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Infrastructure Live! A Hands-On Electric Power Classroom Experience Requiring a Single Rolling Chalkboard

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Abstract

The teaching of broad-based infrastructure engineering courses in civil engineering has grown considerably over the last decade. Typically, survey-type courses covering a wide variety of infrastructure topics allow enduring themes to guide specific content. In the case of one infrastructure engineering course, the enduring themes have been energy, water, and transportation. For many students, water's basic properties are well-understood; direct observation and physical interaction with water concepts like pressure and flow rate result in an innate understanding upon which deeper knowledge can be built. Conversely, the properties of energy, especially electric power, tend to pose special challenges. Although students' lives are inextricably dependent upon electricity, daily experiences generally do not provide for direct, physical, or visual observation of the fundamental concepts or underlying physics of electricity – unless something has gone wrong. Consequently, educators have a bigger hurdle when building on existing knowledge of energy and electricity in the classroom. To address this challenge, the authors leveraged multiple tenants of the Excellence in Civil Engineering Education (ExCEEd) model of pedagogical theory to develop a hands-on demonstrator for the direct observation of a typical household electrical system using a single chalkboard on wheels. This demonstrator allows for the study of a wide variety of electric power concepts, including the difference between energy and power, alternating current and voltage, the function of key safety features and their limitations (circuit breaker operation, ground-fault and arc-fault circuit interrupters, polarized plugs, and grounding), balancing loads, code requirements and the reasons behind them, and more. In service for over a decade, this simple, single demonstrator has helped educate over 2,300 students. This paper is a follow up to a previously published work-in-progress where the authors presented the pedagogy of using the demonstrator -- to include learning objectives, classroom activities, and a model script for a 50-minute experience -- a parts list and instructions for constructing the demonstrator, and a research plan for investigating the demonstrator's impact on student learning. In this paper, the authors present their findings from both instructor feedback and anonymous student responses in an assessment of the demonstrator's effectiveness as a teaching tool.

Introduction

This paper completes a work in progress that was presented at the American Society of Engineering Education (ASEE) National Conference in Baltimore, MD in June 2023 [1]. The focus of that work was to establish the background, development, methodology, and assessment methods for the Power Demonstrator Board used in an Infrastructure Engineering course.

Civil engineers design, manage, and implement the large civil works projects that society requires to function. These civil works projects require trained professionals to ensure the public investment in all aspects of infrastructure is appropriate and safe. Unfortunately, civil engineers are not traditionally well-trained in the electrical power infrastructure, which is a cause for concern. Understanding this need for civil engineers to have a broad base of understanding of infrastructure systems, civil engineering faculty developed as a course to provide students with conceptual models and frameworks to help understand stakeholder analysis, water and wastewater, transportation, and energy and electrical systems [2]. An argument can be made that any student receiving a liberal arts education should have a broad base of topics to help them become well-informed decision makers, especially dealing with infrastructure investment [3]. Due to the increasing complexity of electrical power systems and society's growing reliance on resilient energy infrastructure, civil engineering students need to be educated on how electrical infrastructure functions and is developed. The National Academy of Engineering notes that the solutions for the 21st Century must be "designed for sustainability, giving proper attention to environmental and energy-use considerations" [4]. This puts the onus on civil engineering educators to present the concepts of energy and electricity to civil engineering students in order to help prepare them to conquer the sustainability challenges society is facing by making informed energy-related infrastructure development decisions.

At the core of this paper is the desire to both quantitatively and qualitatively assess the effectiveness of a specific training aid, the "Power Demonstrator Board." It is proven that hands-on learning supported with physical models and demonstrations allows students to better conceptualize, understand, and retain the material presented in the classroom [5]. The Power Demonstrator Board was developed to safely illustrate working electrical components, wiring schemes, and protection devices typically found in residential settings. This teaching aid helps build the foundational building blocks with familiar systems to scale up the knowledge and theory behind larger and more complex systems that serve society. An additional benefit of student learning is an ability to troubleshoot issues and ensure their own residences are safe based on the basic knowledge presented on this simple classroom training aid.

Background and Implementation

Infrastructure Engineering, as it is designed to be taught at the United States Military Academy, focuses on three critical aspects infrastructure and infrastructure systems: water and wastewater systems, energy and electricity systems, and transportation systems. Of these topics, the most challenging to teach to the student population is energy and electricity as it is the most "invisible" and unfamiliar. As such, the ability for an instructor to demonstrate the basic concepts and show the students the topic in action is valuable. The ability for our future managers of civil works and infrastructure investment to grasp energy and electricity concepts is vital. Our world is electrifying, increasing the demand for electrical power generation. To meet this demand sustainably, carbon emissions must be managed, and renewable and/or clean sources of energy must be developed for all energy end uses [6]. Our homes, vehicles, workplaces, and everywhere in between are becoming electrified; thus, civil engineers must understand the basics of electrical generation, distribution, storage, and use to ensure our designs in civil engineering keep pace with rapidly developing technologies.

In the Infrastructure Engineering course, over a quarter of the lessons are focused on energy and electricity. The progression of lessons starts at the energy sources themselves and how energy density of fuels is vital to understanding electricity generation and eventual end use. Electricity generation and transmission across the landscape are supported by the basics of current, voltage, resistance, circuitry, losses, and efficiency. All these topics contribute to the foundational principles that enable students to understand the theory behind the Power Demonstrator Board. At the heart of the infrastructure investment process is the need for the investment to have a positive impact on the users of the development. The Power Demonstrator Board is a way to show how the user is interacting with electricity safely every single day.

In order to assess the effectiveness of the Power Demonstrator Board as a training aid, it is important to first understand the five learning objectives the board is meant to support in a single lesson. Students are expected to be able to do the following:

1. Sketch and explain the functioning of a standard light circuit, receptacle circuit, and circuit breaker panel.
2. Compare and contrast GFCIs (Ground-Fault Circuit Interrupter) and AFCIs (Arc-Fault Circuit Interrupter).
3. Explain how a circuit breaker works and what causes it to "trip."
4. Determine when and why a load is "balanced."
5. Estimate the design electrical load in a residence in terms of voltage, phases, current, and power.

These objectives are specifically focused to help the student understand the electricity user's interaction with the electrical infrastructure of their home and are nested into the broader concepts of the energy block of lessons, such as power generation, transmission, and distribution.

The Power Demonstrator Board and its Evolution

The Power Demonstrator Board has been in use in the Infrastructure Engineering classroom for over a decade, bringing the mystery of residential or commercial wiring to light though its simplicity. The beauty of the board is its simplicity and "transparency" to the students. The original board leverages the low technology of the (in)famous chalkboard to clearly show how a simple schematic can come to life and be more impactful than a complex simulation on a computer [7]. The idea hatched though a goal of unburdening the instructor. Instead of sketching a line-wire diagram on a chalkboard, why not just build the diagram directly onto the chalkboard? The idea snowballed and gained complexity until it replicated a small residence in function of the electrical wiring system. Figure 1 shows the chalkboard version of the power demonstrator board with wiring and several types of electrical receptacles and switches connected to a standard electrical panel.

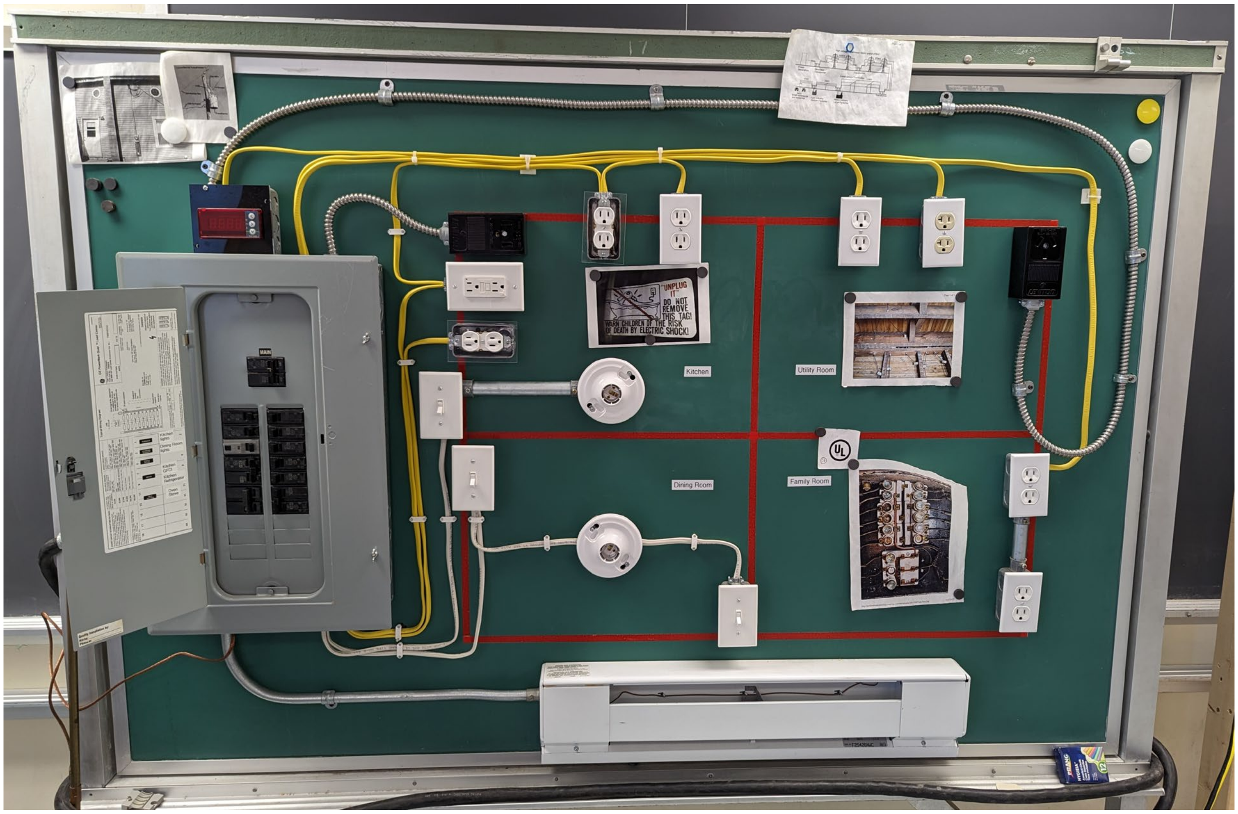

Figure 1: The chalkboard version of the power demonstrator board, 2023

After over a decade of use, an updated version of the Power Demonstrator Board was developed in 2023. The updated version was designed to more closely mimic household wiring in stud framed residences where wires pass though timber studs between the electrical panel and the switch/receptacle/appliance. The instructors envisioned being able to effectively "peel back the drywall of their homes" to show students what is happening within the walls. This falls in line with what Ken Bain discusses in his book, *What the Best College Teachers Do*, where he states that, "highly effective teachers design better learning experiences for their students in part because they conceive of teaching as fostering learning" [8]. The goal is to leverage something familiar within the classroom, like a home's energy system, in order to create a relatable experience that helps build upon course concepts. The new power demonstrator board is specifically designed to function in any classroom, office, or laboratory space, utilizing 120V single phase power instead of three-phase power as in the original version. This allows instructors more flexibility in where the lesson is presented, significantly increasing the number of classrooms where the demonstrator can be wheeled and used at a moment's notice. Neither power source is better than the other, but the flexibility of space requirements is a huge benefit to the single-phase power version. Figure 2 shows the chalkboard version of the Power Demonstrator Board side by side with the new stud framed Power Demonstrator Board. Figure 3 shows the stud framed version of the Power Demonstrator Board electrified with functional receptacles, lights, and electrical meters.

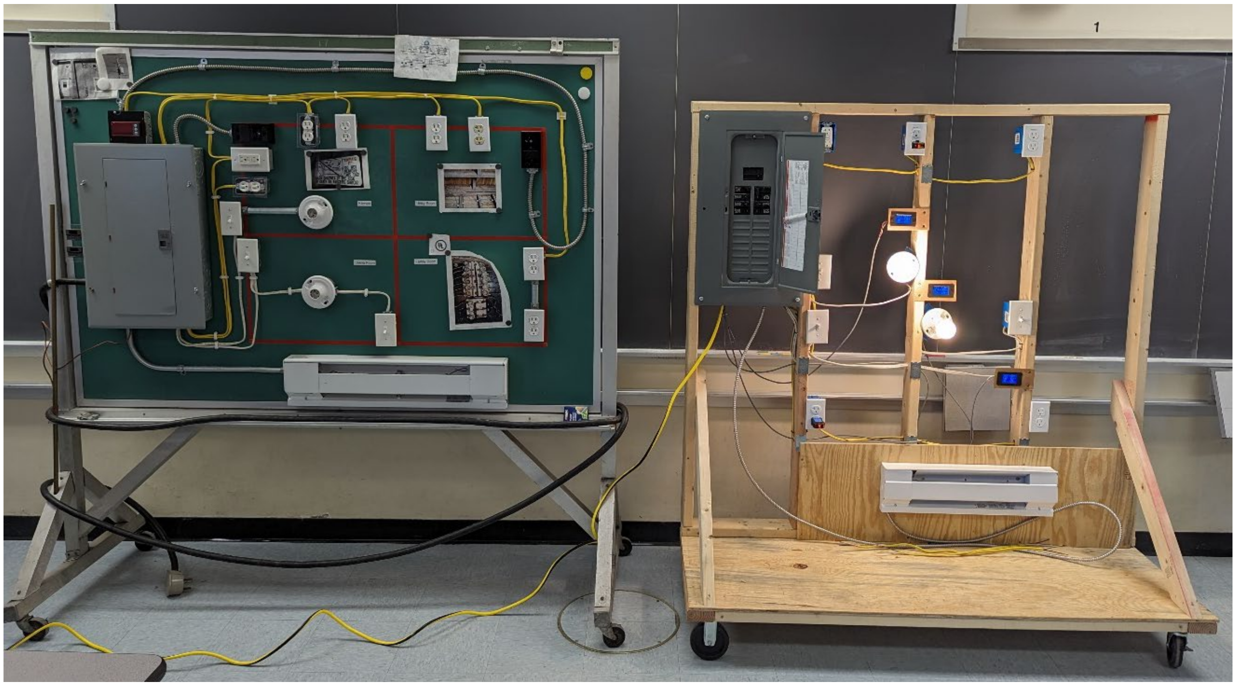

Figure 2: The chalkboard version and stud framed versions of the Power Demonstrator Boards side by side in the classroom. 2024

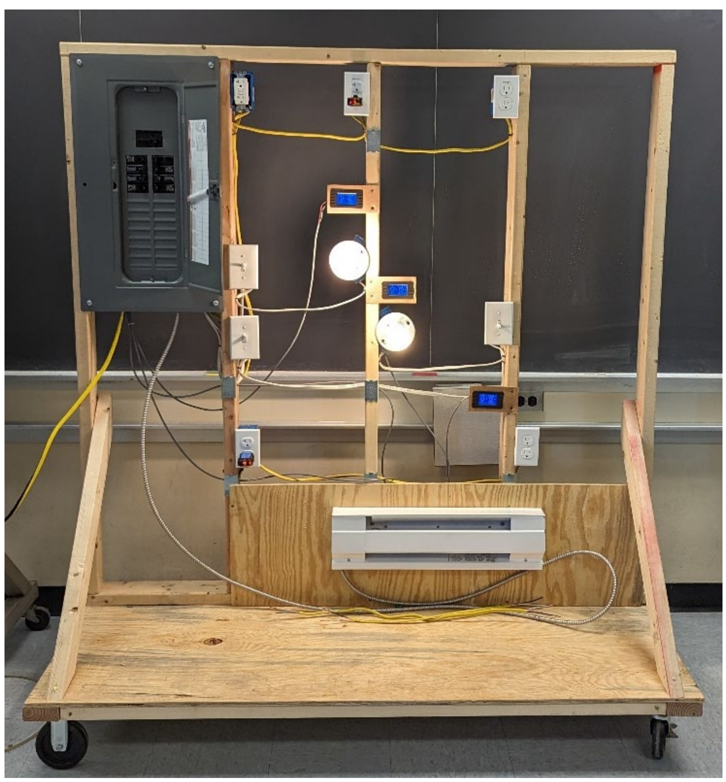

Figure 3: The stud framed version of the Power Demonstrator Board in the classroom with functioning power and electrical meters that measure voltage, current, energy, frequency, and power factor, 2024

Assessment Plan

Following the presentation of the "Work in Progress" of the Power Demonstrator Board at the 2023 ASEE National Conference in Baltimore, MD, the team gathered qualitative and quantitative data to determine the efficacy in aiding student learning to answer the ultimate question being presented within the "Work in Progress," -- is this a worthwhile educational tool [1]? To collect meaningful data, all students in the course were divided into two equal groups. Each student was required to complete a survey before and after the lesson with the Power Demonstrator Board to provide both quantitative and qualitative results. A more detailed explanation of the number and types of questions can be seen below in Figure 4, as well as the four complete student surveys found in Appendix 1.

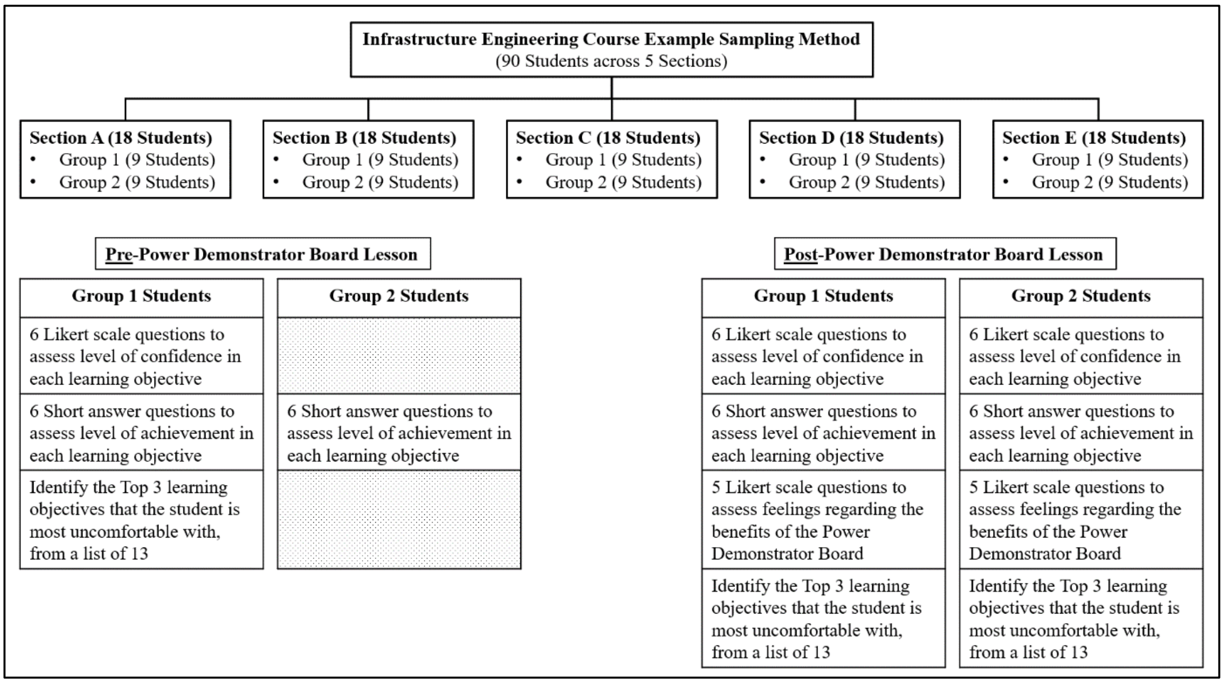

Figure 4: Assessment strategy during each sample semester of CE350: Infrastructure Engineering, dividing the entire course into two even groups to get a balance of responses both before and after the lesson.

Students in "Group 2" were presented with a shorter, qualitative-focused survey before the lesson. Unlike Group 1, Group 2's initial questions were only meant to gauge student knowledge of the material before the demonstrator lesson. In this way, Group 2 was used as a control group to prevent all students from seeing the qualitative questions and perhaps bias an increase in their confidence in the material after the lesson. Specifically, as shown in Figure 3, students in Group 2 did not answer questions about their confidence in a learning objective or identify their top three most challenging lesson objectives.

Results

The results of the student survey support the hypothesis that the power demonstrator board improves student learning. The results are broken down into two categories. The first category is assessed quantitatively with demonstrable ability to correctly answer technical material about topics covered by the power demonstrator board, which we call “achievement.” The second category is assessed by qualitative questions that measure student comfort with the topics, including student perception of their own understanding, which we call “confidence.”

Overall, a sample of 125 students showed a measured improvement of 49% in their ability to correctly answer “achievement” questions, and a 20% improvement in their “confidence” in the material following the lesson. Unsurprisingly, the results demonstrated that attending the lesson with the training aid improved the learning process and built student confidence in the lesson material and the course overall. Still, this is not enough to answer the research question posed. Attending a lesson *should* aid in the learning process, but how effective is the demonstrator?

In order to identify which students gained the most benefit both quantitatively and qualitatively, responses were broken down separately, by both cumulative GPA in their undergraduate education leading into the term they took CE350 as well as by their final grade in the course. For reference, there is a diverse student population in the course, typically comprised of at least 20 different academic majors across all sections. Generally, just over 50% of the students are STEM (Science, Technology, Engineering & Mathematics) majors and the remainder are humanities and social science majors.

The quantitative data shows that improvement in the “achievement” questions is most noticeable within the extremes of both student overall GPA and course performance. Students with a high GPA (above 4.0 as this institution issues a 4.33 for an A+) and those between a 2.0 and 3.0 gained the most knowledge from the lesson and training aid. The students with a GPA above 4.0 demonstrated an improvement of 82%, whereas the students with a GPA between 2.0 and 2.33 improved their performance by 52%, and the students between 2.66 and 3.0 improved by 57%. A similar pattern is observed when analyzing the data in light of the course grade. Students who earned an A+, C+, or C had the largest gains in achievement with increases of 81%, 125%, and 400% respectively. It should be noted that the student population with GPAs between 3.33 and 4.0 had a smaller improvement based on their higher initial performance on “achievement” questions. However, the performance is still substandard by scoring an average of less than 60% of total points possible before attending the lesson. The same population improved enough to receive satisfactory performance if it was a graded assessment, but the results are not wildly higher quantitatively than the initial lower performing groups. While it is difficult to discern student intent or motivations from the data, a possible explanation may be that high-performing students recognize the instructor emphasis reflected in the unique demonstration, and will engage closely, rising to the academic challenge posed to them. The lowest achievers have the largest gap in knowledge, so increased contact time with the material combined with presenting knowledge in a more digestible and physical manner, i.e., incorporating new learning modes, helps those students make measurable improvements. The full data table for the analysis of the “achievement” questions can be found in Table 1 for overall GPA and Table 2 for course grade.

Table 1: "Achievement" question analysis based on student cumulative GPA. The maximum score possible on these questions was 10.

Student Total GPA	Sample Size	"Achievement" Questions			
		Pre-Lesson	Post-Lesson	Change	% Change
Above 4.0	6	4.167	7.600	3.433	82.4%
3.66 - 4.0	22	5.650	8.286	2.636	46.6%
3.33-3.66	22	5.364	7.875	2.511	46.8%
3.0-3.33	25	4.762	6.941	2.179	45.8%
2.66-3.0	30	4.208	6.615	2.407	57.2%
2.33-2.66	12	4.583	5.333	0.750	16.4%
2.0-2.33	8	4.429	6.750	2.321	52.4%
Total Sample	**125**	**4.848**	**7.250**	**2.402**	**49.5%**

Table 2: "Achievement" question analysis based on student course grade. The maximum score possible on these questions was 10.

Student Course Grade	Sample Size	"Achievement" Questions			
		Pre-Lesson	Post-Lesson	Change	% Change
A+	12	4.455	8.100	3.645	81.8%
A	25	5.217	7.533	2.316	44.4%
A-	30	4.964	7.429	2.464	49.6%
B+	16	5.400	6.286	0.886	16.4%
B	18	4.571	6.875	2.304	50.4%
B-	14	4.300	6.000	1.700	39.5%
C+	8	4.000	9.000	5.000	125.0%
C	2	2.000	10.000	8.000	400.0%
Total Sample	**125**	**4.848**	**7.250**	**2.402**	**49.5%**

"Achievement" and the ability to answer questions is not the only recipe for success academically; ideally, students should be confident in the application of the knowledge to truly be successful. Without confidence, there is likely additional stress on individual assessments, or they are unlikely to collaborate and share ideas with peers or apply the knowledge after graduation. Thankfully, the data show there is a measured improvement of 20% in student "confidence" with the material. However, the population that gained the highest boost in "confidence" was not the extremes in terms of GPA and course grade, but instead students closer to the median. In terms of student GPA, students with a GPA between 3.0 and 4.0 saw the largest increase in confidence following interaction with the power demonstrator board. Similarly, students who earned a B or B+ in the course had the largest change in confidence; 27% and 25% respectively. This growth and comfort with the course material is valuable to the student, enabling more direct engagement of the material in group discussions or projects, lowering stress, increasing achievement on individual graded events (exams), and perhaps providing additional time to students in problem sets and exams as they confidently answer questions and move on to the next task. The full data table and analysis for the "confidence" questions can be found in Table 3 for overall GPA and Table 4 for course grade.

Table 3: "Confidence" question analysis based on student cumulative GPA. The maximum score possible on these questions was 30.

Student Total GPA	Sample Size	"Confidence" Questions			
		Pre-Lesson	Post-Lesson	Change	% Change
Above 4.0	6	13.333	13.800	0.467	3.5%
3.66 - 4.0	22	13.571	17.375	3.804	28.0%
3.33-3.66	22	16.000	21.250	5.250	32.8%
3.0-3.33	25	13.450	17.118	3.668	27.3%
2.66-3.0	30	15.857	18.600	2.743	17.3%
2.33-2.66	12	17.444	19.000	1.556	8.9%
2.0-2.33	8	13.750	17.400	3.650	26.5%
Total Sample	**125**	**14.833**	**17.887**	**3.054**	**20.6%**

Table 4: "Confidence" question analysis based on student course grade. The maximum score possible on these questions was 30.

Student Course Grade	Sample Size	"Confidence" Questions			
		Pre-Lesson	Post-Lesson	Change	% Change
A+	12	14.375	17.300	2.925	20.3%
A	25	15.111	18.813	3.701	24.5%
A-	30	15.526	18.412	2.885	18.6%
B+	16	13.364	16.750	3.386	25.3%
B	18	13.556	17.222	3.667	27.0%
B-	14	15.000	16.667	1.667	11.1%
C+	8	17.000	21.000	4.000	23.5%
C	2	**N/A**	16.000		
Total Sample	**125**	**14.833**	**17.887**	**3.054**	**20.6%**

Overall, the student population demonstrated a positive shift in their comfort with the learning objectives. Figure 5 illustrates the positive trend of the student responses to the six Likert-scale "confidence" questions posed in before and after surveys. Perhaps most significantly, and hearteningly, the instances of students having no confidence at all virtually disappeared and the population who had high confidence in the material at least doubled in four out of the six topics.

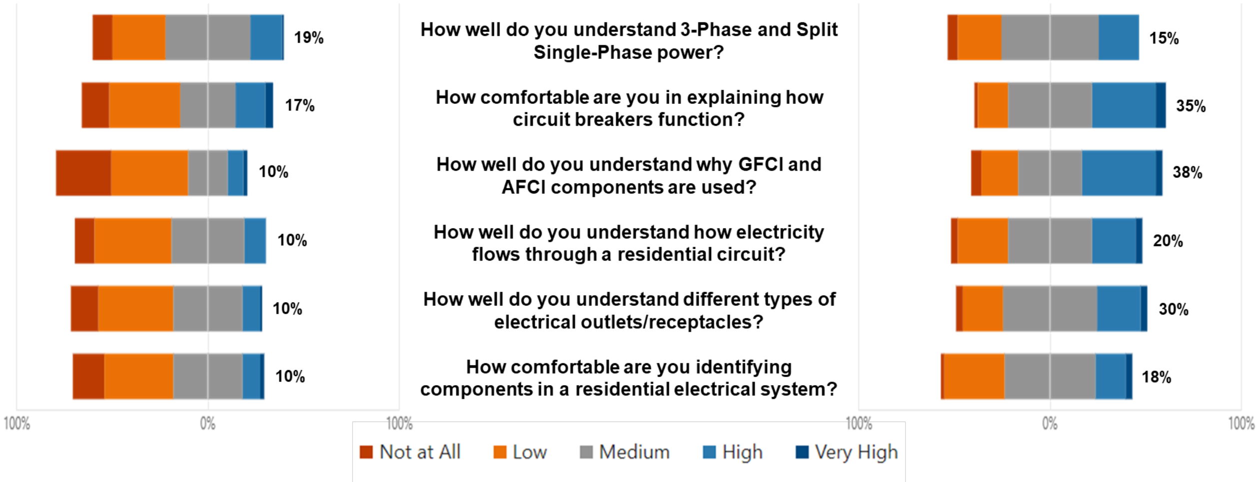

Figure 5: Student responses to the six Likert scale questions regarding their "confidence" in each lesson objective. The left chart is the survey from before the lesson, the right chart is the survey from after the lesson. The percentages to the right of the bars represent the percentage of students that responded "High" or "Very High".

Lastly, the instructors wanted to determine which lesson objectives within the block were gaining the most benefit from this training aid. The survey aims to combine the outcomes of the "Achievement" questions with the direct question to pinpoint the learning objectives that students found most challenging, in both the before and after lesson surveys. The responses to the achievement questions showed that students could effectively describe how a circuit breaker trips and a GFCI trips as well as how a load is balanced in a residential setting. These objectives had the most significant increases in achievement when comparing before to after the lesson by nearly 30% or more each. The next closest learning objective (how a standard circuit functions) improvement in achievement was just above a 15% increase. Full results for the entire study population are shown in Figure 6 relating how effective the lesson and training aid are to understanding of the content. Before the lesson, the objective that students identified in the survey as the least familiar the most was to "compare and contrast GFCIs and AFCIs," and after the lesson it was the second most familiar identified objective. Given that the Power Demonstrator Board is configured to replicate a residential circuit, the training aid effectively fulfills its purpose. The learning objective, "explain the functioning of a standard circuit, receptacle, and circuit breaker panel," was identified as the fourth most common challenge before the lesson but became the third least identified after the lesson. This indicates that students were unfamiliar or uncomfortable understanding how the residential circuit operated in a residential setting before the lesson. However, after the lesson, the students felt more confident in explaining the functioning of residential wiring and circuit breakers.

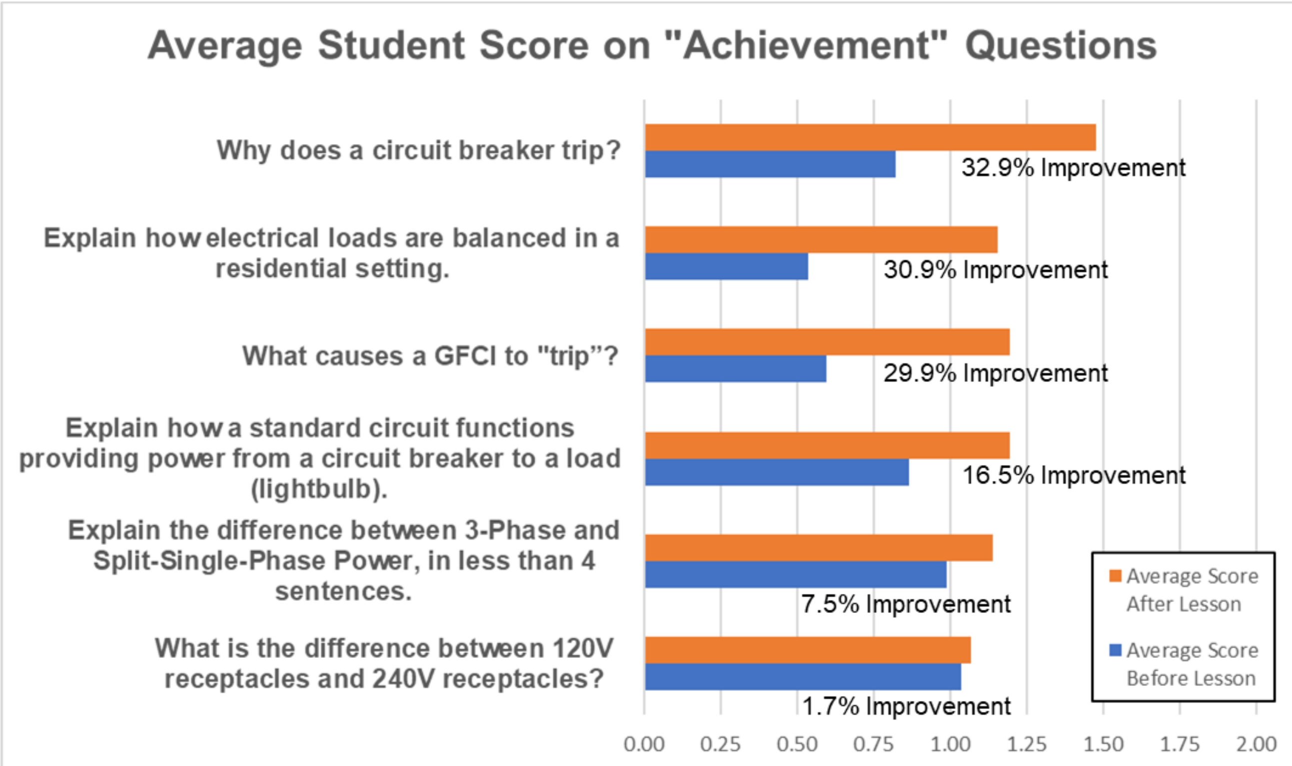

Figure 6: Average student score on "Achievement" questions compares both before and after the lesson. The lesson objectives are organized by change in average score for each objective.

Conclusion

It is clear from the data and results that the lesson, and the power demonstrator board as the focus and centerpiece of the lesson, improve student learning and understanding of the material. Interestingly, the degree to which students benefit is not uniform across the student population. Students on the extremes of the distribution for cumulative GPA and course grade benefit the most in the realm of "achievement" by demonstrating technical responses. Students that were near the mean of the student population with respect to cumulative GPA and course grade were observed to gain the most benefit with respect to "confidence" with the course material, and potentially gained second and third order benefits. This training aid that has been developed and improved over the years is quantitatively improving the learning experience for students in CE350. This study has proved the value of such a demonstration aid in the classroom and reinforces the use of the Excellence in Civil Engineering Education (ExCEEd) teaching model and hands on demonstrations.

The ability to understand the power demonstrator board and how it applies to everyday life may prove to be invaluable in the future. The students have a respect for and baseline knowledge of how their homes are wired for electricity. When a fault occurs or when a circuit breaker trips, they can understand why it happened and how to remedy the situation. This will keep them and those they live with potentially safer and unlikely to make a dangerous repair to an annoying problem they may encounter. Further, understanding household power provides them with an understanding of one of the key systems, repeated worldwide, that drives electrical power use. Arguably, to address sustainability, economic growth, and social stability, the triple bottom line of sustainability, household power use will be a key consideration, and a deeper understanding of the most fundamental building block of one of the world's most ubiquitous systems lays a strong foundation for engaging and addressing this elemental concern.

Future Work

The energy and electricity block is challenging for the students in CE350, and we have identified and constructed a working and effective tool to teach and demonstrate several learning objectives. However, there are still other objectives that need more effective demonstrations. This study identified the following three topics for future development and study when developing new training aids:

- Estimate the design load in a residence in terms of voltage, phases, current, and power.
- Determine appropriate use of different distribution configurations (i.e., delta versus wye).
- Summarize the key steps in transmitting power from a generating station to the distribution network.

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Disclaimer

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Appendix 1 – Power Demonstrator Board Survey for Students

Survey 1: Student Group 1 Survey, Before Lesson

CE350 Infrastructure Engineering

Power Lab Student Survey **Before Lesson Questionnaire – Group 1**

Name: ______________________________

Who is your Instructor and Section? ______________________________

Do you consent to your survey responses being used for research into the effectiveness of teaching techniques and training aids throughout CE350? ☐ YES ☐ NO

Explain the difference between 3-Phase and Split-Single-Phase Power, in less than 4 sentences.

Why does a circuit breaker trip?

What causes a GFCI to "trip"?

What is the difference between 120V receptacles and 240V receptacles?

Explain how a standard circuit functions providing power from a circuit breaker to a load (lightbulb).

Explain how electrical loads are balanced in a residential setting.

Select your comfort level and/or understanding of the following concepts or questions.

	Not at All	Low	Medium	High	Very High
How well do you understand 3-Phase and Split-Single-Phase Power?	☐	☐	☐	☐	☐
How comfortable are you in explaining how circuit breakers function?	☐	☐	☐	☐	☐
How well do you understand why GFCI and AFCI components are used?	☐	☐	☐	☐	☐
How well do you understand how electricity flows through a residential circuit?	☐	☐	☐	☐	☐
How well do you understand different types of electrical outlets/receptacles?	☐	☐	☐	☐	☐
How comfortable are you identifying components in a residential electrical system?	☐	☐	☐	☐	☐

Which three (3) lesson objectives are you most uncomfortable with at this moment?

☐ Explain the energy sector of infrastructure using the Component Model.

☐ Explain voltage, current, power and energy.

☐ Describe alternating and direct current voltage and current.

☐ Identify the major components of the electrical energy system using the Component Model.

☐ Describe resistive, inductive, and capacitive circuit elements and the phase angle associated with each

☐ Describe the key components of a generator and how three-phase AC power is produced.

☐ Summarize the key steps in transmitting power from a generating station to the distribution network.

☐ Identify and explain common single- and three-phase distribution configurations.

☐ Distinguish when to use different distribution configurations.

☐ Explain the functioning of a standard light circuit, receptacle circuit and circuit breaker panel.

☐ Compare and contrast ground fault circuit interrupters (GFCIs) and arc fault circuit interrupt (AFCIs).

☐ Explain how a circuit breaker works and what causes it to “trip.”

☐ Estimate the design electrical load in a residence in terms of voltage, phases, current, and power.

Survey 2: Student Group 2 Survey, Before Lesson

CE350 Infrastructure Engineering

Power Lab Student Survey **Before Lesson Questionnaire – Group 2**

Name: ___________________________________

Who is your Instructor and Section? ________________________________

Do you consent to your survey responses being used for research into the effectiveness of teaching techniques and training aids throughout CE350? ☐ YES ☐ NO

Explain the difference between 3-Phase and Split-Single-Phase Power, in less than 4 sentences.

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Why does a circuit breaker trip?

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What causes a GFCI to "trip"?

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What is the difference between 120V receptacles and 240V receptacles?

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Explain how a standard circuit functions providing power from a circuit breaker to a load (lightbulb).

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Explain how electrical loads are balanced in a residential setting.

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Survey 3: Student Group 1 & 2 Survey, After Lesson

CE350 Infrastructure Engineering

Power Lab Student Survey **After Lesson Questionnaire**

Name: ______________________________

Who is your Instructor and Section? ______________________________

Do you consent to your survey responses being used for research into the effectiveness of teaching techniques and training aids throughout CE350? ☐ YES ☐ NO

Explain the difference between 3-Phase and Split-Single-Phase Power, in less than 4 sentences.

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Why does a circuit breaker trip?

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What causes a GFCI to "trip"?

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What is the difference between 120V receptacles and 240V receptacles?

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Explain how a standard circuit functions providing power from a circuit breaker to a load (lightbulb).

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Explain how electrical loads are balanced in a residential setting.

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Select your comfort level and/or understanding of the following concepts or questions.

	Not at All	Low	Medium	High	Very High
How well do you understand 3-Phase and Split-Single-Phase Power?	☐	☐	☐	☐	☐
How comfortable are you in explaining how circuit breakers function?	☐	☐	☐	☐	☐
How well do you understand why GFCI and AFCI components are used?	☐	☐	☐	☐	☐
How well do you understand how electricity flows through a residential circuit?	☐	☐	☐	☐	☐
How well do you understand different types of electrical outlets/receptacles?	☐	☐	☐	☐	☐
How comfortable are you identifying components in a residential electrical system?	☐	☐	☐	☐	☐

Respond to the following prompts with how much you agree or disagree.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The progression of the energy block lessons and material was beneficial to my learning. (Classroom, Electrical Closet, Power Demonstrator Board)	☐	☐	☐	☐	☐
I feel more comfortable with electrical distribution and use after this lesson.	☐	☐	☐	☐	☐
The training aid (Power Demonstration Board) enhanced my understanding of the common electrical systems and components.	☐	☐	☐	☐	☐
I am more comfortable identifying issues in electrical systems that I may encounter in the future because of the training aid (Power Demonstration Board).	☐	☐	☐	☐	☐
The lesson supported the material we had learned in the classroom previously.	☐	☐	☐	☐	☐

Which three (3) lesson objectives are you most uncomfortable with at this moment?

☐ Explain the energy sector of infrastructure using the Component Model.

☐ Explain voltage, current, power and energy.

☐ Describe alternating and direct current voltage and current.

☐ Identify the major components of the electrical energy system using the Component Model.

☐ Describe resistive, inductive, and capacitive circuit elements and the phase angle associated with each

☐ Describe the key components of a generator and how three-phase AC power is produced.

☐ Summarize the key steps in transmitting power from a generating station to the distribution network.

☐ Identify and explain common single- and three-phase distribution configurations.

☐ Distinguish when to use different distribution configurations.

☐ Explain the functioning of a standard light circuit, receptacle circuit and circuit breaker panel.

☐ Compare and contrast ground fault circuit interrupters (GFCIs) and arc fault circuit interrupt (AFCIs).

☐ Explain how a circuit breaker works and what causes it to "trip."

☐ Estimate the design electrical load in a residence in terms of voltage, phases, current, and power.