What About Grading? Using Standards Based Assessment as a Tool to Assess Competence for Improvisational Engineering Practices

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Shayla Sawyer is a Professor in the Electrical, Computer, and Systems Engineering Department at Rensselaer Polytechnic Institute. Her research explores the interconnection of hybrid materials for high-performance devices. These nano-bio devices are comprised of hybrid inorganic/organic materials, which may include semiconductor metal oxide nanostructures, bacteria, conductive polymers, conductive nanostructures, and bio-chemical solutions. Her overall research goal explores effectively fabricating and characterizing novel materials and sensors with consideration of systems that require sensitivity and/or selectivity to bring quantitative measurements in typically qualitative worlds. The inherent team-based, collaborative focus embedded in her technical research extends to her teaching and learning research. She is the inaugural Director of the Douglas A Mercer '77 Innovation and Exploration Laboratory (Mercer XLab). Dr. Sawyer is a highly regarded teacher for her unorthodox teaching style and Alpha Omega Lab innovation. She has received all four of the highest teaching awards at RPI, including the Outstanding Teaching Award for Innovation in Education in 2025. She was selected by students for the 2023 David M. Darrin '40 Counseling Award.

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Abstract

In this paper, Standards-Based Assessment (SBA) is the assessment tool used to provide grading efficiency, clear communication of expectations to students, and diminish grader variances. It measures students against a set of well-defined learning standards rather than by comparison to other students. Specific learning outcomes are communicated to students at the introduction of the assignment as a set of "I can…" statements. The grading rubric reflects the same "I can…" statement and is a binary choice for graders. The grader simply determines whether the student demonstrated the content in the statement or did not. The work includes the pilot study of SBA in two extreme cases of design opportunities in Summer 2022 courses. Both courses used it as a tool to assess the assignment called Proof of Skills. The first course, Design Studio A, was an open-ended design project course without examinations, homework, or written assignments. The entire course depended on iteration and resubmission of skills in the context of their creative design projects. Teams were widely multidisciplinary, crossing schools and departments. Completion required iteration throughout the semester. The second course was Electric Circuits. It is a second-year fundamental course that is the prerequisite for all other courses in the Electrical, Computer, and Systems Department. Proof of Skills was one individual assessment among other exams, homework, labs with Proof of Concepts, and in-class team assignments. Students could iterate to achieve the entire set of skills over the semester. Could SBA provide a consistent and subjective framework for open-ended design problems?

After the Pilot Study, recommendations were implemented in Electric Circuits in an extended study. Results obtained from surveys, one-on-one interviews, Proof of Skills scores, and lab choices in Spring 2023 and Spring 2025 revealed three key trends central to the pilot study and extended study findings.

1. Proof of Skills using Standards-Based Assessment as the only assessment in Design Studio A, a multi-disciplinary design course, was not tightly defined enough for students to feel accomplishment and success. Proof of Skills in this course was not directly aligned to any future course in a student's discipline.
2. Proof of Skills using Standards-Based Assessment in an introductory fundamental course, Electric Circuits, was tightly defined. Proof of Skills was directly aligned to laboratory skills and those in future courses within the discipline. Students reflected accomplishment and success as their proficiency was translated and reflected in other assignments given in the course.
3. The Omega (Design) lab participation compared to Alpha (Traditional) Lab participation increased from ~50% before Fall 2022 to over 85% in Spring 2025 in the second-year course Electric Circuits. One significant factor includes repeated practice of Proof of Skills to gain confidence before taking a significant risk in their creative design lab choice. SBA established a streamlined approach to grading creative designs relative to course content efficiently.

Background

Improvisational engineering [1,2] in this context emphasizes Design Thinking [3,4] and encourages Design Practice by focusing student learning on mastering individual skills and using creativity to demonstrate mastery through design projects. It is used to deepen knowledge in fundamental courses. Traditional course laboratory assignments are analogous to classical music in which the score is written by a well-known expert, the instructor. Students express mastery by performing a known score with accuracy and precision compared to the expert, with some minor acknowledgement of individual style by approach or documentation emphasis. There is one song with pre-defined notes and therefore only one expected solution. Improvisational engineering is analogous to Jazz in which fundamental knowledge is expressed by creative expression within a well-defined context, often encouraged by a community of players, perspectives, and instruments. The notes played within the context are not entirely pre-defined. The performance is actively adapted to the collective experience. Thus, many solutions are possible. With many creative solutions possible, assessment of improvisational engineering in Design Practice must overcome significant challenges, including longer grading times, shifting expectations from grader to grader, a lack of teaching assistant training to assess solutions that are not pre-defined, and unclear communication of expectations for student success. If these issues are addressed, the potential for impact on assessment style in the age of Artificial Intelligence is profound. Courses would have a means to efficiently and effectively assess live demonstrations, creative solutions in written technical documents, or oral evaluations of mastered skills or fundamental concepts in ways that more closely resemble industry or research experiences in their professional careers. Additionally, students can iteratively prove their skills over the entire semester, ensuring confidence in technical ability for future courses. Confidence leads to a willingness to attempt designing solutions that may fail, verifying them by proving concepts, and troubleshooting to iterate in an open-ended design lab.

In this study, improvisational engineering is practiced in Electric Circuits after proving their competency through Proof of Skills. Students are given autonomy to choose their lab type. The first is the Alpha (Traditional) labs, which are procedural and step-by-step in nature. The instructor provides these students with circuits to analyze to prove a concept. In the Alpha and Omega Lab continuum, Alpha lab students also conduct a small design experiment at the end of each lab to gain some experience with design. The second lab choice is the Omega (Design) labs. The Omega Labs were added to reinforce Design Practice and Design Thinking through improvisation. These labs start with the class theme from an ideation on the first day or an explorative direction decided by the group from a menu of options. It requires proving fundamental concepts with a circuit designed by the students, instead of the instructor, to meet a societal need. It calls upon their creativity while requiring a clear project plan and an acute understanding of course concepts and how they apply to their ideas. The level of abstraction is a significant challenge for students, engaging them in new ways. Omega Labs is an example of improvisational engineering embedded within the curriculum, but it emphasizes constraint to prove course concepts with their designs using the theory taught in the course. The constraints are essential. The primary constraint in Electric Circuits is to prove their concepts using analog circuits with building blocks related to course content associated in each unit (i.e., microcontrollers or digital logic are not allowed). Constraints lead to creative solutions. In addition, students learn through practice limitations, non-idealities, and integration issues that are explained theoretically in future courses. The Alpha and

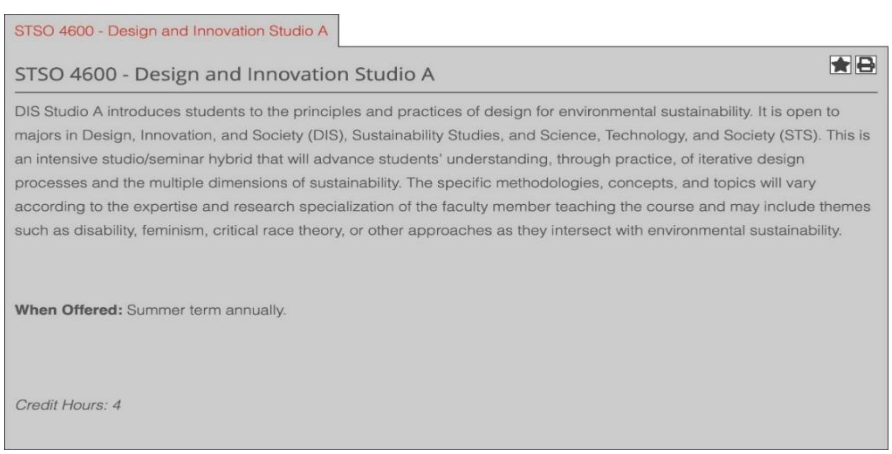
Omega Lab Continuum originated in Electric Circuits and has spread to multiple courses in the curriculum as an ABET experiment to distribute Design Practice to every year of matriculation.

Standards-Based Assessment is used to evaluate students to achieve full competency by 1) providing clear statement of the skills needed 2) providing direct feedback to students on their skill level 3) allowing iteration throughout the semester to ensure skills transfer to other courses. SBA is a grading system that was first applied in K-12 [5]. Since then, studies in higher education have used this system to communicate learning outcomes and their achievement to students in a straightforward way [6-9]. This study investigates skill competency with perceived confidence to attempt a lab that requires creativity before and after the assessment. This is reflected in the lab choice between Alpha (Traditional) labs and Omega (Design) labs directly after the assignment to prove competence.

Pilot Study Course Details

Design and Innovation Studio A (STSO-4600) is an upper-level studio-based course designed to teach the design process yet is a 4000-level course. This course is typically only for Design, Innovation, and Society (DIS) and Science and Technology Studies (STS) students in the major or added minor. The course is multidisciplinary with students from across the university. A team-based design project is the primary assessment over the course. In Summer 2022, the course was co-taught by two engineers, one new engineering faculty member, and one tenured engineering faculty member for the first time and not guided by expectations or experiences of the DIS or STS faculty.

Electric Circuits (ECSE-2010) is a 2000-level introductory course that is offered to students in the Electrical Engineering and Computer Systems Engineering program as their major or added minor. An open-ended design lab is an option for students Omega (Design) Labs. Students can also choose a traditional lab that guides students toward evaluating known circuits Alpha (Traditional) Labs. These labs are one of many assessments that reinforce fundamental course concepts. As the pre-requisite for all courses in the curriculum, the fundamental concepts are essential to learn for future courses. The same tenured faculty member co-teaching Design and Innovation Studio A. taught the course


STSO 4600 - Design and Innovation Studio A

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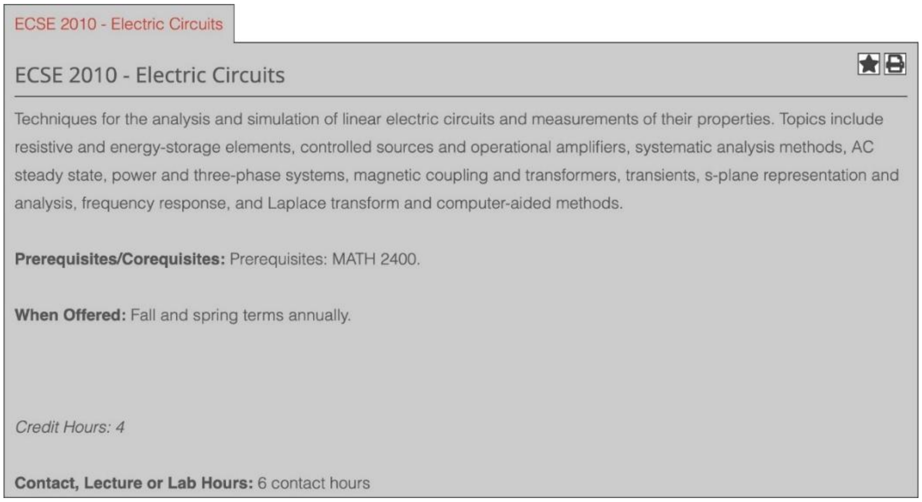
DIS Studio A introduces students to the principles and practices of design for environmental sustainability. It is open to majors in Design, Innovation, and Society (DIS), Sustainability Studies, and Science, Technology, and Society (STS). This is an intensive studio/seminar hybrid that will advance students' understanding, through practice, of iterative design processes and the multiple dimensions of sustainability. The specific methodologies, concepts, and topics will vary according to the expertise and research specialization of the faculty member teaching the course and may include themes such as disability, feminism, critical race theory, or other approaches as they intersect with environmental sustainability.

When Offered: Summer term annually.

Credit Hours: 4

Figure 1: Course catalog description of STSO-44600 - Design and Innovation Studio A



ECSE 2010 - Electric Circuits

ECSE 2010 - Electric Circuits

Techniques for the analysis and simulation of linear electric circuits and measurements of their properties. Topics include resistive and energy-storage elements, controlled sources and operational amplifiers, systematic analysis methods, AC steady state, power and three-phase systems, magnetic coupling and transformers, transients, s-plane representation and analysis, frequency response, and Laplace transform and computer-aided methods.

Prerequisites/Corequisites: Prerequisites: MATH 2400.

When Offered: Fall and spring terms annually.

Credit Hours: 4

Contact, Lecture or Lab Hours: 6 contact hours

Figure 2: Course catalog description of ECSE-2010 – Electric Circuits

Pilot Study Methods and Tools

Standards-Based Assessment

Standards-based grading was used in the pilot study to determine whether students developed and became proficient in the objectives of the content outlined at the beginning of the course. SBA allows students to receive feedback on graded assignments and retry the assignments with the feedback given. However, repetition comes at the cost of repeated grading. The tradeoff of time to assess repeatedly must be balanced with the expectation of time to iterate over the course of the semester.

After the Pilot Study in Summer 2022, Proof of Skills using SBA was implemented into Introduction to ECSE (ECSE-1010) and continued in Electric Circuits (ECSE-2010). For this paper, all data provided reflects the effects of Proof of Skills for students in Electric Circuits (ECSE-2010).

Proof of Skills

Proof of Skills in Electric Circuits is a pre-laboratory assessment that is an individual evaluation of 1) Circuit Simulation 2) Experimental Measurements and Personal Instrumentation 3) Analytical Calculations with Personal Calculator and MATLAB or equivalent 4) Community, communication, asking for help, helping others and answering for yourself "Is this right?". The course focuses entirely on this activity during the scheduled lab session for 2-3 weeks in a collaborative environment. Students sit in a common section in the room depending on the skillset they are working on. Teaching assistants are assigned to help each category, and they are encouraged to help each other during this time. All students are required to submit their own work without duplication of another, however. Proof of Skills offers a few significant structural advantages including: 1) An ability to ensure students new the learning culture (transfers) or new to the discipline start labs with the same competence level of classmates 2) An ability to review or deepen skills from a previous semester 3) An ability to ensure TAs have a template to learn skills relevant to the course 4) An ability to run labs agnostic to instrumentation and simulation tool choice thus any student can use any tool available as long as the can achieve the skill.

Proof of Skills Learning Objectives	Proof of Skills Day 1	Proof of Skills Day 2	Proof of Skills Day 3	Proof of Skills Day 4	Course Competency Check: Must complete AT LEAST the ESSENTIAL SKILLS (in red) by September 17th (to be graded by the day before drop deadline). *After essential skills are completed, you may improve your scores until the end of the semester.*
Circuit Simulation (LTSpice or equivalent)					
I can use operation point dc analysis to find voltages across a resistive circuit (*Must be two or more resistors, hint: to do something useful to you, try to simulate a homework or class problem!)*	Attempted? Graded Score /5	Attempted? Graded Score /5	Attempted? Graded Score /5	Attempted? Graded Score /5	
I can use **AC analysis** to find the frequency response of an RC or RL filter (*hint: find a filter with or without an op amp, we'll understand how this works later!*)	Attempted? Graded Score /5	Attempted? Graded Score /5	Attempted? Graded Score /5	Attempted? Graded Score /5	

Each of the Circuit Simulation Objectives above should reflect the following goals:

1. I can **change my schematic and plot background to white** and cut and paste on an external document
2. I can **change the line thickness and color** of my schematic and simulation output
3. I **can label the simulation output clearly with the circuit schematic component names**
4. I can intentionally show the most relevant part of a simulation by **changing the simulation output window**

Figure 3: Proof of Skills handout example showing a portion of the Circuit Simulation skillset in the Proof of Skills assessment. Essential Skills (in red) are required before the official Alpha or Omega Labs start. Students are marked "proficient" when all formatting standards and the documentation of the correctly performed skill are completed for a total of five points for each skill. Two out of five skills circuit simulation skills are shown. The red essential skills must be completed before labs start. All other skills must be completed by end of the semester.

In Design Studio A, a Standard List was provided that includes 1) Technical Standards, 2) Civic Engagement Standards, 3) Design Standards, and 4) Teamwork Standards. Each student is required to choose from the list of standards within a skillset that is influenced by their project goals. The students can iterate until the end of the course to achieve eleven standards.

Civic Engagement Standards

1. **I can identify the communities affected by or invested in my chosen problem.**
    a. Lists at least 1 community in each of the following categories: those affected by the issue, those who have control over the issue, those who are financially invested in the issue, and those who can design solutions to the chosen problem.
    b. Identifies at least one specific person or organization for each of the four categories in that list.
2. **I can talk to community members and obtain specifications and feedback from them.**
    a. Talks to at least one community member outside of the group.
    b. Documents their needs for the product OR has them use the product and documents their feedback.
3. **I can map the life-cycle of my project.**
    a. Lists the individual components of the project.
    b. Documents the origin and manufacturing of the materials of those components and any associated extractive processes or externalities associated with the creation of those materials or components.
    c. Estimates the lifetime of the product based on data from similar pre-existing products, experimentation, or predictive calculation.
    d. Discusses the end-of-life of the product by determining where the product will end up (e.g., landfill, recycling, compost, etc.).
    e. Provide references for information in each prior step using a pre-defined citation style.
4. **I can state the positions/perspective/opinions surrounding my chosen problem and discuss them in-depth.**
    a. Writes a short report (2-10pgs not including bibliography) on the positions, perspectives, and opinions on approaches to solving the issue.
    b. Discusses others' dissenting views of each proposed solution.
    c. Discusses own opinions of the proposed solutions by outlining pros, cons, and potential unintended consequences of the approach.
    d. Provide references for information in each prior step using a pre-defined citation style.

Figure 4: Example of Civic Engagement Standards in Design Studio A. Students can iterate to achieve a set of eleven standards from any skillset until the end of the course.

Pilot Study Participants

For this study, a Science and Technology Studies (STS) PhD student external to the course, used qualitative methods to understand student, TA, and instructor experiences of Standards-Based Assessment and proof of skills in both the Design Studio and the Circuits course. From Electric Circuits (ECSE-2010), students were asked in class for voluntary participation, and four students indicated interest. Three participated in one-on-one interviews with the researcher, lasting 15-45 minutes long. In addition to student interviews, the TAs were also interviewed about the grading process and duties for the course. The STS researcher also had access to student assignments and course content located on the course's website and Gradescope page. Once interviews were recorded and transcribed, the transcripts were coded and themed, which are then elaborated on in this report.

From Design and Innovation Studio A (STSO-4600), students were asked in class to voluntarily participate in a focus group and fifteen students participated. The focus group took place halfway through the summer semester during a class meeting and lasted 1 hour and 30 minutes. The TA and instructor for the course participated in one-on-one interviews with the researcher, lasting about 45 minutes long. The researcher also had access to course content via course meetings, Gradescope, LMS, and WebEx Teams. Once the focus group and interviews were recorded and transcribed, the transcripts were coded and themed, elaborated in this report.

Pilot Study Results

DIS Studio A – The semester long, open-ended multidisciplinary design project using SBA

In the focus group, students felt a strong disconnect from this course to typical DIS/STS material. This section of DIS Studio A was unique in that the course was half DIS majors and half non-DIS majors. (DIS Studios are typically majority DIS majors.) This course was also different in that a non-STS-affiliated faculty was teaching the course, and the instructor was also a non-STS-affiliated lecturer. And while there were certain strengths to having non-STS faculty members leading the course, students felt it was not utilized to the potential of the course and students. Students vocalized how hearing about either alumni or faculty experiences either in industry or utilizing iterative design would have better-supported course material.

Architecture students were vocally uneasy about what they were supposed to be learning. One bluntly said, "I've learned nothing," to which several students replied in affirmation. At this point, several older DIS students indicated that this class was not set up in the usual manner of DIS studios. One student said, "this class from the DIS perspective didn't help me grow as a designer," to which the other DIS students nodded in agreement.

Students in the DIS Studio focus group did not understand where they stood in the class, regarding grades. This led instructors to individually reach out to students about their grades. Students also indicated confusion about the Standards-Based Assessment, especially regarding specific standards assessed. For example, an assessment that required one or two sentences was considered equal to an assessment that could require hours of graphing or coding. More work would be needed to determine more equality between the various assessments. Students noted that milestones or more deadlines regarding the project would have been an incentive to complete the assessments and the final project. The final day of the class was a presentation day meant to relax student concerns regarding projects and deadlines. However, students did not feel required to complete the project or conduct physical prototypes. In paraphrasing, "Why worry about this project when I have midterms and tests important to my major?" The one response to the survey for this class cited that only 45% of the actual project was completed by the end of the semester.

Students became vocal about their unease with the course. When asked about what their assignments were, there was confusion about the clarity of the content and about course specifics such as project(s) and deadlines. In a way, students felt disconnected from the course and what the course was meant to be based on the syllabus. Some students expressed a stricter grading structure and schedule than what was assigned for the semester.

The Pilot Study Hypothesis 1 for Design and Innovation Studio A was found to be false. ***Standards Based Assessment did not provide a consistent and subjective framework for open ended design problems as well as tightly defined lab projects making it an ideal training for all TAs in lab-based courses that may introduce design or project-based labs.*** Students in the Design Studio course encountered difficulties with the course layout and the Proof of Skills and SBA interventions. First, students felt the course was unorganized, both on Gradescope (online submission and grading system) and in person. Because the course was set up for no hard assignment due dates, many students did not feel compelled to complete a final project, and this hesitancy was seen in the slow progress of group projects. Learning or lack of learning had little consequence in a course requiring only one design project with an entirely open-ended scope based on multidisciplinary interests. Displeasure was apparent despite achieving high grades from accomplishing their standards with an average course grade of an A.

Electric Circuits – Preparation for other assessments to learn specific fundamental skills using SBA

Students conveyed support for SBA at the beginning of the semester to develop the skills for the rest of the semester. They vocalized its importance for course success. Students interviewed did not have a background in electrical engineering or computer systems courses. It was their first interaction with the skillsets necessary to complete labs in this course. These students felt that the course was set up for them to succeed and understand course concepts without fear of failure. However, students wished that the course on Gradescope (online submission and grading system) had more organization. Students expressed strong support for Proof of Skills and the SBA grading. The average course grade for students was a C. Due to its fundamental rigor, Proof of Skills was one of many assessments including exams, laboratories, in-class group quizzes (Team Assignments), final exam, and homework assignments.

The Pilot Study Hypothesis 1 for Electric Circuits was true. ***Standards-Based Assessment provided a consistent and subjective framework for open ended design problems as well as tightly defined lab projects making it an ideal training for all TAs in lab-based courses that may introduce design or project-based labs.*** SBA provides a space for students to learn at their own pace, while safely having a space to fail (with the reassurance of iteration). This could be a solution to some of the retention in engineering seen with what students perceive to be “weeder” courses out of the engineering discipline. “Weeder” courses become “feeder” courses into the discipline when skills and concepts are attainable and retainable. Thus, SBA could work best for introductory-level courses, where students are expected to have similar outcomes on similar projects. This is best for getting the students on the same page, and a way to create more equity in the classroom. However, the assessments and proof of skills must be clear for students, instructors, and TAs to understand (preferably with hard deadlines).

Recommendations

1. Create clear and explicit instructions for each skill should be given with deadlines for essential skills to ensure it is completed before the assignment that follows Proof of Skills.
2. Introduce SBA and Proof of Skills to other fundamental and introductory engineering courses. Especially since these courses are vital to retaining students in engineering, making sure that students all have an equal opportunity to gain the fullest potential in engineering would be key to student success in these courses. This would require conversations and collaborations with other engineering professors and departments.
3. Require learning the same set of specific skill sets for all students rather than choose from a list based on their project needs. Thus, Standards-Based Assessments in the form of Proof of Skills may not be applicable to multidisciplinary design experiences like a capstone experience. It is best for Design Practice within a fundamental course.

Extended Study Experimental Methods Incorporating Pilot Study Recommendations

Proof of Skills using SBA was continued in Electric Circuits (ECSE-2010) in Spring 2023 after the Pilot Study. Proof of Skills was used as the initial preparation for labs before students chose their path of learning through Alpha or Omega Labs. Thus, essential skills are established for every individual student before they learn the course concepts with those skills. Omega Labs is an example of improvisational engineering embedded within the curriculum, but it emphasizes constraint to prove course concepts with their designs using the theory taught in the course. The distribution of Alpha and Omega Labs as Design Practice was the experimental foundation for ABET accreditation data collection during Fall 2024 and Spring 2025. The work became a central part of the Self-Study Report.

This study collected Proof of Skills survey results from Electric Circuits students from Spring 2023 – Spring 2025 (total sample: 472 student responses). This study reviews Spring 2023 and Spring 2025 responses:

> *"Please rate on your confidence in each Skills Set (Circuits Simulation, Experimental Measurements on your Personal Instrumentation, Analytical Calculations and MATLAB, Community, Communication, and Help) BEFORE and AFTER Proof of Skills thus far."*
>
> *"What lab are you choosing?" Alpha (Traditional) Labs or Omega (Design) Labs*

Spring 2023 and Spring 2025 Proof of Skill total scores after iteration throughout the semester are also compared.

Extended Experimental Results

Spring 2023 Electric Circuits: Confidence Level Before and After Proof of Skills within First 3 weeks

Spring 2023 Electric Circuits Proof of Skills Survey Results (N=72) compare the combination of moderate and high confidence to all other uncertainty levels for Circuit Simulation, Analytical Calculations, Experimental Measurement, and Communication. The survey is given after only 3 weeks of the beginning of class before experimenting with course concepts; before Alpha and Omega Labs begin. Table 1 is provided to compare moderate-high confidence levels before and after Proof of Skills. Figures 5-8 provide details of the distribution of confidence for each skillset.

Table 1: Summary of Moderate-High Confidence Levels Before and After Proof of Skills in First 3 weeks in Spring 2023 Electric Circuits (N=72)

Skillset	**Before Proof of Skills Moderate-High Confidence Level**	**After Proof of Skills Moderate-High Confidence Level**	**Confidence Δ**
Circuit Simulation	33.3%	79.8%	+46.5
Analytical Calculation	28.9%	65.3%	+36.2
Experimental Measurement	20.8%	51.4%	+30.6
Communications	52.8%	70.9%	+18.1

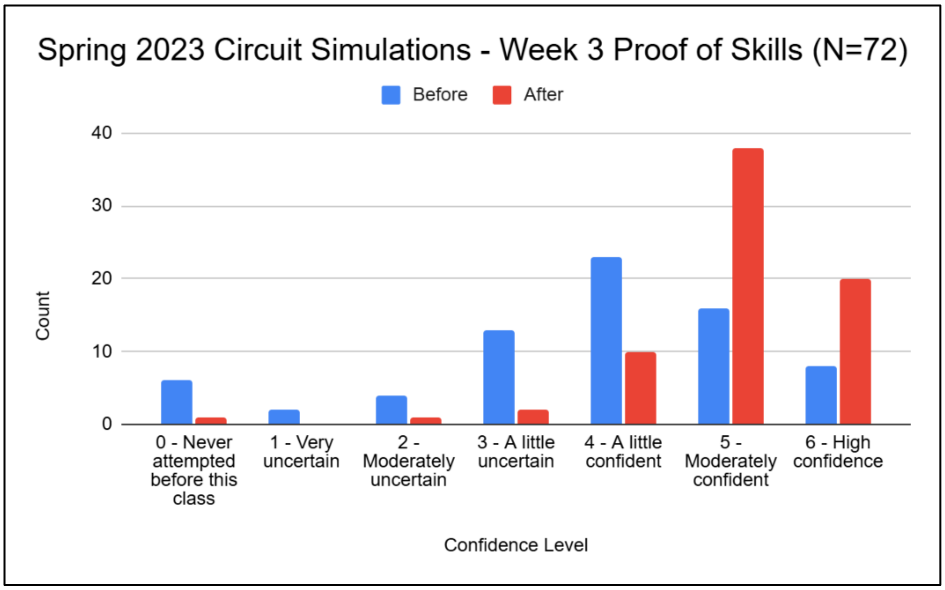


Figure 5: Circuit Simulation Skillset Before and After Proof of Skills in Spring 2023 Electric Circuits (N=72)

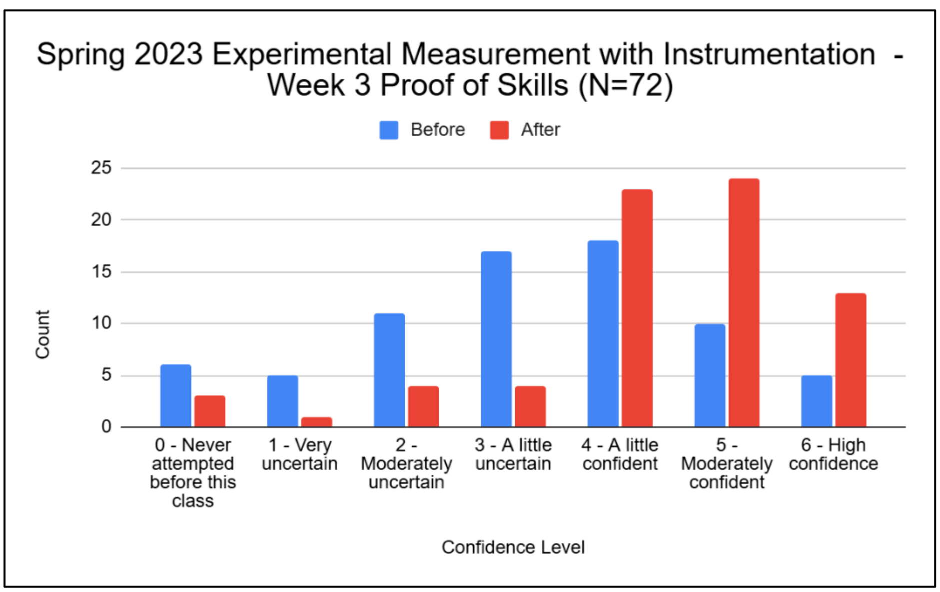


Figure 6: Experimental Measurements with Instrumentation Before and After Proof of Skills in Spring 2023 Electric

Circuits (N=72)

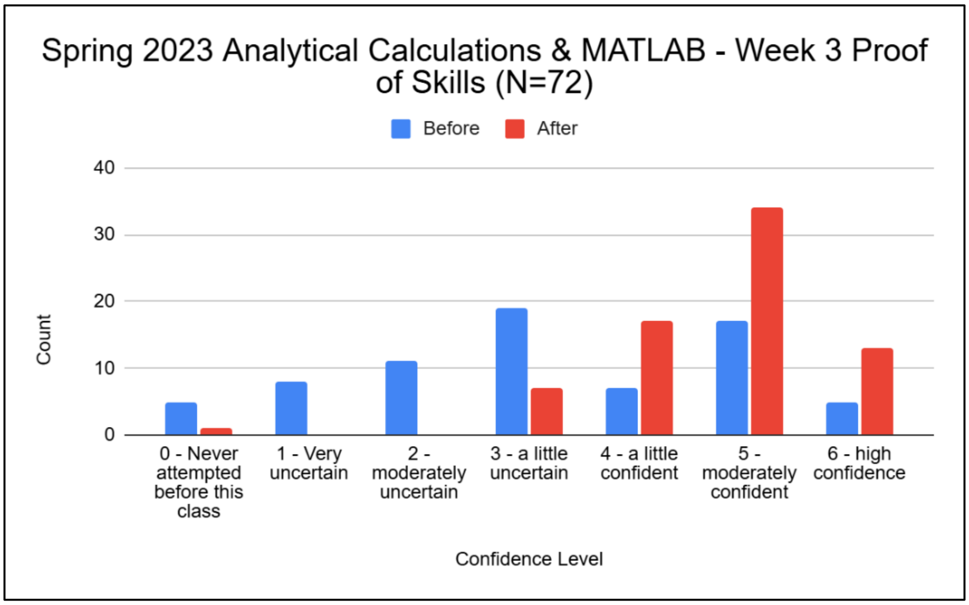


Figure 7: Analytical Calculations & MATLAB Before and After Proof of Skills in Spring 2023 Electric Circuits (N=72)

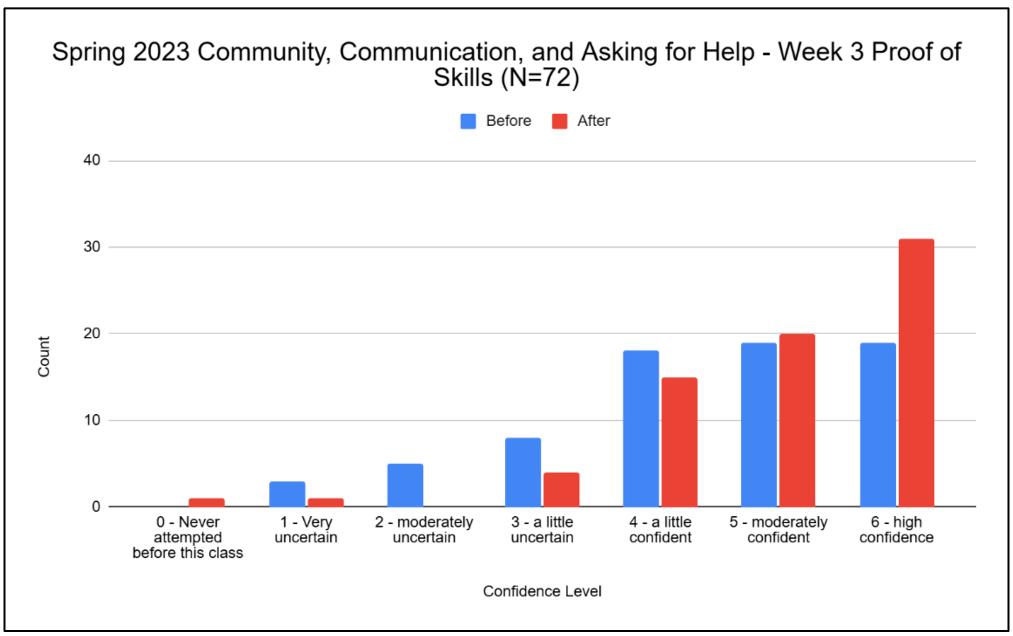


Figure 8: Community, Communication, and Asking for Help (of Teaching Assistants, Student Assistants, Each Other, and Professor) Before and After Proof of Skills in Spring 2023 Electric Circuits (N=72)

By the end of the semester the following total Proof of Skill scores were recorded for Computer Systems Engineering and Electrical Engineering students for Electric Circuits in Spring 2023. These scores represented ABET 3.7 assessment student outcome "… an ability to acquire and apply new knowledge as needed, using appropriate learning strategies." Students show proficiency by the end of the semester for all skillsets as shown in Figure 9.

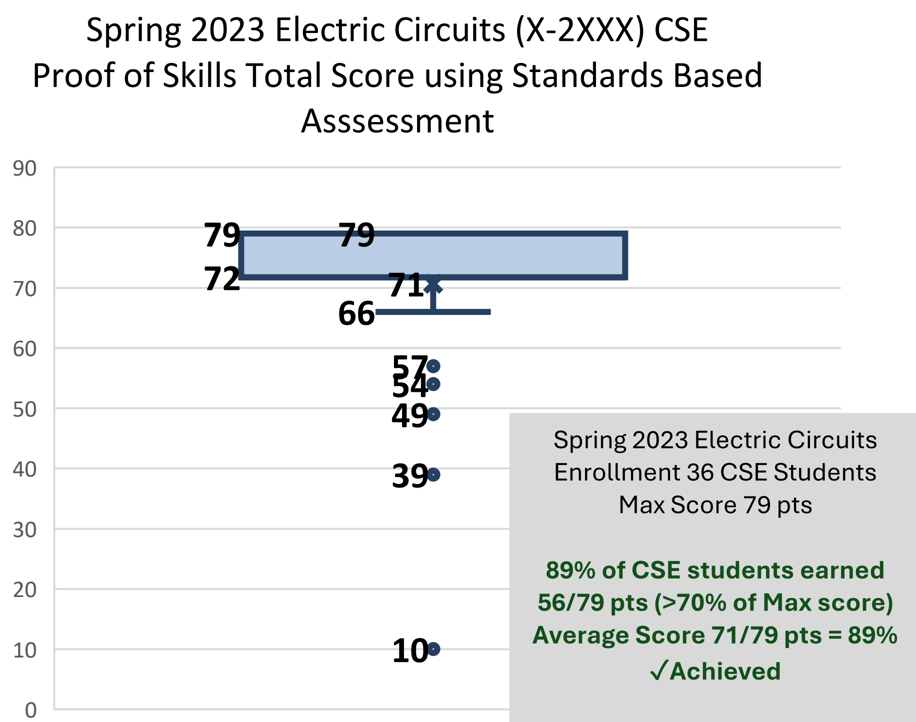


Figure 9: Spring 2023 Electric Circuits Computer Systems Engineering Proof of Skills score over the entire semester.

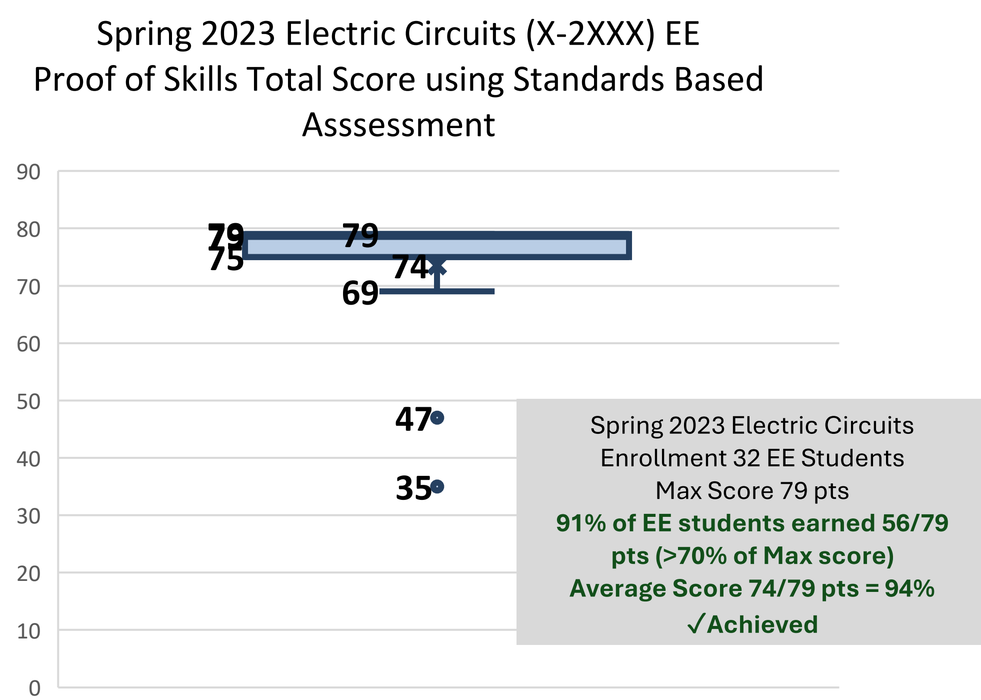


Figure 10: Spring 2023 Electric Circuits Electrical Engineering Proof of Skills score over the entire semester.

Spring 2025 Electric Circuits: Confidence Level Before and After Proof of Skills within First 3 weeks

Spring 2025 Electric Circuits Proof of Skills Survey Results (N=95) compare the combination of moderate and high confidence to all other uncertainty levels for Circuit Simulation, Analytical Calculations, Experimental Measurement, and Communication. The survey is given after only 3 weeks of the beginning of class before experimenting with course concepts; before Alpha and Omega Labs begin. Table 2 is provided to compare moderate-high confidence levels before and after Proof of Skills.

Table 2: Summary of Moderate-High Confidence Levels Before and After Proof of Skills in First 3 weeks in Spring 2025 Electric Circuits (N=95)

Skillset	**Before Proof of Skills Moderate-High Confidence Level**	**After Proof of Skills Moderate-High Confidence Level**	**Confidence Δ**
Circuit Simulation	35.8%	80%	+44.2
Analytical Calculation	10.6%	50.5%	+39.9
Experimental Measurement	16.8%	72.6%	+55.8
Communications	54.4%	73.7%	+19.3

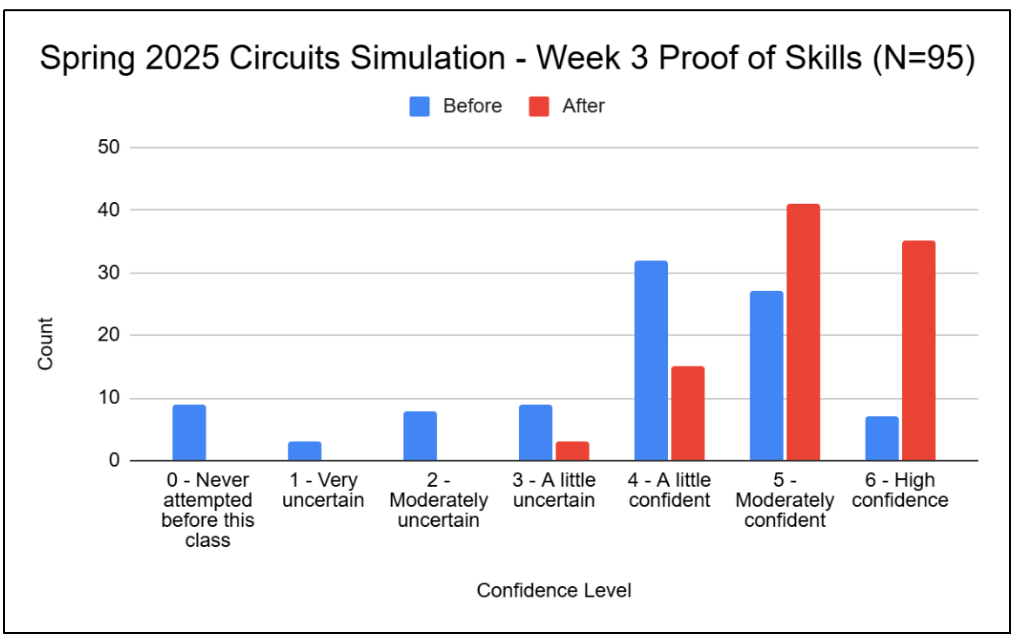


Figure 11: Circuit Simulation Skillset Before and After Proof of Skills in Spring 2025 Electric Circuits (N=95)

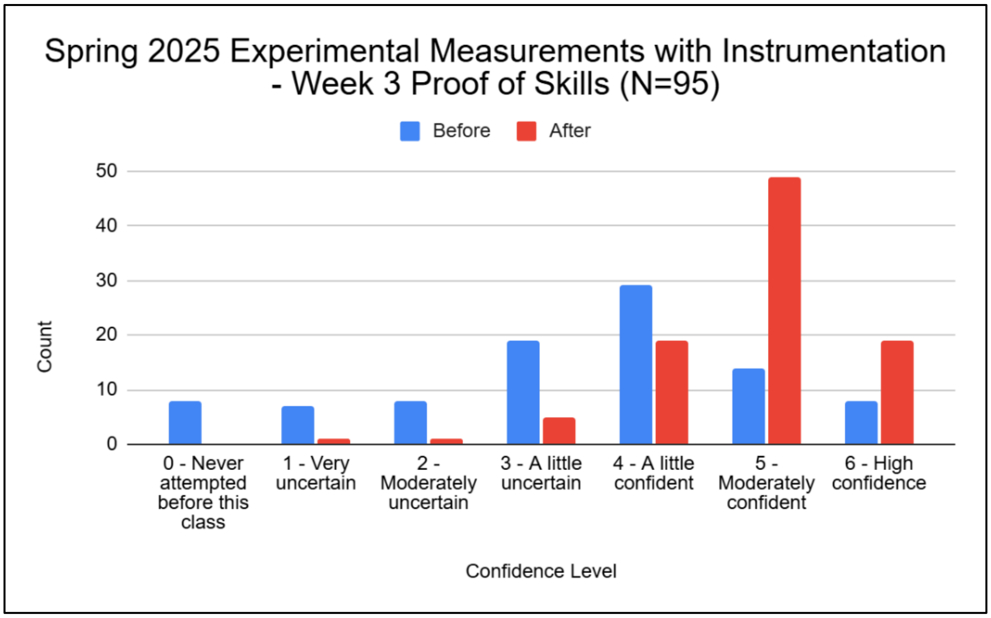


Figure 12: Experimental Measurements with Instrumentation Before and After Proof of Skills in Spring 2025 Electric Circuits (N=95)

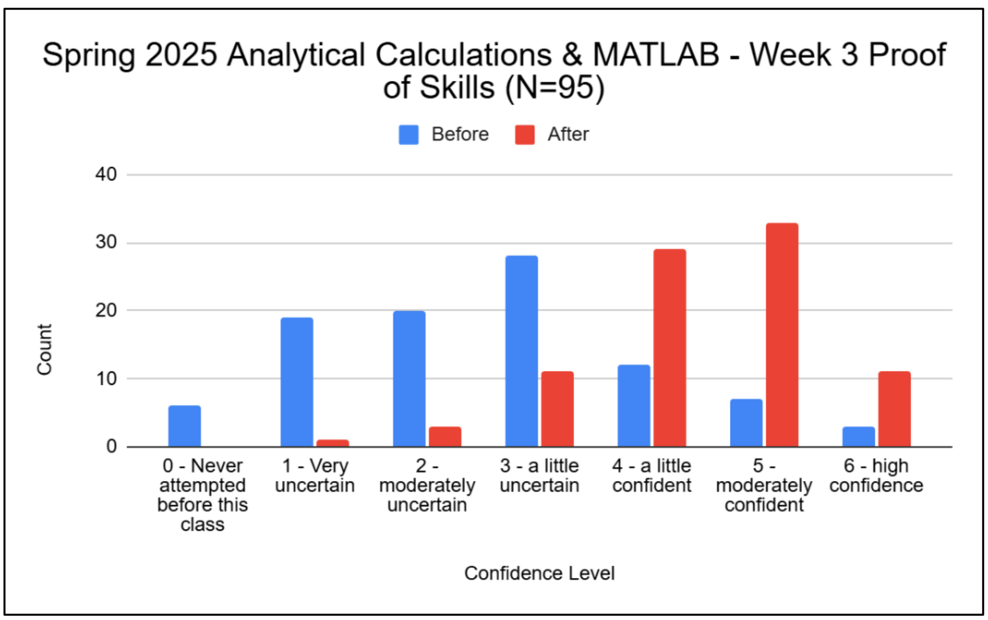


Figure 13: Analytical Calculations & MATLAB Before and After Proof of Skills in Spring 2025 Electric Circuits (N=95)

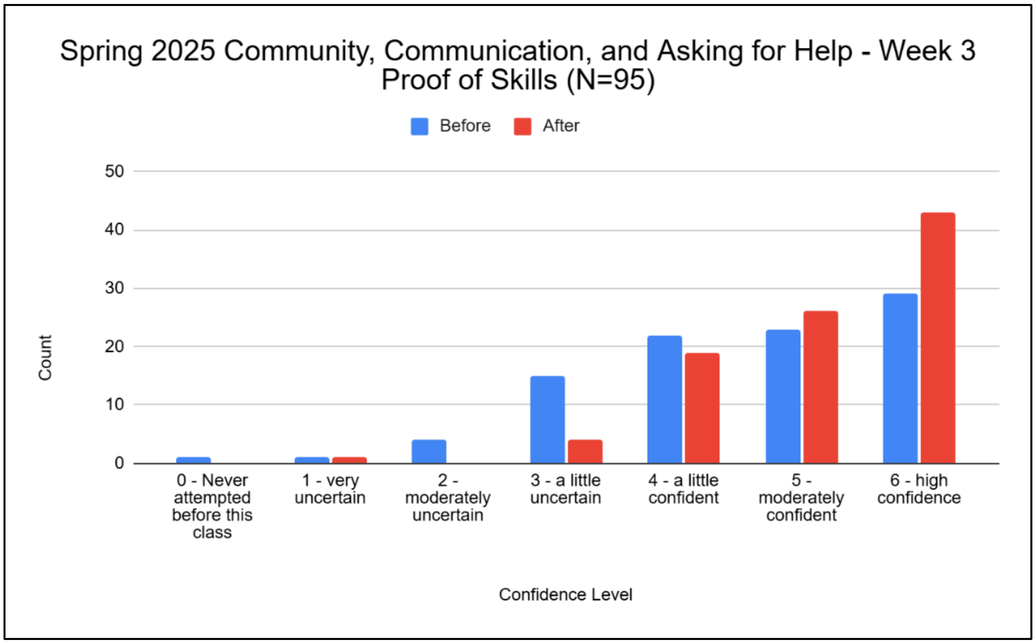


Figure 14: Community, Communication, and Asking for Help (of Teaching Assistants, Student Assistants, Each Other, and Professor) Before and After Proof of Skills in Spring 2025 Electric Circuits (N=95)

By the end of the semester the following total Proof of Skill scores were recorded for Computer Systems Engineering and Electrical Engineering students for Electric Circuits in Spring 2025. These scores represented ABET 3.7 assessment student outcome "… an ability to acquire and apply new knowledge as needed, using appropriate learning strategies." Students demonstrated similar proficiency to Spring 2023.

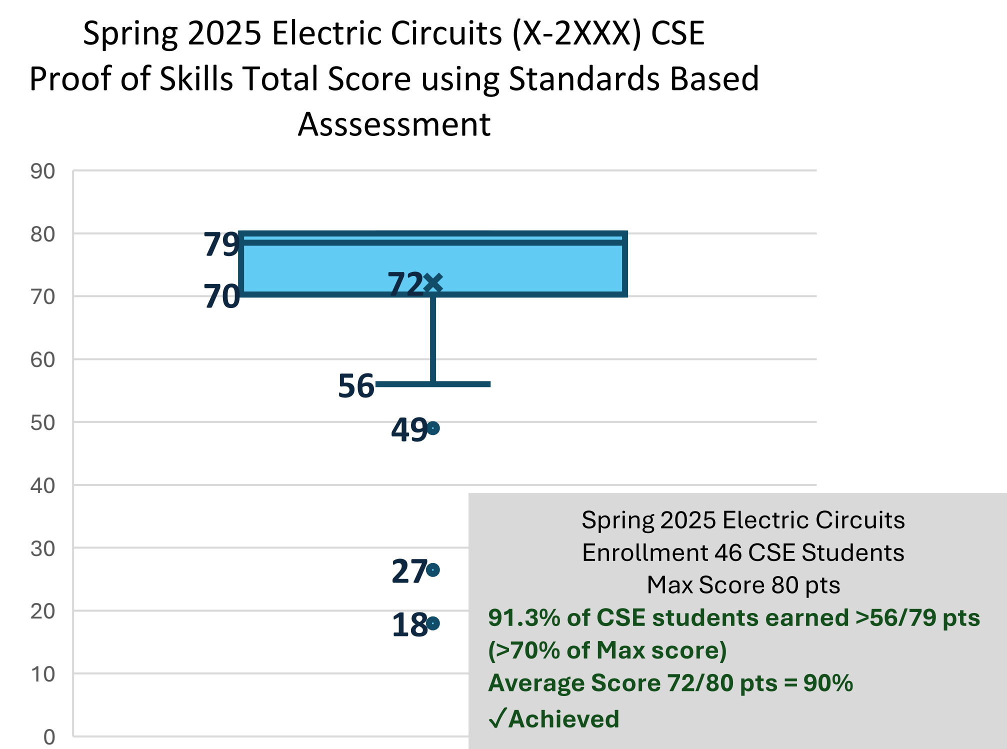


Figure 15: Spring 2025 Electric Circuits Computer Systems Engineering Proof of Skills scores over the entire semester.

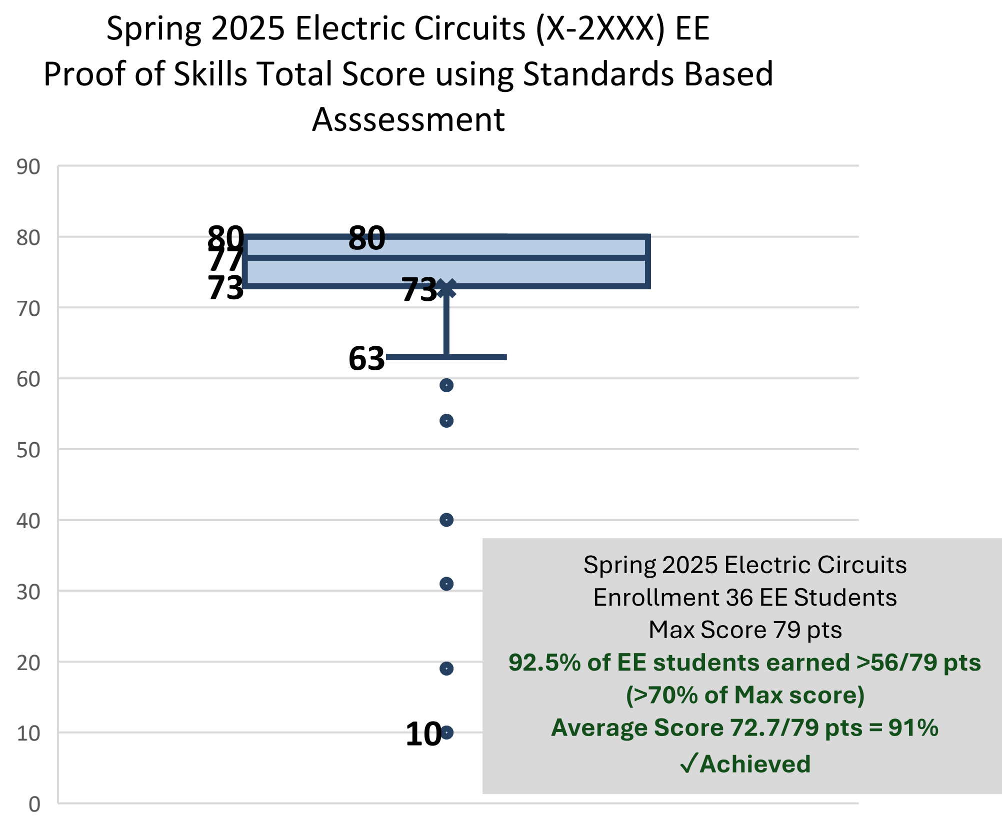


Figure 16: Spring 2025 Electric Circuits Electrical Engineering Proof of Skills scores over the entire semester.

Student Agency and Confidence: Choosing Between Alpha (Traditional) Labs and Omega (Design) Labs

In Spring 2023, the choice to participate in Omega (Design) Labs increased significantly to 81.9% from 51.6% before the creation of Proof of Skills in Spring 2022. By Spring 2025, participating in Omega (Design) Labs increased again to 87.4%. Thus, the Extended Experiment Hypothesis 2 is true. Proof of Skills increases competency and confidence before labs begin and influences their lab choice. Evaluating Proof of Skills using SBA did increase the percentage of students willing to take creative risks reflected by the percentage of students choosing open-ended Omega (Design) labs over the Alpha (Traditional) Labs.

Motivations – Choosing Omega (Design) Labs or Alpha (Traditional) Labs (N=472)

In the same Proof of Skills Confidence Survey, students are asked to disclose their top three reasons for choosing their lab type. "What influenced your decision for Omega Lab? Choose, at most, your top three. (Please mark "I did not choose Omega Labs" if you ***do not*** intend to do at least one Omega Lab)" and "What influenced your decision for Alpha Lab? Choose, at most, your top three. (Please mark "I did not choose Alpha Labs" if you ***do not*** intend to do at least one Alpha Lab)." The survey answers were not easily disaggregated by semester thus the data reflects a larger sample size from 2023-2025 semesters (N=472). All students were provided with the same choices shown below and were required to pick a maximum of three from the following list:

- I am highly motivated by my perceived challenge/risk level of this lab
- I don't like risks I want to know EXACTLY every step to learn
- I'm a top-down thinker...big picture first, small details after
- I'm a bottom-up thinker...small details first, big picture after
- Highly influenced by my lab partner(s) (I wanted to do one, but they wanted to do the other)
- I am not confident in my basic skills yet
- I am confident in my basic skills
- My overall course load this semester
- I believe the final exam is the best way to demonstrate my mastery of knowledge in this course
- Getting out of the final since I do not believe it is the best way to demonstrate mastery of knowledge in this course
- I heard about my lab choice as the BEST choice for me from other students who took the class before
- I want to build my resume/portfolio for future employers (deep experience)
- I believe this lab will be better for my GPA (grade driven)

Top 4 reasons for Omega (Design) Lab (N=472 across multiple semesters)

1. I want to build my resume/portfolio for future employers (deep experience) (48.7%)
2. Getting out of the final since I don't believe it the best way to demonstrate my mastery of this course (48.3%)
3. I am initiative-taking by my perceived challenge/risk level of this lab (31.8%)
4. **I am confident in my basic skillset (28%)**

   ***The choice "I am not confident in my basic skills yet" was second to last at 11th place (2.1%). Only outperforming "I don't like to take risks…" by 0.3% (1.7%) for Omega Labs.**

Omega Lab choices reflect an ambitious metacognitive position with an emphasis on future employment, alternative mastery demonstration, challenge/risk acceptance, and skill confidence.

Top 4 reasons for Alpha Lab choice (N=472 across multiple semesters)

1. My overall course load this semester (33%)
2. I don't like risks; I want to know EXACTLY every step to learn (21.4%)
3. I believe this lab will be better for my GPA (grade driven)
4. **I am not confident in my basic skills yet (14.2%)**

   ***The choice "I am confident in my basic skillset" (9.3%) is 6th for Alpha Labs.**

Alpha Lab choices reflect a cautious metacognitive position with an emphasis on courseload during the semester, resistance to risk, GPA improvement, and recognition of a need to improve skills.

Conclusions

1. Proof of Skills using Standards-Based Assessment as the only assessment in Design Studio A, a multi-disciplinary design course, was not tightly defined enough for students to feel accomplishment and success. Proof of Skills in this course was not directly aligned to any future course in a student's discipline**. Students had little corroborating evidence of their learning in other assessments and were unmotivated to establish their design skillsets. The *Pilot Study Hypothesis 1 was an abject failure in Design Studio A (X-4XXX). Standards-Based Assessment did not provide a consistent and subjective framework for open ended design in a capstone-like course for seniors across disciplines.***
2. Proof of Skills using Standards-Based Assessment in an introductory fundamental course, Electric Circuits (ECSE-2010), was tightly defined. Proof of Skills was directly aligned to laboratory skills and those in future courses within the discipline. Students reflected accomplishment and success as their proficiency was translated and reflected in other assignments given in the course. **The *Pilot Study Hypothesis 1 was true reflecting success in the use of Proof of Skills with Standards-Based Assessment. It provided a consistent and subjective framework for Design Practice in the context of learning fundamental skills to effectively translate to learning course concepts. Recommendations of deadlines, implementing essential skills before labs began, and clear, concise language was implemented after the Summer 2022 Pilot Study.***
3. As a result of Proof of Skills, the Omega (Design) lab participation increased from 51.9% before Proof of Skills was created to over 81.9% in Spring 2023. Participation increased to 87.4% in Spring 2025. **The *Extended Experiment Hypothesis 2 is true. Proof of Skills increases competency and confidence before labs begin and influences their lab choice. Evaluating Proof of Skills using SBA did increase the percentage of students willing to take creative risks reflected by the percentage of students choosing open-ended Omega (Design) labs over the Alpha (Traditional) Labs.***
4. The survey responses regarding lab choice motivations reflect a stark metacognitive difference in the reasons for choosing Omega and Alpha Labs. Omega Lab choices reflect an ambitious metacognitive position with an emphasis on future employment, alternative mastery demonstration, challenge/risk acceptance, and skill confidence. Alpha Lab choices reflect a cautious metacognitive position with an emphasis on courseload during the semester, resistance to risk, GPA improvement, and recognition of a need to improve skills.

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