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Implementing an Effective ABET Assessment Program for a New Bachelor of Science in Engineering Technology Degree

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Implementing an effective ABET Assessment Program for a new Bachelor of Science in Engineering Technology Degree

Abstract

This paper is the second in the sequence of the process established in developing an assessment process for accreditation of the new Bachelor of Science in Engineering Technology (BSET) program at a higher education institution that has previously granted Bachelor of Science in Engineering degrees. The new degree program was launched in the Autumn of 2020 at the Ohio State University. Offered by the regional campuses which have traditionally been feeder campuses to the central campus, this employer-driven program will prepare graduates for high-demand manufacturing occupations that require strong technical and management skills.

The curriculum for the four-year degree program was based on industry needs that will allow graduates of the program to help the state build the manufacturing workforce needed to compete and thrive. The curriculum is driven by a rigorous assessment process and foundational skills for mathematics, physics, engineering, and management skills including the following: problem-solving, innovation, leadership, and change management, operation of automated systems, machining, and electro-mechanical maintenance skills, managing cyber-physical systems, and system-wide implementation and improvement of technological processes for manufacturing firms.

A curriculum development and assessment committee was formed in the Autumn of 2020 to devise a plan for measuring student learning outcomes based on the Engineering Technology Accreditation Commission (ETAC) of the Accreditation Board for Engineering and Technology, Inc [1]. During 2020-2021, the faculty team was charged with the implementation of a robust framework for the assessment of student learning outcomes using Canvas; the university's learning management system (LMS) which can be used as a tool to help in decision-making and continuous improvement. A paper was presented at the 2021 ASEE Annual Conference that introduced the framework developed for this program; this is the second paper in the sequence that will share the implementation of the assessment process and assessment results from the first two years of the program.

The purpose of this paper is threefold: a) to communicate the process of implementation of the framework developed to effectively assess the student learning outcomes using a learning management system for continuous improvement, b) to share the results of the assessment from the first two years of the coursework, and c) to share best practices with peer institutions planning to offer a new degree program in Engineering Technology or similar degrees.

Introduction

A recent increase in demand and supply chain issues and semiconductor shortages have revolutionized the way the manufacturing industry operates. All these issues have contributed to forcing manufacturers to relocate their factories [2]. The future of manufacturing is digital which can help solve complex production and delivery problems. Industrial automation and robotics are in high demand since they help facilitate accurate, safe, cost-effective, and reliable control processes which support community development. According to the U.S. Bureau of Labor Statistics, there has been consistent improvement in employment. In addition, recent hourly and annual earnings are shown to also increase for occupations commonly found in manufacturing [3]. The global market for industrial automation and robots is projected to grow at a compounded annual growth rate of 11.4% in 2022-2029 [4]. With advancements in manufacturing processes and industrial automation, there is an increased demand for highly trained and skilled workers in the state. However, due to insufficient manufacturing engineering technology programs, there is a shortage of qualified candidates to meet the workforce demand for high-tech manufacturing jobs in the state. This necessitates a robust manufacturing engineering technology program to be developed that serves the needs of the local manufacturing industry.

Higher educational institutions promote hands-on experiential learning and provide students with skills that lead to good jobs while fulfilling manufacturers' needs for skilled engineers. Partnerships with neighboring community colleges and technical schools help to realign the existing curriculum, develop new courses, and laboratories, and share resources. These partnerships will not only support students but also help colleges develop new certificate or associate degree programs.

Establishing a new engineering technology program that fulfills ABET ETAC requirements is a major undertaking not only for the administration but also for the faculty and staff. There is a huge responsibility to develop the curriculum and assessment tools to meet the program objectives, achieve student outcomes and satisfy the university requirements. All regional campuses of this institution are uniquely co-located with the area technical schools to collaborate in addressing the talent gap and create educational experiences and employment opportunities in industrial automation and robotics. The Bachelor of Science in Engineering Technology (BSET) degree program was developed to address the growing need for highly skilled college graduates with a manufacturing engineering technology focus. To deliver a quality educational experience and provide the much-needed skills for students to succeed, it is critical that the program has met the academic standards and received recognition for its rigor and quality. The program is designed to increase the recognition of the university's regional campuses as a collaborative entity offering engineering technology programs through partnerships with local technical schools and industry professionals, offering experiential learning through hands-on laboratories, and contributing to workforce development.

This paper will discuss the process of implementing an assessment program for the new manufacturing engineering technology program being offered at the regional campuses of a large research institution. This paper is organized in the following order: I. A Precursor to Manufacturing Engineering Technology Program, II. Defining Objectives and Outcomes, III. BSET Curriculum and Coursework, IV. Program Delivery Methods, V. Program Assessment, VI. Analysis of the Approach, and VII. Best Practices. The paper concludes with acknowledgments and a summary and recommendations for future work.

I. A Precursor to Manufacturing Engineering Technology Program

In 2019, the BSET steering committee was formed to develop a four-year engineering technology degree for students that was manufacturing-focused and leaned toward management and leadership skills. The proposal was driven by research conducted in the neighboring manufacturing facilities with focus groups and statistics from the U.S. Bureau of Labor O*NET occupational data to determine current and future engineering technology skills needed by manufacturers [5]. A consensus reached was that many students will find engineering technology a better educational fit than the existing engineering degree program offered at the university. The steering committee aligned program goals, student learning outcomes, and proficiencies to ABET accreditation guidelines, which will be used to track students' mastery of the subject matter. SME guidelines were also used for the manufacturing concentration. Faculty members, industry advisers, and students formed a team to support this program. Because the regional campuses were delivering this program and the central campus groups were approving the curriculum through their existing curriculum oversight committees, both central campus and regional campus faculty and staff were included in the teams. Manufacturers emphasized the importance of essential skills that graduates should have including critical thinking, adaptability, communication, and flexibility. Course Design Institute (CDI) played a significant role in helping faculty develop courses based on the "Backward Design" process [6]. In the backward design process, student-centered goals and objectives are identified before developing the content of the course.

Initially, it was decided by the steering committee to develop Math and Science courses for the program, however, the idea didn't flow due to a major overlap in the curriculum for these courses. In addition, Math and Science courses are regulated by the College of Arts and Sciences. At the time of submitting the proposal for the new BSET program, it was determined that the majority of the students will find an engineering technology degree as a better educational fit and switch from the engineering degree programs offered at the university. Hence, keeping the general education courses including Math and Science courses would better serve the purpose of this program. Summer 2019 marked the first term for curriculum development with six new courses developed and submitted for approval by multiple campuses, the College of Engineering, and the Academic Affairs Office. For some of the existing courses, the steering committee negotiated with departments to offer separate sections for engineering technology students.

II. Defining Program Objectives and Student Outcomes

Program educational objectives are the broad statements that describe the long-term career and professional goals that are envisioned for the graduates of the program to achieve. It is a common misunderstanding among programs that these objectives are laid out by ABET and are to be assessed each year. According to an article published in 2020, a senior adjunct director at ABET described that program educational objectives differ from student outcomes in four ways: a) degree of specificity, b) role of constituents, c) purpose of assessment, and d) cycles of data collection [7]. It is considered that these objectives as being attained by graduates a few years after graduation. It can be very helpful for departments to map all of the curricula to their program educational objectives to improve awareness among the stakeholders.

From initial research and job data gathered to study the state of the manufacturing industry in Ohio state, the steering committee determined a list of skills required to be successful after graduating from this program. Four program educational objectives (PEOs) were developed for the program in the Spring of 2019 prior to curriculum development. Graduates are expected to possess the following skills:

PEO1 *Systems Thinking and Problem Solving*: The successful student will be able to effectively solve problems by applying the appropriate engineering technologies, tools, and techniques within systems of equipment, controls, and people.

PEO2 *Professional Skills/Communication*: The successful student will be able to demonstrate, appreciate, and master interpersonal communication skills in the modern workplace.

PEO3 *Business Management*: The successful student will be able to understand business terminology, analyze the value of alternatives, and communicate their business, societal and global impacts effectively.

PEO4 *Continuous Improvement*: The successful student will be able to optimize processes and systems with respect to quality, timeliness, and continuous improvement.

Curriculum development was in full swing during 2021-2022 with the majority of the third- and fourth-year courses being developed. Since the program is being offered at regional campuses, there are no guidelines from ABET ETAC about the assessment procedures. A unique quality of successful programs is an ongoing, consistent, and thorough process for the assessment of student learning outcomes. The major components of the Self-Study report are Criterion 2: Program Educational Objectives, Criterion 3: Student Outcomes and Criterion 4: Continuous Improvement. Criterion 3 involves adapting Student Learning Outcomes defined by ABET and developing an effective process of periodic review and revisions to continuously improve the quality, standard, and rigor of the program being offered. These PEOs will be reviewed by the stakeholders once every two years. The stakeholders are students, alumni and industrial advisory council members.

Student Learning Outcomes for the BSET program include the following elements:

(1) an ability to apply knowledge, techniques, skills and modern tools of mathematics, science, engineering, and technology to solve broadly-defined engineering problems appropriate to the discipline;

(2) an ability to design systems, components, or processes meeting specified needs for broadly-defined engineering problems appropriate to the discipline;

(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;

(4) an ability to conduct standard tests, measurements, and experiments and to analyze and interpret the results to improve processes; and

(5) an ability to function effectively as a member as well as a leader on technical teams.

Program-specific criteria apply to engineering technology degree programs with a concentration or a modifier in their titles. Since our degree is focused on manufacturing and industrial automation, the goal is to provide graduates with technical skills in system design, operations, lean and smart manufacturing, industrial automation, and robotics. Leadership skills will be necessary for manufacturing competitiveness and to enter careers in the manufacturing process. Hence, the Society of Manufacturing Engineers (SME) program criteria have been adopted for instruction and assessment of learning outcomes related to:

a) materials and manufacturing processes;
b) product design process, tooling, and assembly;
c) manufacturing systems, automation, and operations;
d) statistics, quality and continuous improvement, and industrial organization and management;
e) capstone or integrating experience that develops and illustrates student competencies in applying both technical and non-technical skills in successfully solving manufacturing problems.

For the purpose of this study, the ABET student outcomes from the general criteria are labeled as SLO# with # representing numbers 1 through 5 and the program criteria are labeled as SME_letter with a letter representing a through e SME outcomes. Performance indicators are defined for each learning outcome which is measurable and helps identify the performance of students and whether they are meeting the learning outcomes or not. These performance indicators are mapped to introductory, intermediate and advanced courses and are discussed in the following sections.

III. BSET Curriculum and Coursework

The proposed BSET program, designed to be ABET accredited, will focus on the design, development, and analysis of a curriculum that covers foundational and instrumental topics including but not limited to lean manufacturing, industrial automation, robotics, operations and project management, technology applications, network systems, and security. The proposed program will require 121 credits of undergraduate coursework including a one-year capstone project requirement. The goal of this Engineering Technology program is to prepare industry-ready students to take up production, automation, and sales engineer positions as well as plant manager, engineering lead, and chief executive officer positions at the manufacturing plants. The curriculum is prepared to allow students to grow as independent learners and excel in their academic and professional tasks.

The program consists of lab-intensive applied courses, which will be delivered at the regional campuses in collaboration with the neighboring technical colleges. As seen in Table 1, the degree-required courses include higher-level of manufacturing and automation along with business and project management courses. The program is also open to students transferring from community colleges and technical schools. Hence the collaborations serve the regional campuses well by attracting talent from these neighboring technical schools. Most of the courses are co-listed on the schedules and shared among regional campuses. This allows the regional campuses to share their resources including faculty. Regular faculty teaching the same courses collaborate and meet weekly to prepare class schedules, assignments and exams and also map out assignments for assessment.

Foundational Coursework (Transferrable from Engineering Programs)
Fundamentals of Engineering, Introduction to Engineering Technology, Physics, Chemistry, College Algebra, Calculus, Modeling and Problem-Solving with Spreadsheets and Databases, Introduction to Programming, Technical Writing, Culture/History Foundation, Ethics, Gender Diversity Foundation, Citizenship
Introductory Technical Coursework (Transferrable from Technical Schools)
Engineering Graphics, Statistics and Applications in Quality, Project Management, Engineering Economics, Manufacturing Processes I and II, Mechanical Processes, Electrical Circuits, Introduction to Robotics
BSET Program Requirements (Degree Requirements)
Mechanical Processes, Industrial Automation using Programmable Logic Controllers, Operations Management, Leadership and Change Management, Intelligent Manufacturing and Automation, Electrical Power and Drives, Network Security and Safety Applications, Lean and Six Sigma Principles, Facility and Layout Integration

Table 1: Curricular Summary of the BSET Program

The following courses provide a snapshot of what students can expect to learn while pursuing an engineering technology degree at Ohio State. Since the previous paper was published, there have been major developments in the curriculum, especially with the development of the final-year courses. The capstone project is still two-semester long and involves project management and technical aspects of manufacturing and industrial automation.

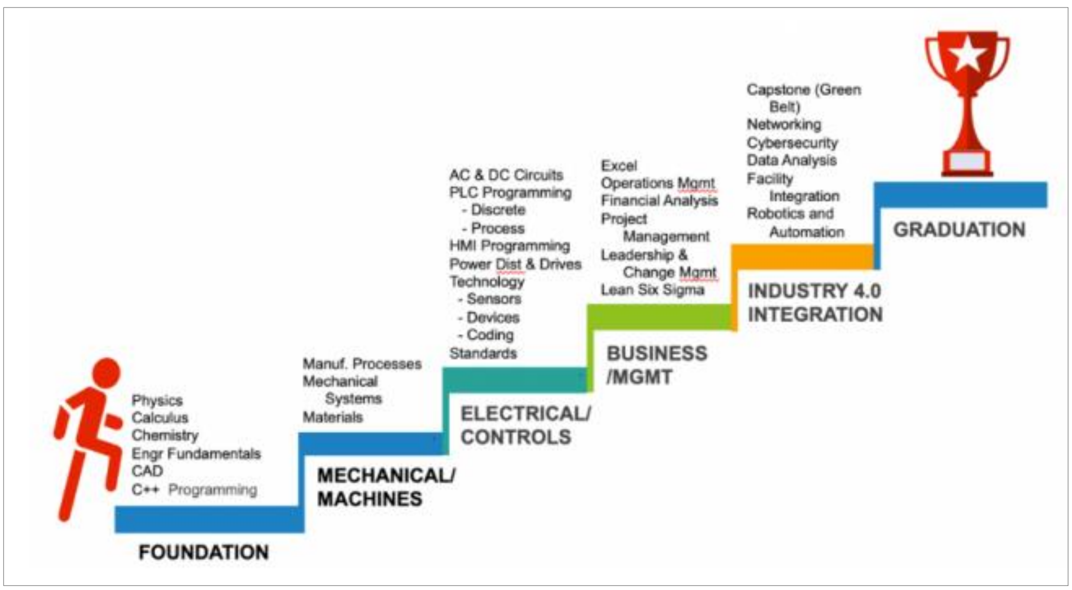

Figure 1: Course Framework for the BSET Program

IV. Program Delivery Methods

The Engineering Technology program is developed to be administered by the regional campuses because of their strong history of supporting the needs of their surrounding communities and collaboration with co-located community/technical colleges and area manufacturers. It will be offered at four regional campuses within the university system. However, only three campuses have started offering coursework in the Autumn of 2020. The fourth campus plans to administer courses beginning Autumn of 2023. The goal is to maintain consistency in course offerings across campuses, especially for outcomes assessment and ABET accreditation purposes.

The College of Engineering offers baccalaureate degree programs in engineering that are EAC/ABET accredited. Therefore, there is an outcomes assessment committee at the college that mandates policies and procedures. The Engineering Technology program is also part of the College of Engineering, but it is only offered at regional campuses. Students from co-located community colleges can transfer their credits for a four-year degree. Laboratory experiments for some of the courses are taught at the co-located technical schools to allow sharing of the facility and resources. Most of the technical courses consist of 2 hours of lecture and 2 hours of lab sessions per week. The courses utilize state-of-the-art technology for manufacturing and industrial trainers from Amatrol, Programmable Logic Controller from Allen Bradley, and Robots from FANUC. The co-located technical schools have the ability to offer labs which provides flexibility in scheduling laboratory sessions. During COVID-19, some of the courses were taught in hybrid and remote learning formats. Post-pandemic, learning pedagogies have been adopted to better serve the needs of the students by offering online/hybrid courses to support students at all regional campuses. Regional campuses are benefitting from this setup and co-listing courses and sharing faculty. Courses that do not involve laboratory components could be taught remotely where students from all regional campuses can attend. The use of LMS along with a Zoom platform for video conferencing has made it possible to deliver content remotely.

V. Program Assessment

Assessment is a process by which programs can identify, collect, and evaluate data for the attainment of student learning outcomes and program educational objectives [1]. The assessment process helps programs establish and reinforce guidelines for faculty and staff to follow in evaluating outcomes, obtaining feedback and making evidence-based decisions that lead to program improvement. Although there are several resources available through the ABET website, engineering and technology programs face challenges in designing and establishing assessment frameworks. Previous studies have shown that successful assessment strategies can be developed for programs offered at multiple campuses [6]. To develop a robust assessment mechanism, programs usually form a team of faculty and staff and train them to facilitate the process and provide guidance on outcomes mapping, curriculum revisions, and changes to the program. Faculty and administrative support are necessary to run a smooth process. Industry partnerships also play a vital role in curriculum development as well as the assessment of outcomes. The sections below explain the assessment process in detail.

A) Assessment team and training

The Ohio Manufacturing Institute conducted industry focus groups in six regions of the state and found that manufacturing occupations were high in demand and employers were requesting next-gen engineering and technological skills. Another finding was that there is a lack of pipeline for management and leadership positions. To address these needs, a new program was launched in the Autumn of 2020. In the previous paper, the formation of the assessment team was discussed including the required training. The team was trained on Institutional Data Policy (IDP) to ensure data security and protection of the university's institutional data. The team also completed Canvas Affiliate training to be able to import outcomes into courses. Additional training modules included Family Educational Rights and Privacy Act (FERPA) and CyberSecurity training. In addition, the roles and responsibilities of the team were established and the ABET criterion was studied and the assessment cycle with a timeline was scheduled.

For the first two years of course offerings, the assessment team has volunteered numerous hours developing performance indicators and rubrics, importing outcomes in all introductory course shells, training faculty to conduct assessments, gathering student artifacts and evaluating assessment results. In the second year, a curriculum development and assessment committee (CDAC) was formed which was a governing body for the curriculum revisions and updates on the assessment process. ABET committee was a sub-committee of the CDAC.

B) Data Management and File Sharing System

Assessment data and its evaluation are necessary components of any accreditation. Whether it is a direct assessment or an indirect one, the results help the program with continuous improvement. And, due to the institutional data policies reinforced at higher education institutions, there is a requirement to store the data on university-managed systems. Student education records are private data for the university and must be stored on the university-managed cloud storage system. At Ohio State, OneDrive is used for file storage and sharing. Shared folders were created to store not only student artifacts and assessment results but also accreditation-related documents. Information about the program development, course offerings, faculty, syllabi, assessment results, etc. resides on the cloud. With four regional campuses, it is necessary to carefully organize the data relevant to each campus. Since it is the first engineering technology program at the university, the program will be seeking an initial accreditation which might require a readiness review. Therefore, an effective strategy is to follow the readiness review template to organize the content. According to the readiness review document, folders were created and organized systematically. Instructors are only given access to a shared folder where student artifacts and assessment results are to be stored.

C) Mapping Program Educational Objectives to Student Outcomes

Program educational objectives described in section II are mapped to ABET student outcomes and were published in the first paper. There have been no changes to those mappings. PEOs are scheduled to be reviewed every two years by students, alumni, and industrial advisory council. The feedback from the stakeholders will be discussed among the steering committee before revisions are made to the PEOs.

D) Mapping Student Learning Outcomes to Courses

Effective assessment process, periodic review of student learning outcomes and educational objectives and proper documentation are requirements of programs requesting initial accreditation. For the past several years, direct and indirect assessments of student outcomes and program objectives have become the assessment standards for engineering and engineering technology programs. Direct assessment involves mapping student learning outcomes to tests, homework problems, projects, and other assessments in the course and collection of student submissions. It also requires analysis and interpretation of results to provide recommendations for changes to the courses. To perform the direct assessment, the team began scheduling meetings with the faculty to map out student learning outcomes. Since third- and fourth-year courses were recently developed, the course developers were required to incorporate ABET student learning outcomes in the syllabi and map those out to assessments in the course.

Performance criteria, performance vectors, and performance indicators have been described in many articles to be the guidelines through which performance could be measured [10, 11]. Performance indicators were developed earlier and discussed in the previous paper which serves as a tool to assess the competencies. A sample of the performance indicators for one of the student learning outcomes (SLO4) is provided in Table 2. Our paper published earlier described the rationale to begin assessment of student learning outcomes in the first semester which was to ensure students' progress is monitored from the first year of their program. The assessment team decided not to assess mathematics and physics courses since those were not regulated by the College of Engineering and monitoring assessment was tedious. Therefore, only first-year engineering and engineering technology courses were considered for the assessment of student learning outcomes. Another unique characteristic of this program is that all engineering and engineering technology students take introductory courses such as Fundamentals of Engineering I and II. Therefore, it is necessary to identify and segregate engineering technology students for assessment purposes. So, the assessment team identified students who declared their major as engineering technology and shared that information with the faculty to perform assessments of only those students.

ABET Student Learning Outcomes	Performance Indicator (PI)	Course
SLO4 - An ability to conduct standard tests, measurements, and experiments and to analyze and interpret the results to improve processes	SLO4_a: Read and follow the design experiment procedure. (Knowledge)	ENGR 1181, ENGRTEC 1500, ENGRTEC 2300, ENGRTEC 2500, ENGRTEC 3100, ENGRTEC 4300
	SLO4_b: Collect measurement data on appropriate variables. (Application)	ENGR 1181, ENGRTEC 1500, ENGRTEC 2300, ENGRTEC 2500, ENGRTEC 3100, ENGRTEC 4300
	SLO4_c: Analyzes and compares the experimental data and results to the theoretical models. (Analysis)	ENGRTEC 2300, ENGRTEC 2500, ENGRTEC 3100, ENGRTEC 4300
	SLO4_d: Explain the observed difference between the model and experiment and offer basic explanations. (Evaluation)	ENGRTEC 2300, ENGRTEC 2500, ENGRTEC 3100, STATS 3440, ENGRTEC 4300
	SLO4_e: Draw conclusions by interpreting results and provide recommendations to improve processes. (Conclusion)	ENGRTEC 2300, ENGRTEC 2500, ENGRTEC 3100, ENGRTEC 4300

Table 2: Performance Indicators for Student Learning Outcome 4 and course mapping

From the table, it is evident that each outcome has been mapped to at least four courses in the program and it was intentionally done to address the lack of data for assessment and to monitor the progress of the students. In case of course cancellation, data from another course could be assessed to measure the competence of the outcome. Also, this mapping will be revised based on faculty feedback after the initial offering of the courses. In addition to laying down the measurable indicators, faculty can utilize the description of these indicators within the rubrics set up in the LMS.

E) Assessment Tool and Rubrics

Most of the courses offered at this institution utilize the learning management system to deliver the course content. All the courses offered at regional campuses are delivered using the same learning management system as the central campus. Canvas Learning Management was used for the assessment of performance indicators and eventually the student learning outcomes. Curriculum development experts have offered support to the faculty developing engineering technology (ENGRTEC) courses and setting up the framework in Canvas. In addition to creating assignments, quizzes and exams in the system, rubrics are also developed to streamline the process of outcomes assessment. Rubrics were developed using a standard 5-point Likert scale with 5: Consistently exceeds expectations, 4: Exceeds expectations, 3: Meets expectations, 2: Needs Improvement, and 1: Inadequate. Since the rubrics for performance indicators were developed outside of Canvas, the scales were consolidated into four main categories: 5-4: Exceed Expectations, 3: Meets Expectations, 2-1: Needs Improvement, and 0: Inadequate. Figure 2 shows the Canvas view of the rubric from the administrative side for the performance indicator (SLO4_a). The descriptors for each of these scales are determined by the assessment team and then reviewed by the faculty for accuracy and alignment with the expectations in the course. Figure 3. shows the Canvas view of the rubric from the instructor side for the same performance indicator (SLO4_a). As seen the rubrics appear in the grading section of Canvas and are ready to be assessed by the instructor.

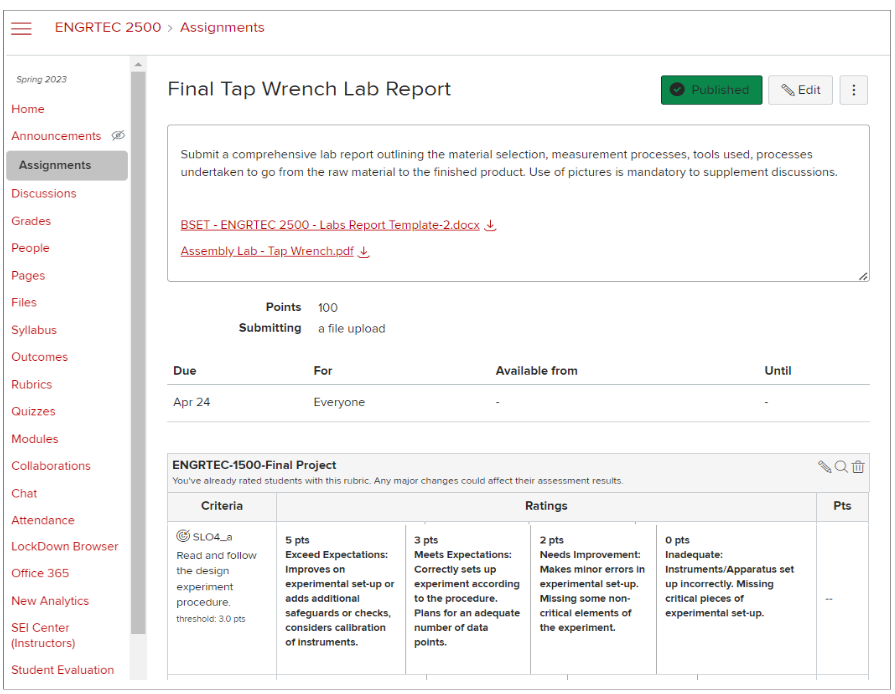

Figure 2: Administrator view of Canvas rubric for Performance Indicator SLO4_a

Faculty training sessions were organized by the assessment team prior to the start of the semester and training materials were shared. The assessment team sent regular emails to faculty reminding them to complete the assessments in their respective courses. At the end of the semester, each student received an assessment score on a scale of 1 to 5 indicating their performance on the assigned problem. At the conclusion of the assessment, instructors were required to download the spreadsheet from Canvas and upload it to the shared cloud centralized location along with the student artifacts from the course. The spreadsheets with assessment scores and student artifacts were evaluated by the assessment team.

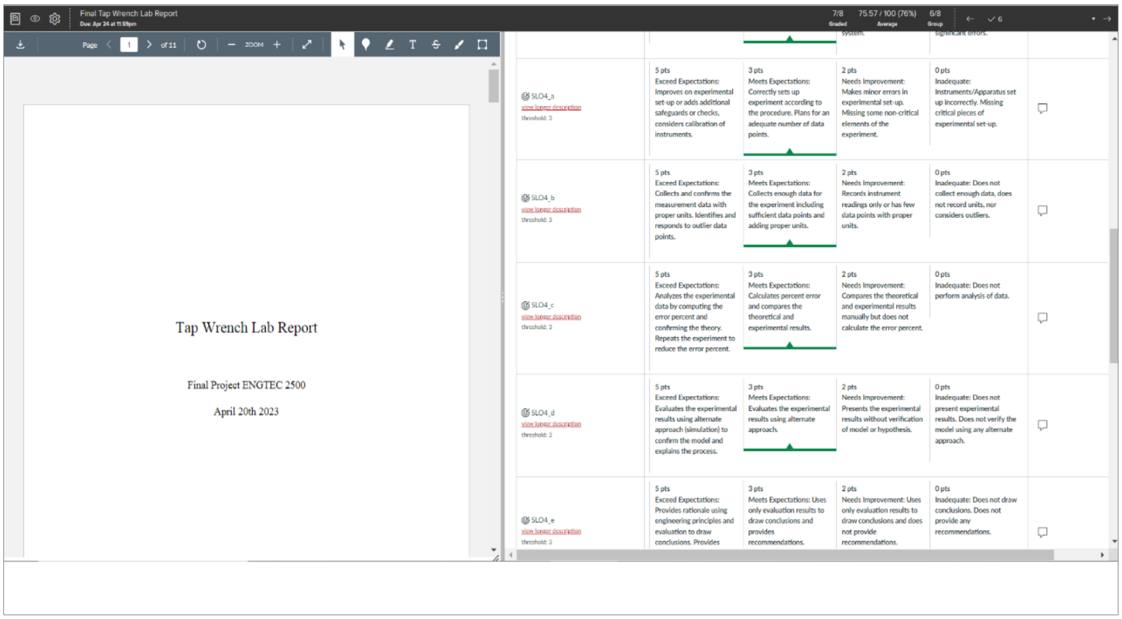

Figure 3: Instructor view of Canvas rubric for Performance Indicator SLO4_a

F) Assessment Cycle

The assessment is conducted solely by the instructors teaching the courses. This setup is to ensure the assessment results are based on the instructor's observations of the students in class. The assessment process must be periodic in order to allow continuous improvement; hence the fiscal cycles are chosen. The assessment period is split into two cycles: Cycle A - odd academic fiscal years (2021, 2023, etc.) and Cycle B – even academic fiscal years (2020, 2022, etc.). In the first year when the program was launched (2020-2021), performance indicators from outcomes SLO2, SLO3, SLO4, SLO5, SLO_SME_a, SLO_SME_b and SLO_SME_c were assessed in Fundamentals of Engineering I (ENGR 1181), Fundamentals of Engineering II (ENGR 1182), Introduction to Engineering Technology (ENGRTEC 1200), Manufacturing Processes I (ENGRTEC 1500), Manufacturing Processes II (ENGRTEC 2500) and Engineering Graphics with AutoCAD (ENGRTEC 1600). In the following semesters, more outcomes were assessed in second- and third-year courses. For instance, in ENGRTEC 2300, outcomes SLO1, SLO3 and SLO4 were assessed. Table 4 shows the courses assessed so far and those that are scheduled for assessment in the 2023-2024 cycle. After evaluating results from previous cycles, it was decided that the courses that didn't meet the target will be assessed again in the following cycle. To ensure continuous improvement, the feedback from instructors and student evaluations will be incorporated into the future course offerings. These changes will be documented in the Self-Study report as well.

G) Assessment Results and Discussion

As part of the outcomes assessment, instructors are trained to download the student submissions from Canvas and upload them to the shared university-managed cloud storage system. Our institution uses Office365 and OneDrive for data storage and management. Faculty meetings are scheduled at the beginning of the semester to offer training on assessment and collection of results and feedback. Instructors are required to complete the curriculum worksheet with the information pertaining to their classes such as course numbers, lecture/lab schedule, and delivery modes. They also upload the syllabus to the shared OneDrive folders. During the semester, instructors conduct the assessment of student learning outcomes and download the learning mastery results from Canvas at the conclusion of the semester. Any recommendations for improvement, either from the course instructor or from the assessment team are documented In Autumn 2020, courses were offered in online and hybrid formats due to COVID-19 restrictions and that eased the process of assessment since students were required to submit the work on Canvas. In 2021, the programs returned to in-person teaching modes, but the content was still delivered through Canvas. Instructors were asked to make copies of any assessments completed on paper as proof of student submissions. These will be available to program evaluators at the time of ABET site visit.

Introductory Level	Intermediate Level	Advanced Level
Fundamentals of Engineering I and II (ENGR 1181 and 1182)	Introduction to Robotics (ENGRTEC 2100)	Will be assessed in the final year of the program
Introduction to Engineering Technology (ENGRTEC 1200)	Introduction to Electrical Circuits (ENGRTEC 2300)	
Manufacturing Processes I and II (ENGRTEC 1500 and 2500)	Mechanical Processes (ENGRTEC 3700)	
Engineering Graphics (AutoCAD) (ENGRTEC 1600)	Introduction to Industrial Automation – PLC1 (ENGRTEC 3900)	
Introduction to Spreadsheets and Databases (CSE 2111)	Lean and Six Sigma (ENGRTEC 4195)	

Table 3: Courses assessed so far in the program

Evaluation of the accumulated data from these assessments is a key factor in determining actions for continuous improvement. Assessment results from all campuses were collected on OneDrive and analyzed during term break. The results were discussed during CDAC meetings and then shared with the faculty. The assessment team had established task structures and expectations for faculty to allocate time efficiently through regular meetings. In recent semesters, course coordinators are assigned the responsibility to communicate with the instructors at all regional campuses and collectively review the assessment mapping and make recommendations to the assessment team. The administrative support has also helped in communicating expectations to the faculty about this assessment process. The deans at the regional campuses played a key role in encouraging the faculty member to train on the rubrics and assess students' performance in courses. Discussions during the faculty meetings and feedback via email resulted in the expression of recommendations for closing the loop and promoting consistency among all regional campuses for continuous improvement of the program.

Results from Autumn 2020 assessments showed that the current mapping for most of the courses is accurate, however, some results were not meeting the target. As seen in Table 4., there are some outcomes meeting the target in FY21 and some that didn't. The assessment team and the instructors met to discuss the results and propose changes. Instructors teaching Fundamentals of Engineering I had discussed the project notebook expectations. Students are required to complete a software design project and maintain a website for documentation purposes. Instructors relied on the website and the content posted by the students to assess SLO3_a learning outcome. With clear instructions for students and technical writing support, the performance on this outcome was improved in FY23. A lab report for the same course was used to assess SLO3_c and it was observed that the assessment results were low. During the faculty meeting, it was discussed that the assignment had several tables related to wind blade designs and graphs for power generation and it was difficult to evaluate their understanding of the technical topics from those tables and graphs. Therefore, another assignment was chosen to assess this outcome. An assignment from MATLAB programming section of the course was chosen to assess student's ability to use visual aids to illustrate technical concepts. As seen in the table, the assessment results were improved in the following cycle. As more courses were offered, SLO3_e was also assessed. Similar reports were generated for other outcomes and their respective performance indicators. This provides some guidance on the assessment process and history of the curriculum for the ABET Self-Study report.

ABET Student Outcomes - General Criteria	SLO Code	Cycle A - FY21		Cycle A - FY23	
SLO3: 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	**SLO3_a**: Communicates technical or non-technical topics, data and information in an organized written format.	**ENGR 1181** - Project Notebook	72.17%	**ENGR 1181** - Project Notebook	100%
	SLO3_b: Presents technical and non-technical topics and data effectively in an oral format.	**ENGRTEC 1200** - Final Mentor Presentation **ENGR 1181** - Elevator Pitch Video for Users	94.29% 79.17%	**ENGRTEC 1200** - Final Mentor Presentation **ENGR 1181** - Elevator Pitch Video for Users	100% 100%
	SLO3_c: Uses visual aids (graphics, tables, charts) to illustrate technical and non-technical topics, data and results.	**ENGR 1181** - Wind Turbine Lab Report	50%	**ENGR 1181** - MATLAB Class 12 Application **ENGRTEC 2300** - Oscilloscope Lab Worksheet	89.00% 80.91%
	SLO3_d: Uses graphical design tools to illustrate concepts.	**ENGRTEC 1600** - Project #9 - Piping and Instrumentation Diagrams	100%	**ENGRTEC 1600** - Project #9 - Piping and Instrumentation Diagrams	84.76%
	SLO3_e: Identifies and uses approriate resourses (library, online, books, articles, professional manufacturing standards, etc..) for researching technical and non-technical topics.			**ENGRTEC 2300** - Wiring Diagrams Lab	100%

Table 4: Sample assessment results and comparison

Indirect assessments are conducted in the form of instructor feedback and student evaluations. A Qualtrics survey has been developed for instructors to complete at the end of the semester which helps gather more evidence-based evaluation and offer recommendations for improvement. Any information from Student Evaluation of Instruction pertinent to the program will also be evaluated.

VI. Analysis of the Approach

ABET requires programs to assess the student learning outcomes for accreditation, but the assessment process varies from one program to another. All the engineering programs are accredited at the Ohio State University, but due to the nature of the engineering technology program, the assessment process is different. First, there are two different commissions for engineering and engineering technology programs. Second, the engineering technology program is offered only at the regional campuses. Assessment strategies depend on the nature of the operations at the regional campuses which are mostly different from the central campus. Previous studies have shown that all assessment methods include some bias and have limitations [8]. Since the program will submit the self-study report for ABET accreditation on behalf of all the campuses, it is critical that the curriculum offered is consistent and assessment results are combined to provide guidance for continuous improvement. Our current approach is determined to ensure compliance with ABET criteria and consistency among regional campuses. Once the final year courses including capstone courses are offered, there will be more outcomes to assess. The goal is to assess all of the student learning outcomes in the capstone courses to measure student growth. The most prominent characteristic of this program is the analysis of regional campuses and identifying strengths and weaknesses to improve teaching efficacy. The assessment team believes that this approach is effective for the program, and it will continue to evolve as student enrollment increases.

VII. Best Practices

Based on what was learned from the experience, the authors would like to share some of the best practices. In hopes that they provide guidance for new programs that are planning to prepare for ABET accreditation.

- *Training*: Training faculty members on the assessment of student learning outcomes is critical in collecting reliable assessment data. Knowledge of accreditation policies and ABET criteria is fundamental for assessment and the assessment team should be required to attend ABET workshops. Training on institutional data policy, LMS, and file storage systems must be mandated by the programs.
- *Access to University-Managed File Storage Systems*: Due to the pandemic, several institutions were required to maintain the assessment data on their university-managed file storage systems for online ABET visits. This has enhanced the ability of all institutions to use these systems for assessment data. The assessment team chose to organize the material in a way that outlines the ABET criterion in Self-Study which has made it easier to locate the material for each criterion on OneDrive. For instance, Criterion 4 requires documentation for when, where, and how the performance indicators were assessed in the courses and action items for continuous improvement. Instructor feedback, evaluation of assessment data and other relevant information is stored in this folder based on each action item. Instructors are granted access to the “Student Archive” folder so that they are able to upload artifacts from Canvas. It is recommended that institutions follow the same approach for easy access to the material.
- *Utilizing Rubrics within the LMS*: Student performance is measured against the competencies/rubrics that are developed to assess measurable performance indicators.

Utilizing the LMS for assessment will be an effective time-saving technique, especially for programs that use such systems for content delivery. The assessment team has created rubrics in Canvas for each course of the program. When a new course is created in the beginning of the semester, the performance indicators that are mapped to the course along with their respective rubrics are imported to facilitate the instructors in assessment.

- *Effective Communication*: Collaboration among administrative staff and faculty is necessary for an effective program. The accreditation process demands effective communication of the objectives and expectations of the program from all stakeholders. Accreditation of the program not only grants credibility to the programs but also acknowledges the efforts of the faculty and administration that strive for academic excellence. Instructors must be informed about the expectations and time commitment for the assessment of learning outcomes. For programs like these which are offered at different campuses, faculty interactions will result in an inclusive environment that fosters teamwork and growth.
- *Role of Course Coordinators*: After three years of course offerings, the assessment team has realized that there is a need to create course coordinator roles to support new instructors. New hires in the program need mentoring to adapt to the university policies and procedures. It is beneficial to grant new instructors access to the master course shell in Canvas to educate them about the course content, assessments, laboratory exercises, and grading policies. It is the responsibility of the course coordinators to grant this access to the new instructors and train them. They are also required to work with instructors from all the campuses, gather feedback and recommendations and forward those to the assessment team. This will facilitate the team in accomplishing shared goals within the expected timeline.
- *Building Partnerships*: To ensure that graduates of the program are prepared to tackle current challenges in the industry, it is important to build partnerships with manufacturing firms. Each campus pursues partnerships with local industries on several fronts. Industry professionals are invited to review the curriculum and offer feedback. They are also invited to speak to the students on specific topics through engineering seminars, clubs, and other venues. IAC is encouraged to support capstone courses by sponsoring projects. These partnerships will help students network with professionals and get a step into the company for future internship or Co-op experiences.
- *Grants to help sustain research and development*: Administrative staff have submitted several grants to federal and state agencies and have been successful in acquiring funds to support this program. Faculty and administration can collaborate on several grants to request funds to help sustain the curriculum development and travel for faculty to attend conferences and workshops.

Summary and Future Work

This paper is the second in the sequence to provide an update on the implementation of an effective ABET assessment process. This paper aims to provide guidance for new engineering technology programs developing assessment processes for ABET accreditation. Although ABET provides updates every year about criteria for accreditation, there is no standard process prescribed for the attainment of student learning outcomes. Curriculum, instruction, personnel, facilities, and processes vary from program to program. The authors believe that this paper will help institutions offering programs at multiple campuses develop a robust process for program assessment. The Program Educational Objectives must be developed based on the mission and vision of the institution. Developing measurable performance indicators for each of the student learning outcomes will help align the coursework to ABET criteria. Indirect assessments such as course evaluations, faculty surveys and capstone surveys would be helpful in providing recommendations for continuous improvement.

At the conclusion of the final year, the assessment team is planning to gather recommendations from capstone courses and close the loop on several outcomes. More data has to be collected to evaluate the efficacy of the program; however, improvements have been made over the course of three years and the introductory courses have been refined. The challenge is to sustain this assessment process over time since several new faculty are being hired at the regional campuses. Training new faculty and ensuring that they maintain the same level of interest in assessment is difficult. A comprehensive assessment program will contain both direct and indirect assessment methods to maximize the strength and validity of an approach.

An industrial advisory council (IAC) is recently formed to help support the program. The advisory council will play a critical role in providing recommendations for curriculum revisions, incorporating industry standards into the program, sponsoring projects for capstone courses, advising graduates, and much more. The assessment team is part of IAC to help bridge the gap between industry professionals and faculty. Since the creation of PEOs, they have not been reviewed. So, the assessment team is planning to set up the review cycle for PEOs and the results will be shared in the following paper. With all these processes in place, the assessment team believes that a cohesive plan has been established for the ABET accreditation process. After attending the annual ABET symposium, the assessment team has begun compiling documents and preparing a Self-Study report for initial accreditation. In the future, the authors will continue to share the lessons learned and recommendations with other engineering technology programs.

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