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BOARD # 184: Mechanical Engineering Curriculum Mapping and Benchmarking Process as Part of a Curriculum Renewal Process

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Work in Progress: Mechanical Engineering Curriculum Renewal Process at Ohio State University

Abstract

In late 2019, the faculty of Ohio State University's Department of Mechanical and Aerospace Engineering began a long-range initiative to redesign the undergraduate mechanical engineering curriculum. The aim was to develop a new set of goals for the program independent from the current curriculum, with a focus on meeting the needs and challenges of modern students as they enter a constantly changing professional environment.

While updating and renewing a mechanical engineering curriculum is not a novel concept, performing a complete redesign of the curriculum is a major undertaking and can be completed utilizing any of many tools and approaches. There are reports in the literature from similar recent efforts, each of which utilized specific methods and tools that were appropriate for their goals and objectives [1, 2, 3, 4, 5, 6].

In this Work in Progress report, we describe the approach currently being utilized at OSU's Department of Mechanical and Aerospace Engineering, and report on the progress to date as well as future plans. The approach used in this report began with an initial faculty workshop that was used to generate discussion and solicit input to better understand the perceived strengths and weaknesses of the current curriculum, as well as assessing the perceived needs of the faculty regarding curriculum redesign.

Following that initial workshop, a committee of department faculty working with a professional from the University Teaching Center began the process of evaluating and renewing the curriculum. The committee began by developing a document summarizing the program goals, student learning objectives, and student proficiencies, which provide the basis for the revised curriculum. These were mapped to the ABET required student learning outcomes [8]. This information was shared with the larger faculty of the department and their feedback was integrated into the document.

While much work is still to be done on this project, the committee and larger faculty are continuing to utilize a structured design process based on *Understanding by Design* by Wiggins and McTighe. The current focus of the work involves collaborating with the departmental interest groups to map the existing curriculum content and evaluate it against the recently developed program goals, student learning objectives and proficiencies. Departmental interest groups are composed of faculty with expertise in each of the curricular content areas of (1) mechanics, (2) system dynamics and control, (3) thermal and fluid sciences, and (4) design and manufacturing. As part of this process, faculty were initially provided with an overview of the Backward Design process for the purpose of completing the mapping exercise. In the upcoming curriculum development phase of the project, they will complete additional training in this methodology. this area. The results of the mapping exercise will be used in the next phase of the project, which will involve determining the core required components of the undergraduate

curriculum as well as more flexible elements of the curriculum that could be elective elements of study, used to develop areas of focus or specialization.

It is important to note that the recently developed goals, learning objectives and proficiencies are intentionally broad and general in nature and not tied to specific topical content, much as the ABET criteria are specified. The additional task of identifying core content topics for the specific curricular areas is the next phase of this undertaking. The combination of core curricular content and the developed goals, learning objectives and proficiencies will be used to develop that set of required courses for the curriculum. One goal of this work is to develop a more flexible program of study that can accommodate students with varying career and industry interests. Another goal for the process is to develop a curriculum that includes varied, yet cohesive, learning experiences for the students to provide a range of activities, interactions and environments. An additional process goal is to integrate topics across the curriculum, thereby reducing the silo effect, as well as improving learning efficiency and program flexibility.

Acknowledgements

This paper is reporting on work done by a committee over the course of several years. The authors would like to acknowledge all of the past and current faculty members who have put in the work to move this project forward. Thank you to Carlos Castro, Rebecca Dupaix, Jung Hyun Kim, Russell Marzette, Sandra Metzler, Satya Seetharaman, Rob Siston, Manoj Srinivasan, Vish Subramaniam, David Talbot, and Dan Wisniewski for serving on the committee over the course of the project to date. Additional thanks go to all of the other members of the mechanical engineering faculty who have given input to the process.

Background and Motivation for the Work

The curriculum of Mechanical Engineering programs at ABET accredited institutions is guided by the requirements published in the ABET document "Criteria for Accrediting Engineering Programs." [8] The document details the necessary criteria that ABET utilizes to assess institutions for accreditation purposes, and it is organized under eight individual criteria. While all of the criteria are relevant to the development of the organization and practices of an ABET accredited engineering program, several of the ABET criteria particularly impact the content and organization of the curriculum for undergraduate engineering programs, including Criterion 3, *Student Outcomes*, and Criterion 5, *Curriculum*.

The current set of Student Outcomes went into effect in the 2019-2020 academic year, and they continue to utilize the concepts of change within the profession and outcome-based education that were first implemented as part of the Engineering Criteria 2000 (EC2000) standards, which ABET began adopting in 1996 [9]. EC2000 shifted the focus from specific inputs, such as the specific content that was taught in the program, to outputs, which are the learnings that students take with them when they leave the program.

Another significant aspect of ABET-accredited programs is that they employ a practice of continuous improvement. This process is implemented at OSU's Department of Mechanical and Aerospace Engineering in large part under the auspices of a Continuous Quality Improvement

Committee (CQIC), which reviews feedback from current students, alumni, employers of our students, and an External Advisory Board, as well as the performance of currently enrolled students to continuously refine and improve the program. The CQIC meets regularly throughout each academic year and presents summary data of the feedback it monitors to the larger faculty annually. This feedback is utilized to make changes within the curriculum, primarily at the individual course level although it has been occasionally utilized in larger-scale curriculum modifications. The entire mechanical engineering curriculum at Ohio State University, an ABET accredited institution, was last revised in a significant manner in the 2012-2013 academic year, primarily to accommodate a structural change in the university from a quarter-based calendar and curriculum to a semester-based schedule.

This constant review and improvement process, as well as the awareness of the larger faculty of societal trends within the profession and the mechanical engineering higher education community, naturally generates discussion as to best practices, and areas for growth, change, and development within our curriculum and its implementation. It was through these discussions and conversations, as well as the support of the department administration, that a curriculum renewal process was undertaken, beginning in 2019. The goal of the curriculum renewal process was to develop a comprehensive mechanical engineering curriculum unconstrained by adherence to the existing curriculum structure, and with a focus on meeting the needs and challenges of modern students as they enter a constantly changing professional environment.

Approach and Early Project Phases

Following the best practices in instructional design and working with a professional from the University Teaching Center, a faculty committee composed of members of the mechanical engineering faculty has employed the Backward Design Process [7] to ensure that the process began with a focus on student learning outcomes and proficiencies, rather than specific course content.

To begin the curriculum redesign process, a retreat was held in December of 2019 to gather input from faculty and staff of the department, with a focus on the question, "*What do we want our students to be able to do, know, and care about after successfully completing the ME program?"* The output of this retreat was six guiding "areas" that would guide a department committee in (eventually) redesigning the curriculum: Problem Solving; Communication; Professional Identity and Ethics; Teamwork, Leadership, and Inclusivity; Information Literacy, Judgement, and Critical Thinking; Character Traits and Self-Directed Learning.

As all readers will know, the Covid-19 pandemic caused many workplace plans and initiatives to grind to a screeching halt. This curriculum renewal initiative of the mechanical engineering program at Ohio State University was no exception. Over the course of 2020-2022, slow progress was made on writing specific program goals to match each of the six guiding areas developed during the 2019 retreat. Next, progress was made on developing the student learning outcomes that would comprise each program goal. Starting in 2022, the curriculum committee was finally able to move the project off the back burner and work with more focus and purpose to build out the student proficiencies, which are the fine-grained skills that make up student learning objectives.

By the beginning of the 2023-2024 academic year, the curriculum committee developed and documented the program goals, student learning objectives, and student proficiencies (see Appendix A). These have been mapped to the ABET required student learning outcomes (see Appendix B).

The set of drafted program goals, student learning objectives, and corresponding student proficiencies were shared with the larger faculty body in the department in November 2023. The committee facilitated discussion with the faculty members and encouraged them to leave feedback in the form of specific comments tied to one of the program goals, student learning objectives, or student proficiencies.

This information was shared with the larger faculty of the department in November 2023, and their feedback was collected. The faculty members who participated with feedback provided insightful comments and ideas that were helpful to the committee. During spring of 2024, the committee reviewed the faculty feedback and incorporated it into the central document containing the proposed program goals, student learning objectives and student proficiencies. This document is included as an appendix.

Current Work: Curriculum Mapping

In the fall of 2024, the committee began the detailed process of mapping the program's current curriculum to the proposed program goals, outcomes, and proficiencies. This mapping effort continues into spring 2025 as it is a very detailed and involved activity for a department with 64 undergraduate courses on offer. After identifying every undergraduate course currently on offer in the program, including required courses and electives, the committee has begun to work with the course coordinators to discuss each currently offered course and compare it to the proposed goals, outcomes, and proficiencies. The course coordinators were asked to evaluate each proficiency with the question: "Is this proficiency embedded in your course curriculum or instruction?" If the answer is yes, then the instructor is asked to break down how the specific proficiency item is covered and/or assessed, using the ratings found in Table 1.

Table 1: Ratings for proficiencies in current ME courses

Coverage	**Assessment**
Proficiency is not covered	Directly assessed at least once
Proficiency is mentioned	Embedded in course activities but not assessed
Proficiency is emphasized	

The preliminary output of this mapping exercise has begun to provide detailed accounting of the current coverage and assessment of these proficiencies. This information can be used to identify gaps across the multiple years and opportunities for additional coverage and scaffolding of these proficiencies across the yet to be developed curriculum, and which aspects of the department's current curriculum will be relevant and useful in the (yet-to-be-developed) future version of the curriculum.

When embarking on this phase of the project, the committee consulted with the Department of Civil, Environmental, and Geodetic Engineering (CEGE), who had recently completed a similar curriculum redesign activity within the last few years. The ME committee received spreadsheets for tracking the results of the mapping, as well as valuable insights from the CEGE Engineering department chair regarding ways to promote faculty engagement with this phase of a curriculum redesign project. The spreadsheets were developed by the University's internal center for teaching and learning, based on the methods presented in Wiggins, et al.

In addition to the mapping exercise, the committee is in process of soliciting feedback from a number of other stakeholders, including the department external advisory board, current undergraduate students in the program, recent graduates of the program, and representative industry professionals who frequently hire entry-level mechanical engineers. This work was originally targeted to have been completed in 2024, however the requirements and logistics of the initial phases of the project exceeded original estimates with respect to time and resources necessary to meet the project goals.

Curriculum Mapping Observations

The output from the curriculum mapping exercise was collected and summarized in spring semester 2025, as seen in *Figure 1: High Level View of Current Curriculum Mapped to the Proposed Proficiencies.* This is a snapshot of the current mapping, which utilizes an Excel spreadsheet to visualize coverage and assessment levels across the required courses offered by the Mechanical and Aerospace Engineering department. The spreadsheet view is intentionally zoomed out to a small scale to provide an overall picture of the existent curricular coverage.

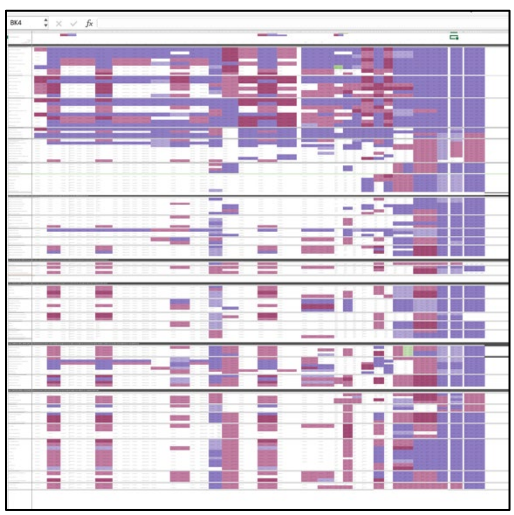

Figure 1: High Level View of Current Curriculum Mapped to the Proposed Proficiencies

The spreadsheet organization is outlined following. Each row contains an individual proficiency, and columns correspond to the individual courses. If multiple instructors evaluated the same course, their evaluations were each added to the spreadsheet as a unique column. The courses are listed in numerical order, which generally corresponds to the path of study through the program, with 2000-level courses (in the leftmost columns in Figure 1) typically being taken during a student's sophomore year. The rightmost columns in Figure 1 represent capstone course options, which are taken during a student's last two semesters. There are five ME capstone course options represented in this mapping exercise, as these are the five capstone options that come from within mechanical engineering. Mechanical engineering majors may choose one capstone course from multiple options offered within the department or from other departments.

The cells of the spreadsheet contain the faculty ratings on coverage and assessment of the proficiencies, using the method outlined in *Table 1: Ratings for proficiencies in current ME courses*. After the course coordinators completed the spreadsheet for their respective courses, the team then color-coded the spreadsheet to create a 'heat map' to help with visual interpretation of the data. The color-coding scheme is shown in Figure 2.

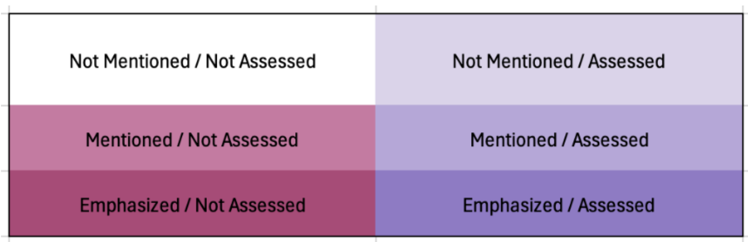

Figure 2: Color coding used with mapping spreadsheet

In analyzing the data, the team set out to investigate four research questions:

1. *To what extent in the curriculum are the proposed proficiencies covered?*
2. *To what extent in the curriculum are the proposed proficiencies assessed?*
3. *What is the correlation between coverage and assessment in the individual courses?*
4. *How extensive is the coverage at the 2000 level, at the 3000 level, and at the 4000 level?*

Note that the current analysis does not include any courses offered outside of the department, whether the courses are required or electives. Future work will include expanding the mapping exercise to include all courses in the ME major so that a comprehensive view can be obtained.

Analysis of Question 1: *To what extent in the curriculum are the proposed proficiencies covered?*

The exercise showed that students are being exposed to various aspects of problem identification throughout the core curriculum. In the earlier courses there is somewhat lighter coverage when it comes to defining success, identifying key stakeholders, and synthesizing sources, whereas these proficiencies are emphasized widely in the senior year in the capstone courses.

Notably, the core courses had frequent coverage and assessment of many proficiencies under Goal A: "The successful student will be able to identify, define, formulate, and solve complex engineering problems by applying tools, methods, and principles of engineering, science, and mathematics." The proficiencies frequently covered and assessed most often fell under the first four objectives in Goal A:

- Objective A1: Identify and analyze problems, ask appropriate questions, and define the success criteria.
- Objective A2: Identify the interactions and interconnectivity within a problem
- Objective A3: Develop an appropriate strategy and methodology in pursuing a solution.
- Objective A4: Solve problems across mechanical engineering with analytical methods.

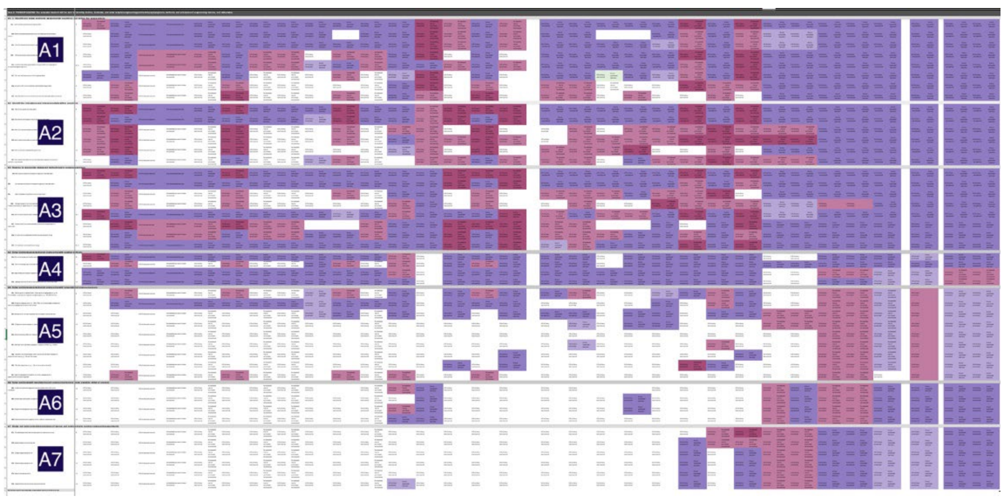

Figure 3: Mapping of Goal A

This general result of an emphasis on problem solving did not surprise the team as it is a foundational quality of engineering from any discipline and therefore is a core aspect of ABET accreditation.

Another observation in the area of problem solving related to Objective A2 (Identify the interactions and interconnectivity within a problem). There is solid coverage of this objective across the course of study, but the assessment is heavily weighted to the upper-level courses and capstone. From this, the team sees an opportunity to strengthen the emphasis on interactions between outside and inside of the discipline, and between people.

The team also observed that during the 2000-level and 3000-level courses there is a dearth of coverage *and* assessment of proficiencies that fall under objectives A5, A6, and A7, which focus on problem solving with computational engineering tools, solving problems via manufacturing to create a tangible artifact, and establishing a hypothesis to be tested. These objectives are assessed in many of the capstone courses along with some other 4000-level courses.

This trend of bunching coverage and assessment in capstone and 4000-level courses continues into the proficiencies under Goals B-F; Goal A is the only goal with regular assessment across multiple courses in each year of study.

In the initial round of mapping, there were several instances where multiple instructors completed a mapping exercise for the same course. These instructors had all taught the course relatively recently, so it was interesting to observe that the instructors' evaluations often varied significantly. Figure 4 shows an example of this variation. The highlighted section of the mapping spreadsheet contains four evaluations of the 2000-level statics course, as completed by four different instructors. The committee noted that these variations could result in a significantly different learning experience depending on the specific course instructor.

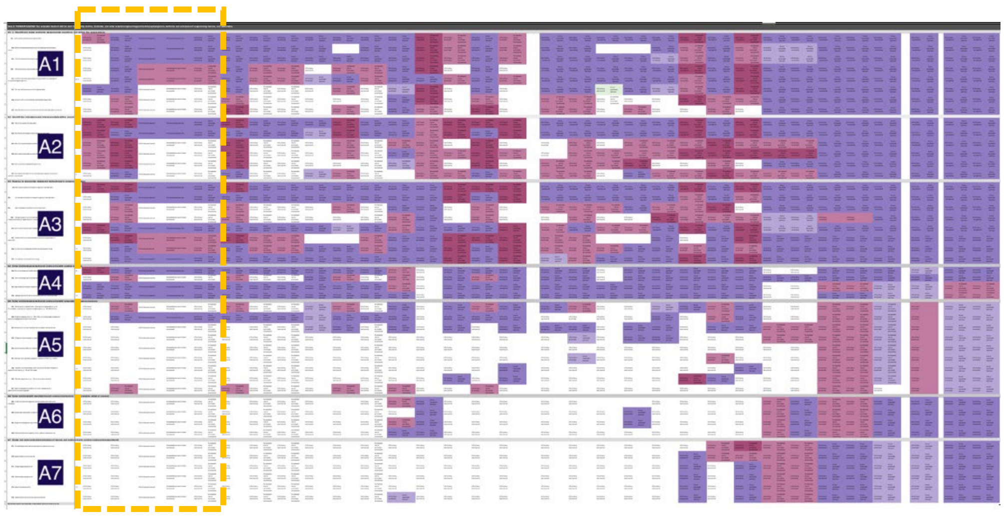

Figure 4: Differences in Instructor Evaluation of One Course

Analysis of Question 2: ***To what extent in the curriculum are the proposed proficiencies assessed?***

All of the proposed proficiencies are assessed at least once in the current core courses, though Goal C (Professional Identity and Ethics: The successful student will be able to understand the profession in relation to self and society and be able to operate professionally, ethically, and with societal awareness and integrity) had the lowest frequency of assessment.

Through visual assessment of the spreadsheet the team observed that if a proficiency is assessed, it is more likely to be "emphasized" rather than "mentioned." This observation, and the related questions of when, at what level, and how much it is necessary or useful to assess the various proficiencies will be important areas to explore as the faculty evaluate and develop new courses and curriculum.

Fifty-one out of the 131 proposed proficiencies (38.93%) were assessed in only one or two courses of the core curriculum. Of these 51 proficiencies:

- all 51 were assessed in capstone courses
- 25 were assessed in the ME 2850 Numerical Methods course
- 18 of the proficiencies were assed only in capstone courses

Additionally, the team observed that proficiencies under Goal B (Communication) and Goal D (Teamwork) were very sparsely assessed in 2000- and 3000-level courses but was very heavily assessed in upper-level courses, especially capstone. This is another important area for discussion as we develop the new curriculum, to ensure that students are building these proficiencies across the entire academic experience and not doing so solely or primarily at one point in their academic journey.

Analysis of Question 3: ***What is the correlation between coverage and assessment in the individual courses?***

Several courses seem to assess approximately 50% of the proficiencies covered, such as ME 2010 Statics and ME 2900 Introduction to Design Manufacturing. Many courses covered fewer than 50% of the covered proficiencies, such as ME 3260 System Dynamics ME 3360 System Integration and Control, ME 3870 Measurements and Data Analysis, and ME 4870 Multidisciplinary Mechanical Engineering Lab. In stark contrast, it was noted that three of the capstone offerings assessed over 90% of the covered proficiencies.

Analysis of Question 4: ***How extensive is the coverage or assessment at the 2000 level, at the 3000 level, and at the 4000 level?***

When analyzing the results of the mapping exercise, the most striking observation that the team made was that the 4000 level courses were assessing a disproportionate load of the proficiencies, with capstone courses carrying a significant majority of the assessments. One aspect of this observation is related to Objective A7: Relate and apply underlying principles of science and engineering to conduct engineering experiments. The 2000 and 3000 level courses do not emphasize this proficiency (except for one 2000-level design course), and then it is heavily emphasized and assessed during the 4000-level courses. By not assessing this significantly early in the curriculum, it is possible that we are unintentionally communicating to students in the early years of our program that experimentation and prototyping are not important or central activities in engineering.

Similarly, the team observed that within Goal B (Demonstrate visual communication skills for technical and non-technical communications and appropriate level of detail) only *one* proficiency was emphasized and assessed consistently across the 2000, 3000, and 4000 levels, which was Proficiency B3a: Create effective graphs, charts, and other visual representations of data. All other proficiencies under this goal were primarily emphasized and assessed in the 4000-level courses, which again, may be unintentionally conveying to our students that these communication skills are not an important aspect of engineering.

The results from Goal D (The successful student will be able to contribute to a successful team by taking on different roles within the team, and through creating a collaborative and inclusive environment) exhibited a similar pattern. It seems that many 2000- and 3000-level courses cover the topics of teamwork, but they are generally not assessed until it comes time for capstone. Given that capstone is largely focused on teamwork, it would be beneficial for students to practice this before getting to the course where their success is largely dependent on their ability to function in a team.

The results from Goal F (The successful student will be able to exhibit a growth mindset, persevere through learning experiences, and exhibit resilience when facing challenges) show that these concepts are covered at some level in all levels of the curriculum. In general, self-directed learning is somewhat de-emphasized in 3000-level courses, with both emphasis and assessment weighted heavily towards 4000-level courses. Students are generally pushed throughout the curriculum to use this engineering judgement and relevant knowledge to extend themselves and expand their base knowledge and skills. From a curricular standpoint, de-emphasis in 3000-level courses may suggest a missed opportunity to understand our students overall meta-cognition when approaching challenging topics, knowledge of which could serve to enhance retention.

In addition to a lopsided load on the 4000-level courses, the exercise also showed that some coverage seems to be bookended at the 2000 level and 4000 level, but very sparse (or absent) in the 3000 level, which can be seen with the following goals, objectives, and proficiencies:

- **Objective A6:** Solve problems with manufacturing and engineering tools to create a tangible artifact or product
- **Proficiency B2d:** Use written format to clearly explain current or proposed work in non-technical terms and to a scientific audience, including how work contributes to the discipline and society at large
- **Goal C:** Professional Identity and Ethics
- **Objective D1**: Demonstrate positive communication while working within a team
- **Objective D3**: Promote inclusivity and collaboration amongst the team and stakeholders
- **Objective D4:** Participate in mentorship as both mentee and mentor
- **Objective F3:** Persevere in the face of challenges (but also know when to change strategy)
- **Objective F5:** Navigate ambiguous situations

Another trend that emerged from the initial data is that the use of computational tools is not comprehensively emphasized or assessed at any level within the core curriculum. This is likely a result of the manner in which these tools and approaches are primarily organized into a range of technical elective course offerings in the current curricular structure, and so therefore they do not feature prominently within the core, required curriculum that has been evaluated to date. This may impact students' ability to integrate learnings in the computation spaces into their overall learning experience, as electives are often taken concurrently with capstone, or other culminating experiences. This should also be a featured area of discussion in the development of the revised curriculum.

An initial look overall at where coverage, assessment, and emphasis is occurring by level yields some interesting results. Overall data suggests that some proficiencies are being covered at multiple levels, as shown below in Table 2 below. While this may serve to emphasize or strengthen some important concepts overtime, it also highlights the opportunity for optimization of the curriculum to enhance flexibility. For example, if multiple embedded pathways within the curriculum address core proficiencies this potentially lends towards more flexibility for students.

Table 2: Coverage of Proficiencies by Level

Course Level	Number of Proficiencies Covered	% of Total Proficiencies
2000	119	91%
3000	115	88%
4000	131	100%

As suggested above, and shown in Table 3 below, assessment is heavily weighted towards the 4000-level courses. This may present an opportunity to rebalance the curriculum in terms of student workload, gain new insights into how our students are performing, and where we can better support their learning and student experience. For topics to be more flexibly integrated into the curriculum understanding these aspects more clearly can serve to enhance efficiency.

Table 3: Assessment of Proficiencies by Level

Course Level	Number of Proficiencies Assessed	% of Total Proficiencies
2000 Level	80	61%
3000 Level	61	47%
4000 Level	129	98%

Table 4 shows an uneven distribution relative to emphasis and assessment. To improve flexibility and variety associated with career and industry interest, or the students' broader experience, where the curriculum emphasizes and assesses readiness to progress to more advanced or focused topics may need to evolve. For example, removing legacy prerequisite barriers within the curriculum might impact a student's ability to explore a broader range of options.

Table 4: Number of Proficiencies Both Emphasized and Assessed by Level

Course Level	Number of Proficiencies Emphasized and Assessed	% of Total Proficiencies
2000 Level	73	56%
3000 Level	52	40%
4000 Level	121	92%

***Note that there was a data corruption for the proficiencies associated with objective C4 *Demonstrate societal awareness through an ability to identify needs, challenges, and problems in a local, regional, and global context*, so the team currently has no analysis about those proficiencies. This will be corrected in future phases of the project.

Future Work

Future work that the committee plans to embark on includes:

- Continue mapping exercise to include *all* courses required in ME curriculum, specifically those offered from other departments.
- Expand the mapping exercise within the department to have all faculty members participate, with the goal of understanding the variation among instructors who all teach the same class.
- Determine which mechanical engineering topics should be core parts of the curriculum, and which topics might be optional or included in the curriculum as areas of specialization. This will be informed by information gathered from a variety of sources including benchmarking of peer institutions, consulting with the core competencies represented on the FE exam, and by consulting with our department's faculty interest groups
- Working with faculty interest groups to train all faculty members on the Backward Design Process, so that all faculty will be able to focus on curricular redesign without focusing on a given topic, class, or subject area.
- Develop new courses that will make up the new curriculum

This curriculum renewal process is being presented under the Work in Progress designation at ASEE with the goal of making connections with other mechanical engineering faculty who are interested in or have experience with such an undertaking, to further the shared knowledge of the mechanical engineering higher education community. We look forward to the discussion and insights that will be gained from this experience at ASEE.

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Appendix A: Background and Terminology

Terminology used by the Curriculum Renewal Committee

Program Goals: Together, program goals make up a broad description of what our students will be able to do, know, and care about after completing the full academic program. The goals articulate the concepts, theories, knowledge, and/or skills that students will possess upon graduation. To achieve a given goal, students need to master the constituent *learning outcomes*. A program goal is typically comprised of multiple student learning objectives.

Student Learning Outcomes: These are measurable indicators of student learning and achievement. Student Learning Outcomes describe desired changes in skill, knowledge, or behaviors related to a desired program goal. Outcomes should be specific and focus on a single achievement at a time, so multiple outcomes will be associated with any given program goal. To successfully achieve an outcome, students often (but not always) need to master specific *proficiencies*. [Note: Student Learning Outcomes are sometimes referred to as *Expected Learning Outcomes*, or *Student Learning Objectives*. These phrases all describe the same thing.]

Student Proficiencies: These are fine-grained skills, knowledge, behaviors, and attitudes that are necessary for the student achieve the student learning outcomes. A proficiency should describe a singular learning accomplishment or mastered skill.

Process & Best Practices

The committee has followed best practices of instructional design to define the program goals, student learning outcomes, and student proficiencies in a manner that largely transcends the specifics of mechanical engineering topics. This will allow freedom in curriculum redesign so that a specific goal, outcome, or proficiency is not tied to a given topic, class, or subject area. This approach can be used to design either an entire curriculum or an individual course.

The methodology that the committee has utilized is known as Backward Design (*Understanding by Design,* Wiggins and McTighe, 2005). The work has been performed with assistance from Dr. Teresa Johnson, originally of the OSU University Center for Teaching and Learning, who is experienced in this work. Specifically, Dr. Johnson has extensive experience using Backward Design in the development of entire curriculums. While Dr. Johnson has moved into another position within OSU, we are fortunate that she will be continuing to support us in this process.

Background on ABET

ABET is the engineering accreditation body for undergraduate engineering programs. ABET requires that an engineering program:

> *"… must have published* ***program educational objectives*** *that are consistent with the mission of the institution, the needs of the program's various constituencies, and these criteria. There must be a documented, systematically utilized, and effective process, involving program constituencies, for the periodic review of these program educational objectives that ensures they remain consistent with the institutional mission, the program's constituents' needs, and these criteria.*"

Notably, ABET does **not** stipulate what the program educational objectives should be, so there is latitude for programs to tailor them according to their needs.

Furthermore, ABET stipulates "The program must have documented student outcomes that support the program educational objectives… **Student outcomes are outcomes (1) through (7), plus any additional outcomes that may be articulated by the program**." This means programs must show that students are at minimum meeting ABET outcomes 1-7, and programs may add additional outcomes as desired.

Details of ABET's student outcomes 1-7, as well as other details of accreditation can be found here.

Appendix B: Proposed Program Goals, Student Learning Outcomes, and Student Proficiencies

A. Problem Solving

Program Goal: The successful student will be able to identify, define, formulate, and solve complex engineering problems by applying tools, methods, and principles of engineering, science, and mathematics.

To meet this program goal, the successful student will be able to:

1. **Identify and analyze problems, ask appropriate questions, and define the success criteria.**
    a. Identify knowns and unknowns of a given problem
    b. Deduce the knowns and unknowns that are implied by specialized vocabulary terms
    c. Infer the relevant assumptions for a given problem
    d. Define the relevant scope/boundaries of an open-ended problem
    e. Translate the problem goals and objectives specified in informal language into more precise engineering terms
    f. Extract/define success criteria for a given problem
    g. Account for different stakeholders' needs while defining a problem
    h. Synthesize information from different sources to define a problem statement

2. **Identify the interactions and interconnectivity within a problem.**
    a. Identify components of the problem.
    b. Describe the relationships of the components of the problem.
    c. Identify the relevant disciplines outside of ME.
    d. Identify how it involves subject areas within ME.
    e. Identify the impact on people and organizations.
    f. Describe how the problem interacts with and impacts adjacent components, systems, or processes.

3. **Develop an appropriate strategy and methodology in pursuing a solution.**
    a. Identify potential solution techniques for a given articulated problem
    b. Articulate potential solution techniques for a given articulated problem
    c. Identify and understand the current state of the art
    d. Categorize an activity for various levels of technical development (e.g., fundamental research, applied research, technology application & best practices)
    e. Determine the relevant scientific and engineering principles
    f. Evaluate the effectiveness and viability of a solution technique subject to constraints
    g. Articulate the rationale behind the selection of a proposed strategy
    h. Articulate a structured solution strategy

4. **Solve problems across mechanical engineering with analytical methods.**
    a. Determine the appropriate physical principles

b. Determine an appropriate conceptual model of a device, system, or process.
c. Apply the appropriate governing equations to create a mathematical model.
d. Apply appropriate mathematical techniques and tools to solve the problem.

5. **Solve problems across mechanical engineering with computational engineering tools:**
    a. Basic programming skills with lower-level programming languages (e.g. C or C++) and higher-level programming and scripting packages (e.g., MATLAB or Python)
    b. Solve governing equations (e.g., ODEs, PDEs, simultaneous algebraic equations, optimality) using appropriate numerical methods
    c. Basic parametric study: expand on theoretical paper/pencil calculations
    d. Design a component on paper vs. geometric/CAD software (e.g., Solid Works)
    e. Solve mechanics problems vs. exposure to FEA software (e.g., ANSYS)
    f. Solve fluid/thermal problems on paper vs. exposure to CFD (e.g., FLUENT)
    g. Solve electromechanical and mechatronic systems problems on paper vs. exposure to software (e.g., Simulink, Simscape)
    h. Multi-domain systems, e.g., fluid-structure interaction (A)
    i. Understand and identify the abilities, limitations, and appropriate applications of machine learning and AI

6. **Solve problems with manufacturing and engineering tools to create a tangible artifact or product.**
    a. Implement solutions utilizing a variety of classical and modern fabrication techniques
    b. Consider approaches and strategies for assembly
    c. Navigate the challenges of integration with complex systems
    d. Evaluate the solutions through verification, validation, and assessment

7. **Relate and apply underlying principles of science and engineering to conduct engineering experiments:**
    a. Establish a hypothesis to be tested or quantities to be characterized
    b. Design the experiment conceptually
    c. Design the physical experiment
    d. Realize the physical experiment
    e. Experiment and collect data
    f. Analyze it with statistics or other computational tools

8. **Synthesize solutions, knowledge, or approaches from multiple disciplines.**

B. Communication

Program Goal: The successful student will be able to communicate effectively with various audiences, using various forms of written, visual, and verbal communication.

To meet this program goal, the successful student will be able to:

1. **Verbally communicate knowledge of science and engineering methodology, results, and implications to technical and non-technical audiences.**
    a. Evaluate the different venues or outlets available for communicating specific concepts or research
    b. Select the most appropriate oral communication venue(s) for a specific topic or research
    c. Select the most appropriate media or technology for communicating orally to a specific audience
    d. Create effective and purposeful presentations for technical and non-technical audiences
    e. Deliver a clear full-length presentation with content and format selected for a target audience
    f. Recognize and describe, orally, the implications of one's professional work to society on local, regional, and global scales
    g. Create an "elevator pitch" that succinctly describes a project's goals, results, and impacts

2. **Demonstrate writing skills for technical and non-technical communications and appropriate level of documentation.**
    a. Evaluate different audiences for communicating proposed ideas or results.
    b. Writing thoughtful and informative emails and potentially other social media
    c. Write clear electronic documentation for ongoing project management and completed projects (e.g., readme files in folders containing files)
    d. Use written format to clearly explain current or proposed work in non-technical terms and to a scientific audience, including how work contributes to the discipline and society at large

3. **Demonstrate visual communication skills for technical and non-technical communications and appropriate level of detail.**
    a. Create effective graphs, charts, and other visual representations of data
    b. Create a poster that succinctly describes a project's goals, results, and impacts
    c. Create an effective visual presentation to communicate a project's goals, results, and impacts

4. **Receive and respond to critical feedback from varied sources.**
    a. Receive and interpret critical feedback in verbal and written forms
    b. Respond in writing to critical feedback of written work (e.g.,manuscripts, proposals, reports, etc.)

5. **Engage in productive and professional dialogue online and in-person.**
    a. Ask appropriate questions to probe for new knowledge
    b. Develop competency to respond verbally to unanticipated questions
    c. Demonstrate professionalism, courtesy, and transparency in all communication methods
    d. Make good faith attempts to understand opposing points of view

C. Professional Identity and Ethics

Program Goal: The successful student will be able to understand the profession in relation to self and society and be able to operate professionally, ethically, and with societal awareness and integrity.

To meet this program goal, the successful student will be able to:

1. **Fully describe the discipline of engineering and the sub-discipline of mechanical engineering.**
    a. Initiate a clear career path utilizing discipline

2. **Discern the ethical considerations and implications of engineering decisions, in the context of their environment, profession, and society at large.**
    a. Consider multiple viewpoints
    b. Engage in meaningful debate with others about difficult/controversial topics
    c. Reflect upon their own professional identity and personal ethical values and the intersection with the discipline

3. **Demonstrate ethical decision-making.**

4. **Demonstrate societal awareness through an ability to identify needs, challenges, and problems in a local, regional, and global context.**
    a. Engage as a citizen leader professionally and academically
    b. Demonstrate engagement in professional societies
    c. Demonstrate the consideration of social justice in decision-making

D. Teamwork, Leadership, and Inclusivity

Program Goal: The successful student will be able to contribute to a successful team by taking on different roles within the team, and through creating a collaborative and inclusive environment.

To meet this program goal, the successful student will be able to:

1. **Demonstrate positive communication while working within a team.**
    a. Practice active listening
    b. Demonstrate empathy
    c. Respect other viewpoint
    d. Utilize professional techniques and styles across all communication mediums

2. **Demonstrate effective time management to meet or exceed required outcomes.**
    a. Establish a comprehensive project plan and timeline
    b. Demonstrate appropriate team and individual time management skills
        i. Structuring of team meeting times.
        ii. Demonstrate accountability for individual responsibilities and work
    c. Practice delegation of responsibilities (or ask for assistance) when appropriate
    d. Perform delegated duties in a conscientious manner

e. Demonstrate accountability to teammates

3. **Promote inclusivity and collaboration amongst the team and stakeholders.**
   a. Demonstrate an understanding of the importance and benefits of diversity, equity, and inclusion
   b. Interact productively and professionally with people from different cultural and technical backgrounds
   c. Understand how inclusivity positively contributes to a highly functional team

4. **Participate in mentorship as both mentee and mentor.**
   a. Give feedback
   b. Process feedback
   c. Proactively contribute to the relationship

5. **Practice appropriate individual and team leadership skills.**
   a. Demonstrate flexibility by operating cross functionally
   b. Demonstrate ability to discern whether team needs require leadership or support
   c. Understanding the balance between individual contribution and team collaboration

6. **Understand the unique roles and interactions of individual team members on interdisciplinary teams.**

E. Information Literacy, Judgement, and Critical Thinking

Program Goal: The successful student will be able to use engineering judgement in evaluating data, evaluating external information, evaluating their own capabilities and limitations, and will use that judgement to arrive at sound conclusions.

To meet this program goal, the successful student will be able to:

1. **Apply the principles information literacy to discern the quality, utility, and relevance of existing information.**
   a. Recognize “how and why information has value”
   b. Recognize “what makes a source authoritative”
   c. Demonstrate “persistence and flexibility when searching” for information
   d. Demonstrate competent use of information search tools

2. **Discern the quality, utility, and relevance of data, independent of source.**
   a. Choose appropriate tools or methods for the evaluation of data
   b. Use appropriate engineering equations and estimation techniques to perform common sense checks of data
   c. Assess the appropriateness of assumptions, input, and outputs
   d. Confirm the validity of engineering solutions
   e. Assess the plausibility and reasonableness of data
   f. Verify and validate simulation data

    g. Confirm the validity of experimental data

3. **Assess their own capabilities, limitations, and performance as individuals or team members.**
    a. Engage in reflection to self assess their own capabilities and performance
    b. Identify the skills needed to successfully tackle a given engineering problem
    c. Identify their own role in the solution strategy
    d. Recognize and describe the need for outside expertise on a given project

F. Character Traits and Self-Directed Learning

Program Goal: The successful student will be able to exhibit a growth mindset, persevere through learning experiences, and exhibit resilience when facing challenges.

To meet this program goal, the successful student will be able to:

1. **Demonstrate meta-cognition through critical awareness and reflection on their growth and development as a learner.**
    a. Interrogate their own thinking and explain it to others
    b. Explain how they best learn
    c. Monitor and assess their own depth and quality of learning
    d. Identify how their thought processes have evolved

2. **Demonstrate their agency as learners**
    a. Demonstrate the ability to plan a successful learning strategy
    b. Set learning objectives, initiate action, reflect on progress, and adjust towards accomplishing that objective
    c. Co-create path of learning that aligns technical electives, extracurricular, and other experiential learning opportunities with future career goals

3. **Persevere in the face of challenges (but also know when to change strategy)**
    a. Evaluate the nature of challenges (ex. Technical, interpersonal, time, resources, mental, physical)
    b. Identify a potential path forward
    c. Selection a reasonable course of action
    d. Embrace setbacks and challenges and view them as opportunities to evolve thought processes and learn

4. **Demonstrate a balance between divergent and convergent thinking.**
    a. Cultivate different perspectives
    b. Explore a diverse set of perspectives and alternatives when appropriate
    c. Identify the scenarios that benefit from divergent vs. convergent thinking
    d. Integrate aspects of diverse perspectives and alternatives into a cohesive concept or action

5. **Navigate ambiguous situations**
    a. Acknowledge ambiguous elements of situations

b. Appropriately communicate ambiguity in a timely manner
c. Identify relevant knowledge domains
d. Identify resources
e. Generate assumptions
f. Develop multiple plans
g. Assess risk
h. Take action to reduce uncertainty
i. Periodically evaluate the situation

6. Apply existing knowledge to unfamiliar problems.

a. Use engineering judgement to appropriately extrapolate from existing knowledge to approach novel problems
b. Identify relevant knowledge domains
c. Demonstrate an ability to extend their current knowledge base and incorporate new knowledge

7. Acquire new knowledge, skills, and expertise.

a. Stay current with technological advances
b. Be aware of resources for continuing education

Appendix C: Mapping of Current ABET Outcomes to Proposed Program Goals

A. Problem Solving

Program Goal: The successful student will be able to identify, define, formulate, and solve complex engineering problems by applying tools, methods, and principles of engineering, science, and mathematics.

Relates to ABET Outcome 1: an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

Relates to ABET Outcome 6: an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

B. Communication

Program Goal: The successful student will be able to communicate effectively with various audiences, using various forms of written, visual, and verbal communication.

Relates to ABET Outcome 3: an ability to communicate effectively with a range of audiences.

C. Professional Identify and Ethics

Program Goal: The successful student will be able to understand the profession in relation to self and society and be able to operate professionally, ethically, and with societal awareness and integrity.

Relates to ABET Outcome 2: an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

Relates to ABET Outcome 4: an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

D. Teamwork, Leadership, and Inclusivity

Program Goal: The successful student will be able to contribute to a successful team by taking on different roles within the team, and through creating a collaborative and inclusive environment.

Relates to ABET Outcome 3: an ability to communicate effectively with a range of audiences.

Relates to ABET Outcome 5: an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

E. Information Literacy, Judgement, and Critical Thinking

Program Goal: The successful student will be able to use engineering judgement in evaluating data, evaluating external information, evaluating their own capabilities and limitations, and will use that judgement to arrive at sound conclusions.

Relates to ABET Outcome 4: an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

Relates to ABET Outcome 6: an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

F. Character Traits and Self-Directed Learning

Program Goal: The successful student will be able to exhibit a growth mindset, persevere through learning experiences, and exhibit resilience when facing challenges.

Relates to ABET Outcome 6: an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

Relates to ABET Outcome 7: an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.