WIP: Inventory First-Year Courses in Direct Enrollment Engineering

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Abstract

This Work-in-Progress paper inventories and analyzes department-specific first-year engineering courses across University of Illinois Urbana-Champaign, The Grainger College of Engineering. The aim of this paper is to document the structure, learning objectives, ABET alignment, and Entrepreneurial Minded Learning (EML) integration within these courses.

First-year engineering programs vary widely across institutions, but direct-enrollment colleges face additional complexity because students enter immediately into their major department. At the University of Illinois Urbana-Champaign, twelve engineering departments each offer their own introductory course, which differ in credit hours, instructional format, technical emphasis, design components, and assessment methods. Collaborative discussions among instructors from all first-year engineering courses were used to identify shared practices for introducing curiosity, connections, and value creation in foundational engineering curricula. Each syllabus was analyzed to map ABET outcomes, EML components, learning activities, and course logistics.

Preliminary findings suggest considerable variability across departments in design exposure, experimentation, technical depth, team project structure, and support resources such as peer learning assistants. This inventory provides the foundation for developing a community of practice among first-year instructors and supports efforts to create more coherent and equitable first-year learning pathways across the college.

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Introduction

First-year engineering students enter college with a strong sense of curiosity and a desire to understand what engineers do, yet their early experiences can vary widely depending on how institutions structure the first-year curriculum [1–3]. Entrepreneurial Minded Learning (EML) highlights the first year as a key opportunity to develop the 3Cs – curiosity, connections, and creating value, that support students in understanding and practicing engineering in meaningful ways [4,5]. For many institutions, a common first-year engineering course provides a unified pathway for building these early competencies.

However, in direct-admit to University of Illinois Urbana-Champaign, where students enter directly into their major program, first-year experiences are often decentralized. Each department independently determines credit hours, instructional methods, learning objectives, assessment strategies, and the extent to which design, experimentation, and/or professional skills are introduced. All twelve departments in the University of Illinois offer distinct introductory courses that differ in meeting structure, design emphasis, technical depth, and pedagogical approach. This diversity reflects disciplinary identity, but it also raises important questions about coherence, equity, and alignment with both ABET outcomes and EML objectives.

Prior literature highlights the importance of the first year in shaping engineering identity, retention, and long-term student success [3]. Studies consistently show that students value hands-on learning, real-world relevance, teamwork, and opportunities to "see themselves" as engineers early in their degree programs [1–3]. At the same time, research indicates that students often feel uncertain about their preparedness, confused about disciplinary expectations, or disconnected from engineering practice when early experiences lack structure, design exposure, or opportunities for curiosity-driven exploration [2,3]. These findings underscore the need for intentional and well-aligned first-year experiences, particularly in decentralized models.

Research on EML shows substantial variation in how curiosity, connections, and creating value are embedded across engineering programs, suggesting that departments may benefit from shared language, common modules, or coordinated approaches to incorporating these learning aims [4,5]. Findings from experiential learning literature, including short-term international engineering programs, further demonstrate that reflective, applied, context-rich learning environments strengthen communication, cultural awareness, and engineering problem-solving outcomes relevant to early engineering education [6]. ABET scholarship additionally identifies persistent challenges in aligning course-level assessments with program-level outcomes, motivating the need for clear mapping of where foundational competencies are introduced [7].

Foundational work by Reid established a widely used classification scheme for "Introduction to Engineering" courses, demonstrating how first-year offerings vary nationally in structure, outcomes, and assessment practices [8]. More recent efforts, including the expanded taxonomy by Reid, Reeping, and Spingola [9] and qualitative syllabus analyses conducted at the University of Virginia [10], show that first-year engineering courses continue to evolve, with differences in design exposure, programming integration, professional skill development, and disciplinary emphasis. However, these studies primarily examine national trends or multi-institution comparisons rather than cross-department variation within a single direct-admit college.

Despite the importance of the first year and the availability of national frameworks, limited research documents how multiple department-specific introductory courses differ within a single engineering college or how these differences influence students' early development of skills aligned with ABET and EML. This Work-in-Progress study addresses this gap by conducting a systematic inventory of department-specific first-year engineering courses in University of Illinois Urbana-Champaign. Building on the objectives outlined in the abstract, this introduction sets the stage for examining (1) ABET outcome alignment, (2) EML integration, and (3) the logistical and pedagogical structures that define each course including credit hours, meeting formats, assignment types, design and experimentation components, software tools, and support resources. By comparing these elements, we aim to understand how departments introduce foundational engineering skills, where common themes emerge, and how a more cohesive first-year experience while still maintaining departmental identity might be supported across the college.

Ultimately, this analysis provides a framework for faculty to reflect on their course structures, share best practices, and participate in a developing community of practice focused on improving the first-year engineering experience. The findings also create a starting point for future alignment efforts, including the development of shared EML modules, common assessment tools, and opportunities to ensure that all first-year students regardless of major experience curiosity-driven, value-creating, and professionally meaningful engineering learning.

Experimental Methods

This study was conducted at a University of Illinois Urbana-Champaign enrolling more than 60,000 students, with twelve departments housed within The Grainger College of Engineering. Unlike institutions that use a common first-year engineering model, the University of Illinois Urbana-Champaign follows a hybrid structure. All engineering students are required to take ENG 100, an introductory 1-credit course supporting their transition into the engineering curriculum. Alongside this shared experience, most students enter the university directly admitted to a specific major, and many are required to take one or more department-specific introductory courses that vary in credit hours, instructional formats (lecture, lab, studio, or hybrid), and levels of technical depth. Although an exploratory engineering unit exists for undecided students, the majority begin with a declared major. Faculty expressed growing interest in understanding how these diverse first-year experiences compare across departments and whether shared best practices could improve coherence and equity across the college. This study examines syllabi from nine introductory courses to inventory structures, expectations, and opportunities for student learning.

Data were analyzed for nine first-year engineering courses drawn from aerospace, mechanical, electrical and computer, industrial and systems, civil and environmental, bioengineering, engineering orientation, and technology entrepreneurship. Syllabi and course documents including learning objectives, weekly schedules, assessment structures, project descriptions, instructional formats, and topic lists were reviewed to construct an initial inventory of course logistics, content, and curricular expectations. Course instructors participated in informal follow-up discussions to clarify the intent behind course structures, the role of design and laboratory components, and the types of learning experiences each department prioritizes. These conversations contextualized how instructors view opportunities for students to develop curiosity, make interdisciplinary connections, and create value in their first-year coursework. To compare courses systematically, several analytic matrices were developed. An ABET 1-7 outcome matrix captured the extent to which each course addressed each of the 7 ABET program-level outcomes. A course logistics matrix summarized credit hours, meeting formats, assessment types, design and experimentation expectations, and instructional staffing models. A course content comparison matrix examined technical and non-technical skill emphasis, including design practices, experimentation depth, computational tools, professional skills, and communication tasks. Additionally, an EML 3C matrix was constructed to examine how each course incorporated the Kern Entrepreneurial Engineering Network's three elements of the entrepreneurial mindset: curiosity, connections, and creating value.

For the EML analysis, each syllabus was coded using a three-level classification system. Activities were labeled Explicit (E) when courses included targeted assignments or instructional language that directly referenced EML principles or clearly framed curiosity, connections, or value creation as intended learning goals. Instances were coded as Implied (I) when course elements aligned with EML concepts such as open-ended problem framing, contextual analysis, or exploratory learning without explicitly naming the 3Cs. Finally, courses were marked as None (N) when no identifiable components related to curiosity, connections, or value creation were present in the syllabus.

This coding framework supported consistent interpretation across courses. Together, the matrices provided a structured foundation for identifying cross-course patterns, areas of divergence, and opportunities for shared practices across the college's distributed first-year curriculum.

Results and Discussion

Analysis of the eight introductory engineering courses (Table 1) showed substantial variation in credit hours, weekly contact time, instructional formats, project expectations, and enrollment patterns. Credit hours ranged from 1 to 4, producing contact hours spanning from 1 hour in TE 100 to 5 hours in ECE 110 and SE 101. Lab-intensive courses such as ME 170, ECE 110, SE 101, and CEE 190 offered structured hands-on experiences with physical systems, while courses such as ENG 100, BIOE 120, and TE 100 emphasized discussion, studio work, or conceptual exploration. Team projects were present in nearly all courses, but their scope differed widely including electronics prototyping, infrastructure feasibility studies, glider and rocket design, human-centered design, and entrepreneurial problem framing. Enrollment patterns also differed, with department-based courses serving 130–310 students while ENG 100 enrolled more than 2,700 students in a term. Support models reflected these logistical differences, with lab-based courses relying heavily on graduate and undergraduate assistants, while discussion-focused courses utilized peer leaders or minimal staffing. Collectively, Table 1 illustrates that students across different majors encounter meaningfully different learning environments and expectations during their first semester.

Technical and professional skill development also varied across the nine courses (Table 2). Courses with strong design or build elements (AE 100, ME 170, ECE 110, and CEE 190, SE 101) introduced students to iterative problem-solving, modeling, CAD tools, embedded systems, or data-driven experimentation. In contrast, BIOE 120, ENG 100, and TE 100 emphasized conceptual framing, human-centered approaches, ethical reasoning, or introductory professional skill development rather than traditional engineering design activities. Experimentation opportunities varied: ECE 110 and BIOE 100 incorporated direct measurement, instrumentation, and computational analysis, while several courses provided only digital or conceptual forms of experimentation. Software exposure also differed, with some departments integrating tools like Autodesk Fusion, MATLAB, oscilloscopes, or image analysis software, while others used collaborative platforms or no technical tools at all. Despite these differences, all courses incorporated professional and communication skill development through design reports, lab documentation, presentations, peer review, or reflective assignments, though the type and depth of communication tasks varied by discipline. Together, these findings show that students encounter distinct gateways into engineering practice, shaped by disciplinary identity and instructional priorities.

Table 3 highlights how this course structures translate into ABET outcomes. All courses support core competencies such as problem solving, communication, ethics, teamwork, and lifelong learning, but the extent and emphasis differ. Courses with substantial lab or design components (AE 100, ME 170, ECE 110, SE 101, and CEE 190) show broad alignment across multiple ABET outcomes, particularly in engineering design, experimentation, and team-based problem solving. These courses often assess ABET-related skills directly as part of departmental self-study requirements. Courses focused on conceptual or human-centered work (BIOE 120, ENG 100, TE 100) emphasize communication, teamwork, and ethical reasoning but offer fewer structured opportunities for engineering design or hands-on experimentation. Experimentation shows the largest variation, with only a subset of departments providing physical measurement or testing experiences in the first year. Overall, the ABET mapping demonstrates that while each department introduces foundational competencies, students' early engineering trajectories differ depending on their major. These differences highlight opportunities for shared expectations or common modules that support coherence while respecting departmental autonomy.

Analysis of the EML 3C matrix (Table 4) shows that elements of curiosity, connections, and creating value appear across the eight introductory courses, but with varying levels of intentionality and emphasis. Curiosity is the most consistently present, appearing explicitly in ME 170, ECE 110, CEE 190, and TE 100, and implicitly in most others. Connections to real-world contexts, interdisciplinary ideas, or stakeholder needs are present in nearly all courses but are rarely explicit, suggesting that instructors embed these ideas without labeling them as EML. Creating value shows the most variation, appearing explicitly only in CEE 190 and TE 100 and implicitly in a few courses such as ME 170, BIOE 120, and ENG 100. Many department-based courses emphasize technical or conceptual work without framing projects in terms of stakeholder impact. Overall, Table 4 indicates that while EML-aligned practices exist within the distributed curriculum, they remain uneven and often implicit, highlighting opportunities for shared language and coordinated integration of the 3Cs across departments.

Table 1. Course Logistics Comparison

Category	AE 100	ME 170	ECE 110	SE 101	CEE 190	BIOE 100	BIOE 120	ENG 100	TE 100
Credit Hours	2	3	3	3	4	1	1	1	1
Enrollments AYR26	~240 (FA25)	~330 (FA25), ~200 (SP26)	~1000 (FA25), ~1000 (SP26)	~140 (FA25), 170 (SP26)	~310 (FA25)	~130 FA25)	~140 (SP26)	2,700 (FA25)	42 (FA25), 24 (SP26)
Weekly Meeting frequency	1-hr lecture + 2-hr lab	2 lectures + 1 lab	lecture; 3-hour lab	lecture + studio	lecture + project work	2 lectures	2 lectures	2 discussions	1 discussion
Weekly Contact Hours	3 hours	4 hours	5 hours	5 hours	4 hours	2 hours	2 hours	2 hours	1 hour
Meeting Type	Lecture, lab-style build/test sessions	Lecture + CAD labs	Lecture, electronics lab	Lecture, sketching studio, modeling lab	Lecture, design lab, field data	Lecture + group work sessions	Seminar + discussion	Discussion, studio-style	Discussion, studio-style
Team Project	Rocket and Glider design/build/test	Mass-produced consumer product redesign	Autonomous electronic vehicle	Product dissection & redesign	Open-ended infrastructure feasibility study	3 projects (physiology, signals, imaging)	Scientific poster	Human Centered Design section includes needs-finding	Open-ended entrepreneurial project
Graduate Support	Manage lab sessions	Manage lab sessions + Grading	Lead lab sections, office hours, and lab grading	Teaching Assistants lead studio & lab sessions & grading	Grading + Office Hours + Project Mentoring	Task managers + Grading + Class Facilitator	Task managers + Grading + Class Facilitator	N/A	N/A
Undergraduate Support	Grading + Mentoring	Grading + Supporting lab +Peer Mentors	Assist in labs, office hours, and homework grading	Support Teaching Assistants in lab & hold help sessions	Peer Mentoring	Grading	Grading	Peer Leaders are central instructors	Grading + Classroom support

Table 2. Course Content Comparison

Category	AE 100	ME 170	ECE 110	SE 101	CEE 190	BIOE 100	BIOE 120	ENG 100	TE 100
Design Components	Rocket and Glider design	CAD assembly, Design for Manufacturing, Manufacturing cost analysis, HCD	Circuits, sensors, motors, controls	Reverse engineering + redesign	Open-ended infrastructure feasibility study	experimental design, not product design	Conceptual only	HCD (empathy, interviews)	Conceptual only
Experimentation	Prototypes and design iterations	Simulation only, no physical labs	Breadboards, measurements, lab data	Digital analysis only	None	Measurements, audio signals, imaging	None	None	None
Engineering Software Tools	Not significant portion of class	Autodesk Fusion, aPriori	Oscilloscopes, PL	Autodesk Fusion, drawing tools	Excel	MATLAB, Audacity, image analysis	Library tools, citation tools	Slack, Google Drive, campus portals	No required software
Technical Skills	Basic design and manufacturing	Mechanical CAD technical content	Hardware + embedded systems	CAD; engineering depth	Data collection, lit review, estimation	Data computation	Non-technical; literature-based	None	Prototyping, visualization
Professional Skills	Teamwork, ethics	Teamwork, ethics, ideation	Team formation and communication	Teamwork, presentations	Teamwork, ethics, problem solving	Ethics and Teamwork	Ethics and Teamwork	Ethics, Teamwork, Leadership	Teamwork, presentations, Leadership
Technical Communication	Video presentation, written report	Final design report & presentation	Final design report	Written reports, oral presentations, technical drawings	Project report, presentation, email, peer review, career prep	In class peer presentation of data	Technical paper writing, Poster presentation	None	Final report & presentation
Assessment Structure	Reports, calculations, quizzes, reflections, design worksheets	CAD models, design reports, in-class worksheets, presentations	Lab reports, quizzes, lab practical, final project	Labs, sketching quizzes, theory tests, modeling test, design project	Reports, presentations, peer review, quizzes, Excel Analysis, and reflections	Reports, slides, quizzes, MATLAB, presentations, data analysis	Reports, poster, presentations, attendance	Reflections, attendance, presentations, team tasks	Team project, participation, peer teaching, reflections, written and visual syntheses

Table 3. ABET × Course Matrix

	ABET Outcomes						
Course Name	**Problem Solving**	**Engineering Design**	**Communication**	**Ethics**	**Teamwork**	**Experimentation**	**Lifelong Learning**
AE 100	YES*	YES*	YES*	YES*	YES*	YES*	YES*
ME 170	YES	YES*	YES	YES*	YES	YES	YES
ECE 110	YES	YES	YES	YES	YES	YES	YES
SE 101	YES	YES	YES	YES	YES	YES	YES
CEE 190	YES*	YES*	YES*	YES*	YES*	NO	YES*
BIOE 100	YES*	YES	YES	YES*	YES	YES	YES*
BIOE 120	YES	NO	YES	YES*	YES	NO	YES
ENG 100 EU / Non-HCD	NO	NO	YES	YES	YES	NO	YES
ENG 100 HCD	NO	YES	YES	YES	YES	NO	YES
TE 100**							
* Refers to this particular element being assessed as part of the program's ABET self-study							
** Not part of an ABET-accredited program							

Table 4. EML 3C × Course Matrix

Course	Curiosity	Connections	Creating Value
AE 100	Implied	Implied	None
ME 170	Explicit	Implied	Implied
ECE 110	Explicit	Implied	None
SE 101	Implied	Implied	None
CEE 190	Explicit	Implied	Explicit
BIOE 100	Implied	Implied	None
BIOE 120	Implied	Implied	Implied
ENG 100 EU	Implied	None	Implied
TE 100	Explicit	Implied	Explicit

Future Work

Future work will include conducting student focus groups to understand how first-year students perceive the value, relevance, and challenge level of their introductory engineering experiences. A college-wide EML survey is also planned to assess how curiosity, interdisciplinary connections, and value creation develop across departments. Additional directions include designing shared EML modules that can be flexibly integrated into any course, strengthening alignment between course-level assessments and ABET outcomes 1–7, and exploring broader adoption of effective design, lab, or project components identified in this inventory. Collectively, these efforts aim to enhance coherence, equity, and shared expectations across the first-year engineering curriculum.

Conclusion

This inventory of introductory engineering courses demonstrates substantial variation in how departments structure first-year learning, emphasized skills, and the opportunities available for students to engage in design, experimentation, communication, and value creation. Hands-on and design-oriented courses (e.g., AE 100, ME 170, ECE 110, SE 101, CEE 190) align closely with ABET-related competencies, while courses such as BIOE 120, ENG 100, and TE 100 emphasize conceptual framing, professional formation, or early exposure to human-centered design and entrepreneurial thinking. These differences reflect disciplinary identity but also produce uneven early experiences for students across the college.

These findings highlight strengths within individual courses as well as gaps in coherence across the distributed first-year curriculum. While it is necessary to have some differences between departments to build discipline-specific skills and departmental identity, it is also important to ensure that student experiences are comparable across departments. Students' exposure to design, experimentation, computational tools, and value creation varies considerably by major, raising questions about equity and shared expectations during this formative stage.

This Work-in-Progress study establishes a foundation for coordinated improvements by documenting course structures, identifying areas of divergence, and highlighting opportunities for more consistent introduction of core competencies. Future directions include developing adaptable EML modules, refining college wide ABET outcome mapping and building a community of practice among instructors. Together, these efforts can support a more coherent, curiosity-driven, and value-focused first-year engineering experience while preserving the distinct strengths of each department.

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