable. This limitation makes the evaluation part of the PA process cumbersome. Users need to perform several cut/paste operations to construct a comprehensive visual report on attainment of student outcomes.

One way to overcome this deficiency in the Canvas visualization tool is to export the data and generate a custom graphic using Python. Canvas allows for downloading of student grades so that users can develop their own customized data visualization tool outside of Canvas. A convenient way to visualize student outcomes can include a multi-panel graphic that shows the attainment results for a particular student outcome and the student performance level for each category (or PI) of the outcome.

Table 2: Assessment rubric for student outcomes on communication.
SO-3a: Oral Communication

		Exceed Mastery = 4	Mastery = 3	Near Mastery = 2	Below Mastery = 1	No evidence = 0
Content	Diction	Clear and correct Pronunciation. Proper enunciation (Eloquent), No word whiskers. No jargon	Good pronunciation. Unfamiliar and specialization terms explained	Poor enunciation. Partial explanation of specialized terms. Jargon unexplained	Muffled speech, Poor pronunciation Profuse jargon and slang terms used. Multiple word whiskers	Inaudible Excessive slang words
	Modulation* & Gestures	Excellent variety of pitch, power and pace power in delivery. Appropriate facial expression and body gestures	Has variety of pitch pace and power Appropriate facial expression or hand gestures	Lacks one aspect of modulation Lack appropriate forms of gestures	Lacks more than one aspect of modulation. Gesture are mannerisms	Monotone speech Lacks gestures and exhibit inappropriate facial expression
	Timing† (Major Parts)	Excellent overall timing Excellent time ratio for individual parts of the presentation. Finished within allotted time unrushed	Balanced timing appropriate for individual parts of presentation Overall timing is good Finished within allotted time unrushed	Unbalanced timing on individual parts, Overall timing is overtime	Unbalanced timing on individual parts, Gross mismanaged of overall timing is overtime/undue-time	Unbalanced timing on individual parts, Gross mismanaged of overall timing is overtime/under-time
	Introduction & Conclusion	Introduction is specific with concise background. States reason(s) for project (or RQ) followed by expectation. Summary is concise and complete Conclusion ties the solution to problem No new concepts introduced	Introduction is specific, Includes background. States purpose of project. Summary is complete Conclusion links to problem statement Nothing new introduced	Introduction is vague. States purpose of project. Conclusion is lengthy summary. Introduce a new concept	Introduction is unclear or vague. Conclusion has no summary. Conclusion is irrelevant to discussion.	Introduction is unclear. No statement of purpose only what will be described. Abrupt ending. No summary or concluding remarks

SO-3b: Written Communication (Technical Writing)

		Exceed Mastery = 4	Mastery = 3	Near Mastery = 2	Below Mastery = 1	No evidence = 0
Content	**Grammar & Spelling**	No spelling errors Excellent sentence structure Excellent vocabulary	No spelling errors Effective sentences Good vocabulary	Minor spelling errors Long sentences Technical slang words	Major spelling errors Poor sentence structure use of slang or jargon	Major spelling errors Grammatically incorrect sentences Profuse use of slang
	Punctuation	Excellent use of variety punctuation to ease readership. Use typographical mark for footnotes and diacritical marks Author citations correct and complete References of cited work in correct form and according to industry journals and scientific journals (e.g., xyHT, SaLIS)	Correct use of variety of punctuation marks Correct typographical marks for footnotes etc. References cited correctly of industry (e.g., xyHT)	Correct use few of punctuation marks random capitalization Citation are incomplete	Poor use of few punctuation Citation are incorrect	Excessive punctuation errors No citations Missing references
	Format & Components	**Title**, **Author name**, **Affiliation**, **Introduction**, **Body** with subsections such as *Data*, *Methods, Results* (shown in graphs or table) and, *Discussion*. **Conclusion** section include summary that address the problem/question posed in introduction and title. **Acknowledgement**, **References, Appendix**	**Complete document** All parts included: Title, Author name & Date, Introduction, Body *with one or more subsection*s such as *Data*, *Methods*, *Results* (shown in graphs or table) and, *Discussion*. Conclusion References	**Incomplete document**. Missing one of more of the following element: Title Introduction, Method Conclusion References No separation of Methods into subsections	**Mostly incomplete**. Missing more than two major sections of a technical report.	**Wholly incomplete** Report is fashioned into only separate paragraphs. Unclear transition between key ideas
	Logical	Excellent organization. Logical development. Strong Coherency, Influential	Organized. Logical Coherent	Poorly organized. Thoughts are out of logical order	Disorganized Difficult to follow logic	Illogical. Writing is incoherent

SO-3c: Graphical communication (for hardcopy production such as industry standard blueprints)

		Exceed Mastery = 4	Mastery = 3	Near Mastery = 2	Below Mastery = 1	No evidence = 0
Content	**Cartographic Balance**	Excellent Use of white space Wholly Uncluttered Excellent use of elements • Color • Line type • Symbols	Effective Use of white space Uncluttered Effective use of elements • Color • Line type • Symbols	Good visual balance Partially cluttered Need improvement on use of elements • Color • Line type • Symbols	Ignored cartographic principles poor arrangement of graphic elements	Violates all cartographic principles
	Annotations	Excellent annotation style and placement, font size Legend complete and clear Scale shown	Appropriate placement, font size Legend complete and clear Scale shown	One essential cartographic element is missing	Appropriate placement, font size Legend complete and clear Scale shown	No annotations
	Completeness & Accuracy	**Excellent representation of required content.** Excellent presentation of Information/Content Data accuracy & metadata Form/layout conforms to industry standard format – • Title Block, • Notes, • All Symbols • Revisions block • Signature Block	**Required content present** Correct presentation of information/content Complete and correct data accuracy statement Form/layout conforms to industry standard format – • Title Block, • Notes, • All Symbols • Revisions block • Signature Block	**Missing information** Data accuracy partially explained Conform to industry standard format but missing essential major elements such as Title Block, or Notes. Symbols not explained	**Missing critical information** Omission of fundamental data quality statements violate industry standard format – Form/layout does not conform to industry standard format Missing major elements such as Title Block, or Notes.	**Incorrect Information/Content** Missing data statement violate industry standard format

We have developed a simple python script for enhanced visualization of the student performance using simulated data for SO-3. Four performance criteria were used to assess the oral and the written communication skills but only three performance criteria were used to assess graphical communication skills (see Table 2).

Figure 4 shows an alternate data visualization that is presently not a Canvas capability. The multi-panel graphic, developed using Python, shows a comprehensive visual output of the evaluation results for the communication criterion. As mentioned above, the evaluation of communication was divided into oral, written and graphical communication skills. Performance results are displayed in three columns. Each column shows a pie chart at the top and a bar chart at the bottom. The pie charts represent the average results on the achievement for a specific outcome. The assessment strategy defines attainment as 70% of the students achieve a score of 70% (i.e., mastery level) or higher.

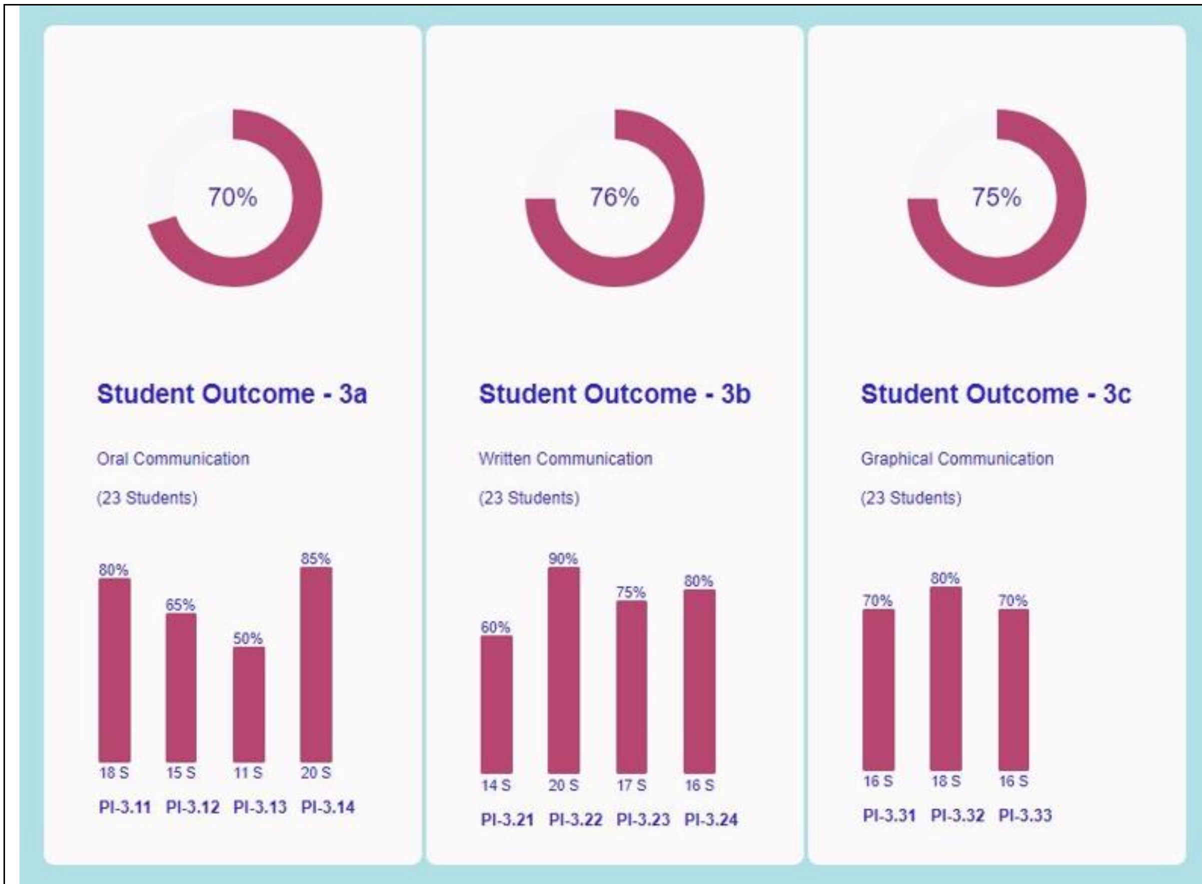

Figure 4: Data visualization on summative assessment of communication skills. Pie charts (top) show the average performance for each outcome while the bar charts (bottom) shows the performance levels in each categories of an outcome. This output shows outcomes for the three communication modalities.

The bar charts, on the other hand, show the performance in each of the categories of a specific outcome as described in the rubric. Consider the results for oral communication. 80% of the students achieved mastery on diction (PI-3.11), 65% achieved mastery on modulation and gestures (PI-3.12), 50% achieved mastery on timing of the major parts of public speaking (PI-3.13), and 85% of students achieved mastery on introductory and concluding statements. A careful review bar charts indicate opportunity for remedial action onb modulation and gesture skills as well as the ability to understand and improve on the appropriate time allotments of the various parts of an oral presentation. However, the pie charts indicate that the student outcomes for all three modalities of communication are attained and no remedial action is required. However, the bar charts provide details on student performances for each criterion and signals to the program director on opportunities for remedial action and program improvement.

This type of visualization (Figure 4) is presently not available in Canvas. The graphic in Figure 4 exhibits a program's overall performance and student learning, its strength, weakness, opportunity for improvement. The graph can be analyzed to identify threats that stymie student learning and development. Student outcomes depicted in the graphic clearly show the global (average) outcomes in pie charts, but more importantly, the granular level of the performance in bar charts for each aspect of a criterion as described in the rubrics. This type of visualization provides a multiview perspective to program directors on the performance of the program. This type of graphical output also reveals the strengths and weakness in student performances in specific aspects of an outcome as well as help identify where potential remedial action is needed to improve the program.

3.0 Summary and Conclusion

Most HEI's have invested in LMS to improve student learning and teaching effectiveness. As an information system, Canvas provides significant advantage in program assessment with automatic data collection, analysis, and data visualization capabilities. The *Speedgrader* tool, combined with the LMG, supports high fidelity assessment of student learning provided a well-designed grading rubric is implemented and is consistent with specified student outcomes criteria. Furthermore, well-designed rubrics, when implemented in Canvas, can enforce uniformity and consistency in grading student assignments and reduce subjective scoring of student work.

We have demonstrated how to exploit Canvas' data collection, grading and visualization capabilities to support high fidelity assessment and evaluation of student performance and program effectiveness. The effectiveness of an assessment processes is only as good at its rubrics. While student outcomes are concise statements describing what student should be able to do, rubrics should describe the student development at granular levels in order to reveal the learning accomplishments. We have shown an example of a rubric for three modalities of the communication criterion of ETAC. Assessment and evaluation of results for our small sample showed that the students excel in written and graphical communication skills but the program failed to adequately prepare students for public speaking. Remedial actions was recommended for course upstream.

Canvas' visualization tool displays pie charts for each performance criteria as defined in the rubric. But the graphic is not exportable. This limitations precludes an easy and straightforward assessment of a program's overall performance on student outcomes. To overcome this data visualization limitation, a custom Python script was developed to generate a multi-panel graphic that shows the average performance in a pie chart and the detailed performance levels for each performance indicator in a bar chart for each student outcome. Such customized data visualization provides a global overview with sufficient details on student performance. Such graphical output is useful for identifying threats that could potentially stymie student learning.

The authors believe that this paper will incentivize institutions to encourage their faculty to exploit Canvas' capabilities in order to help automate their workflow and ensure consistency on student work appraisals. Because of its popularity with HEI's, Canvas should improve its data visualization module in several ways. One improvement could be to enable an export capability of its pie-charts that is activated through its LMG. Secondly, Canvas should consider improving its visualization tool to include an option for a multi-panel output of the results on student outcomes similar to the example that was develop for this work.

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