Objectives

The goal of this project is to evaluate the applicability and efficacy of a collaborative learning environment for electrical engineering education, with a focus on high voltage engineering. The proposed project will rely on interdependent collaboration between Western Michigan University (WMU) and Mississippi State University (MSU) to assess student learning outcomes in high voltage engineering obtained via computer simulations (performed at WMU) and physical laboratory (located at MSU). The powerful synergy of simulation and experimentation not only maximizes the utilization of resources, but also expands the scope of knowledge and expertise within the field of high voltage and power engineering.

The objectives of this project are as follows:

1. Assessing the efficacy of the collaborative learning environment in achieving the following student learning outcomes defined by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (EAC-ABET) [1]:
   - Student Outcome (b): Ability to design and conduct experiments as well as analyze and interpret data.
   - Student Outcome (e): Ability to identify, formulate and solve engineering problems.

2. Comparing WMU and MSU student learning outcomes of high voltage engineering curriculum. WMU students will learn these concepts with a primary focus on simulation tools, while MSU students will learn them with a primary focus on the physical laboratory.

3. Generating a best practices guide for the application of the proposed collaborative learning environment in other engineering and technology disciplines.

The development of the proposed collaborative learning environment will rely on a collaboration with Dr. Joni Kluss, faculty member of the Paul B. Jacob High Voltage Laboratory at MSU, the largest university-operated high voltage laboratory in North America. This project will utilize data collected from students enrolled in ECE 5950 High Voltage Engineering at WMU, as well as 4673/6673 Fundamentals of High Voltage Engineering at MSU during Fall 2018 semester. Students will be divided into different groups utilizing and sharing resources available at their institute – mainly computer simulation assets and laboratory facilities. Scoring rubrics based on the ABET outcomes listed above will be used to assist in evaluating each simulation and/or lab report included in these courses.

2. Motivation and impact

STEM education needs are aimed at extending the reach of STEM fluency to all students regardless of their socioeconomic status or geographical location with a focus on developing knowledge and skills to solve complex problems, collect and evaluate evidence, and interpret information [2]. Such skills and knowledge are all core principles in electrical engineering education. However, availability of resources and facilities is often limited for all education targets but particularly for underrepresented groups. At the same time, industry is very often looking for graduates with laboratory experience and familiarity with specialized equipment and standardized procedures. By expanding the availability and access to laboratory resources, the quality, span, and effectiveness of electrical engineering education can be significantly improved.

All universities have specific areas of specialization and associated dedicated equipment for education and research in electrical engineering. It is unrealistic for a single organization to have all of the necessary equipment, facilities, and workforce to cover the entire span of this complex multidisciplinary field. The proposed project is designed to facilitate exploitation of educational resources and increase communication between user groups, thereby expanding the availability of previously restricted resources.

This project will test the proposed collaborative learning environment in the field of high voltage (HV) engineering, given its crucial role in electrical engineering. HV engineering is considered the backbone of all energy systems. Without proper electrical insulation research, development and design, energy systems cannot be operated in a reliable and economic manner. Comprehensive and effective HV engineering education requires exposure to HV laboratory paired with state-of-the-art simulation tools. However, availability of HV facilities for education is rare on a global scale. Numerous universities may offer degrees in electrical engineering but only a select few have facilities to support HV experimental activities. At the same time, there is an exponentially growing industry demand for engineering graduates with expertise in HV subjects given the trend to increase the voltage levels used in electric transmission systems. In addition,
the HV performance of a large variety of equipment from the electrical grid has to be thoroughly tested before installation to avoid premature deterioration or failure. A recent report prepared for the Department of Energy [3] acknowledges the condition of power infrastructure as one of the main priority issues currently faced by the electric power sector. Furthermore, another priority issue listed in this report is the aging skilled workforce in power and energy systems. According to [3] “the workforce that currently serves the (power) industry is shrinking and continues to mature”. Providing the next generation of electrical engineering graduates with comprehensive knowledge, training and skills in HV engineering using both laboratory and simulation tools is crucial to achieve efficient and robust performance of future electric grids.

3. Assessment methods

This project will assess the following student learning outcomes in high voltage engineering curriculum based on ABET [1]: outcome (b): ability to design and conduct experiments as well as analyze and interpret data, and outcome (e): ability to identify, formulate and solve engineering problems. The performance indicators to demonstrate student learning outcome (b) are:

- Knowledge of experimental approaches: Given the situation, identify as many experimental approaches as you can to obtain the necessary data to solve the problem. Briefly discuss each one and assume that you have no resource constraints.
- Knowledge of data collection methods: Given the situation, identify as many ways to obtain the needed data as possible. Discuss the pros and cons of each.
- Experience conducting experiments independently (not “canned” experiments): Describe your personal experience in actually designing and conducting an experiment, and then analyzing and interpreting the results.
- Ability to analyze and interpret data: Given the raw data, how would you reduce it to engineering units and how would you interpret the results based on the given graph of data. Include discussions about accuracy and uncertainty of the data.

The assessment methods for outcome (b) are: simulation for independent experiment, and lab report for independent experiment. A scoring rubric that will be used to assist in evaluating the simulation and/or lab report for each of the performance indicators is shown below:

<table>
<thead>
<tr>
<th></th>
<th>4- Exceeds</th>
<th>3- Meets</th>
<th>2- Progressing</th>
<th>1- Below</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Knowledge of</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>approaches</td>
<td>Given a hypothetical situation: Can cite several experimental approaches</td>
<td>Given a hypothetical situation: Can cite one experimental approach</td>
<td>Given a hypothetical situation: Can cite experimental approaches but none that satisfies the situation</td>
<td>Given a hypothetical situation: Cannot cite any experimental approaches</td>
</tr>
<tr>
<td><strong>Knowledge of</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>data collection</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>methods</td>
<td>For the given hypothetical situation: Can cite several ways of obtaining raw data necessary to satisfy the situation and can discuss the pros and cons of each</td>
<td>For the given hypothetical situation: Can cite at least two ways of obtaining raw data necessary to satisfy the situation but cannot discuss the pros and cons of each</td>
<td>For the given hypothetical situation: Can cite ways of obtaining raw data, but none that will work to satisfy the situation</td>
<td>For the given hypothetical situation: Cannot cite any ways of obtaining raw data necessary to satisfy the situation</td>
</tr>
<tr>
<td><strong>Experience</strong></td>
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<tr>
<td></td>
<td>Has practical experience designing, conducting experiments and analyzing and interpreting data independently</td>
<td>Has been part of a team that has practical experience designing, conducting experiments and analyzing and interpreting data</td>
<td>Has participated in experiments that were designed and set up by someone else, but were conducted by the student and where the student analyzed and interpreted results</td>
<td>Has never conducted an experiment nor analyzed or interpreted experimental results</td>
</tr>
</tbody>
</table>
### Ability to Analyze and Interpret Data

<table>
<thead>
<tr>
<th>Ability to Analyze and Interpret Data</th>
<th>Given a set of data; Can describe how to convert into engineering units, graph, determine trends, can discuss accuracy and uncertainty of the data</th>
<th>Given a set of data; Can describe how to convert into engineering units, graph, determine and discuss trends, but is unable to discuss accuracy or uncertainty</th>
<th>Can convert raw data to engineering units and graph, but cannot adequately discuss errors, uncertainty, or trending.</th>
<th>Cannot start the task of analyzing or interpreting data</th>
</tr>
</thead>
</table>

The performance indicators to demonstrate learning outcome (e) are:

- Can extract an engineering problem from multifaceted problem
- Can take an engineering problem and set up an approach to solve it
- Can solve an engineering problem appropriate for the bachelor-of-science level

The assessment methods for outcome (e) are: simulation, student work in exam question, and student work in homework assignment problem. A scoring rubric that will be used to assist in evaluating the simulation, exam question, and/or homework assignment problem for each of the performance indicators is shown below:

<table>
<thead>
<tr>
<th>4- Exceeds</th>
<th>3- Meets</th>
<th>2- Progressing</th>
<th>1- Below</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Extracts engineering problem from a multifaceted problem</strong></td>
<td>Identifies engineering problems as distinguished from other problems also identified and engineering resources necessary to address it</td>
<td>Identifies engineering problems and engineering disciplines needed to address it, but does not identify other facets of the larger problem</td>
<td>Has trouble identifying an engineering problem from a larger problem and is unable to identify engineering disciplines needed to address it.</td>
</tr>
<tr>
<td><strong>Can set up solution approach</strong></td>
<td>Sets up an innovative or unique approach to solve the problem that demonstrates real mastery of the material</td>
<td>Sets up a standard approach to solve the problem</td>
<td>Tries many approaches before being able to solve the problem</td>
</tr>
<tr>
<td><strong>Can solve engineering problems</strong></td>
<td>Solves &gt;90% of engineering problems from student work used for assessment. Scores &gt;85% on the relevant sections of the FE exam</td>
<td>Solves &gt;75% of engineering problems from student work used for assessment. Scores &gt;75% on the relevant sections of the FE exam</td>
<td>Solves &lt;75% of engineering problems from student work used for assessment. Scores &lt;65% on the relevant sections of the FE exam</td>
</tr>
</tbody>
</table>

### 4. Dissemination

**Targets.** The proposed project targets undergraduate and graduate students in the fields of electrical engineering. This pilot program is focused primarily on high voltage engineering. An undergraduate and/or graduate course on HV engineering does not exist as such at WMU. However, a special topic course in advanced areas will be offered in the Fall 2018 semester (ECE 5950). This option will be used to introduce a hybrid undergraduate/graduate level High Voltage Engineering course that fully mirrors the lecture and assignment contents of the split level course 4673/6673 Fundamentals of High Voltage Engineering currently offered at MSU by Dr. Joni Kluss.

This project provides an unprecedented opportunity for the Electrical and Computer Engineering (ECE) program at WMU to offer a high voltage engineering course that is currently unavailable due to lack of laboratory facilities, thus directly impacting the current ECE program, attracting more students to the institution, expanding future research projects, and comprehensively training professionals in this crucial topic. According to direct interest expressed by students to the PI of this project, it is expected that 15 to 20
students will register to this first course offering at WMU during the Fall 2018 semester. Once the effectiveness of the collaborative learning environment is established, the PI will submit an ECE program curriculum change to add the course High Voltage Engineering as a regular course to be offered at least once each academic year.

**Resulting information.** The main information produced as a result of this project can be classified as follows:

- Collected student assignments and reports. These materials will be used for student outcome assessment based on the methodology described in Section 3 of this proposal.
- Complete course material, including syllabus, schedule, practice projects and collaboration procedure for each project. This will serve to develop a best practices guide on the use of the collaborative learning environment, aiming at its potential application in other courses that would benefit from shared resources (such as computational tools, laboratory assets, and others).

**Dissemination procedures.** The information resulting from this project will be documented in detail by the PI of this project and shared with all interested faculty members after the conclusion of this project. The procedures envisioned for effective dissemination include:

- Inclusion of sample student assignments and reports (concealing personally-identifying information) in the ECE Department archive for future reference of all faculty members.
- An electronic copy of the complete course material of the course High Voltage Engineering, as well as a best practices guide on collaborative learning, will be made available through the ECE department website and the instructor’s site after the conclusion of this project.
- Verbal communication will the ECE undergraduate and graduate committees, as well as with all faculty members of the ECE department during at least one departmental meeting in the Spring 2019 semester to discuss the results of the assessment of course outcomes and the proposed learning environment.

5. **Timeline**

- **Fall 2018:** Assessment of outcomes of course ECE 5950 using collaborative learning environment between WMU and MSU.
- **Spring 2019:** Completion of evaluation of outcomes, documentation and dissemination.

6. **Budget**

A graduate student assistant will be hired during the Fall 2018 semester to support the creation of course material, course assessment and documentation of results. The hired student should have a strong background in electromagnetics and previous experience with the software tools to be used (COMSOL Multiphysics, MATLAB and EMTP). This student will be hired at an SEQ level (highly skilled position) for 10 hours per week and 20 weeks total.

\[
\text{Pay rate}\, $20/hr\, (SEQ\, level) \times 10\, \text{hr/wk} \times 20\, \text{wks} = \text{TOTAL}\, = \text{$4000}
\]

7. **References**

