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EET Freshman Circuits Course for the Changing Student Population

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Introduction

A 'freshman circuits' course was introduced into the curriculum of our EET (Electrical Engineering Technology) program ten years ago. This course acquaints freshman students with electrical models, software packages, instrumentation and project organization that will be required in upper-level classes. The motivation for developing a freshman course came from a sense of declining student interest in the electronics field; the initial objectives we had for the course were to a) engage with freshmen entering our program who faculty would otherwise not come into contact with until the sophomore/junior years, b) generate interest in and motivation for the electronics field through lab exercises and projects, as well as to acquaint students with the topics noted above.

Although we did not evaluate our objectives for increasing interest in the field, there seemed to be another problematic aspect of students entering the program. In the past number of years, and now noticeable in the freshman course, math preparedness has declined among students. Additionally, students are coming into the EET program with decreasing levels of technical/tooling familiarity. The failure rate for the course in the past bunch of years is 25-30%. Students do not meet the minimum requirement for passing the course by either no longer attending the class, and/or score poorly on the written exams and hands-on lab exams. In this paper some new/enhanced class activities are discussed and an idea for future implementation is presented for the category Great Ideas for Teaching.

Math Preparedness and Tooling Experiences

ET (Engineering Technology, which includes EET and MET [Mechanical Engineering Technology]) is related to, but quite different from theoretical engineering degrees. In understanding the ET student, it is helpful to note that the National Academy of Engineering documents that [1] the emergence of Engineering Technology as an academic discipline can be trace to the mid-1950s for 2-year associate degree (and 1960s for the four-year bachelor's degree), when curricula in traditional engineering programs began to focus more heavily on advanced science and mathematics coursework and de-emphasized hands-on lab work. The author has observed that the prototype ET student of the past several decades has tooling experiences, confidence and enthusiasm for hands-on technical applications and works hard to obtain enough math skills to be effective in their academic program. Some of our ET students attempted theoretical four-year engineering programs before joining us.

General observations suggest that math preparedness is declining among students attending the course. Math preparation is expected, particularly algebra techniques for defining and solving single-variable linear equations that represent a word problem. Mathematical equations are important in their representation of physical systems and in procedures like units-conversion. We will see in Section 3 that more time was allocated to setting up and solving word problems, in order to show and explain all steps in defining a representative equation and working through steps to isolate the unknown variable.

While math preparation is expected, tooling is something students will gain experience with throughout the curriculum, as it is coupled with practical theory - this balance is a foundation of Engineering Technology programs. It has been observed that students coming to the program with some tooling experiences in their past may take leadership roles in lab groups and exhibit greater confidence during the lab portions of the course, which positively support the analytic portions in most cases. We are seeing that students are also coming into the EET program with decreasing levels of technical/tooling familiarity, and while prior experience is not required in the freshman course, it may tend to negatively impact confidence levels. Early technical/tooling experiences are often gained through informal participation in technical projects with a relative/mentor or by attending technical elective courses, when available, in high school.

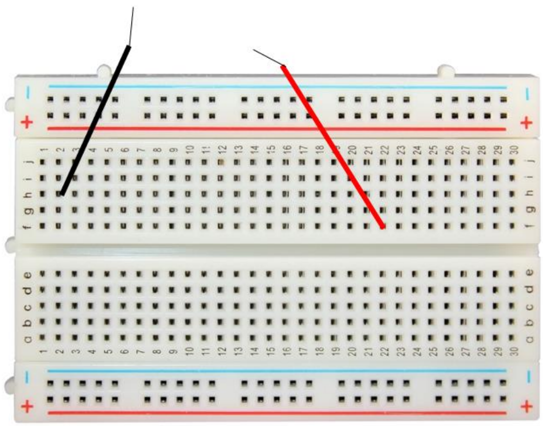
Informal observations point to greater confidence among freshmen students who have these kinds of early technical/tooling experiences and/or have a solid algebra math background. Students from underrepresented populations in STEM and from first-generation families may have greater likelihood of attending high schools where funding limitations impact math instruction and availability of technical elective courses [2].

Enhanced Course Activities to Support Math Preparedness and Tooling

Improving Breadboarding Skills: Breadboarding circuits is a standard activity in our lab courses. Students in the freshman class exhibited difficulty placing components to match a circuit schematic, which is a drawing that indicates how components are connected. In the freshman class we often deal with a series circuit in which components are connected to form a loop. We added an introductory lab to become familiar with the breadboard – students identify specific nodes on the breadboard (our solderless breadboards have an x-y grid) for component placement and ultimately for circuit construction from a schematic. In the beginning exercises students investigate pairs of breadboard nodes for continuity. nodes of the breadboard. Students then place resistors between assigned nodes and then take resistance readings between pairs of nodes. (See the sample lab exercises below).

Step 3: Check for Continuity between two breadboard points h2 and f22

1. Set DMM to the lowest resistance reading
2. Insert black and red jumper wire into nodes h2 and f22, respectively
3. Make sure probes are connected to proper inputs: Black lead to "COM" and red to "Ohms"
4. Touch the probe leads together to verify DMM operation
5. Touch one probe lead to the wire connected to node h2 and the other lead to the wire connected to node f22
6. Fill in the result (yes/no). For overload, indicate with 'Overload' or 'OL'



Point A	Point B	Meter Reading	Continuity (Y/N)
h2	f22		

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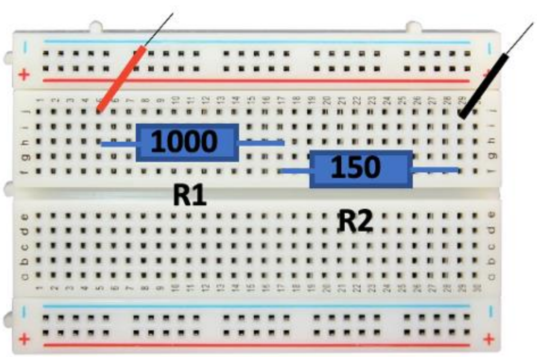
Part 4 – Breadboarding Series Resistors

1000 Ohms

150 Ohms

1. Place each resistor in the breadboard nodes indicated below
3. Place red and black 2-3 inch stripped wires in breadboard nodes indicated below.
4. Set the DMM to read resistance.
5. Connect DMM to the red and black wire as noted
6. Record DMM readings using scales noted in table
7. Indicate best scale for the reading



Resistor Placement

Res	Value		
1	1000 Ohms	h5	h17
2	150 Ohms	f17	f29

Wire Placement

Red Lead	Black Lead
i5	j29

DMM Placement

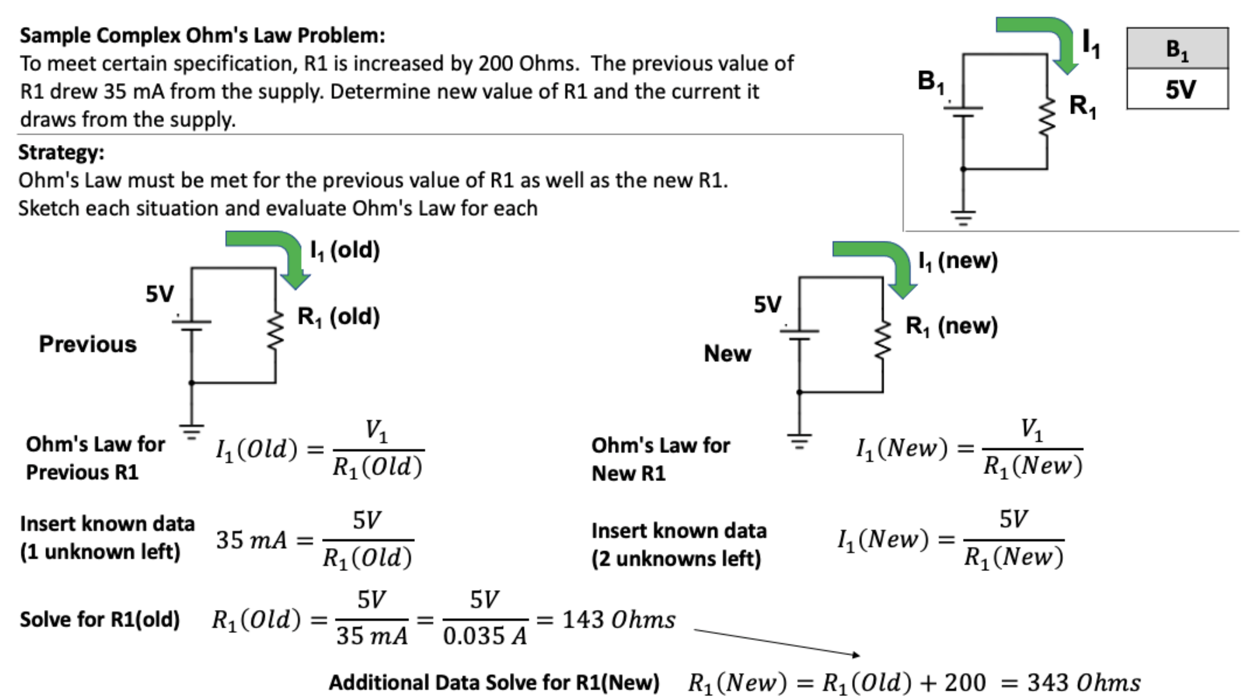
COM (Black Lead)	Black wire
V / Ohm (Red Lead)	Red wire

Measurements

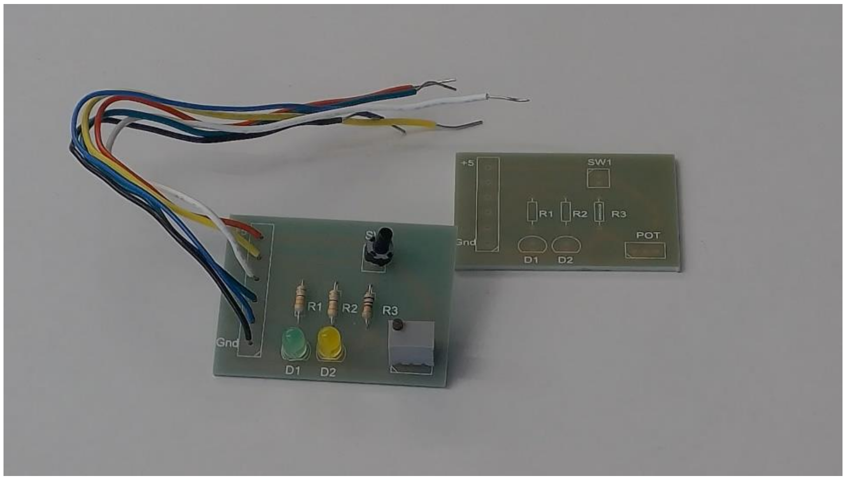
Scale	200 Ohm scale	2000 Ohm scale	20k Ohm scale
DMM Reading			

Math Preparedness - Improving Algebra Skills: When we introduce Ohm's law, which states the linear relationship between current and voltage of a resistor, students solve simple word problems where 2 values are given, and the 3rd must be found. We developed Ohm's Law word problems with additional complexity, where two simple algebraic equations based on Ohm's Law can be developed and solved (see example below). Mathematical equations are important in their representation of physical systems and in procedures like units-conversion.

Circuits studied in the Freshman Circuits class can be represented by 'simple' algebraic equations that can be solved with basic steps of isolating a single unknown value. Note that this past semester, more time was allocated to problem solving to show and explain all steps in setting up equations and working through steps to isolate the unknown variable.



Providing a Soldering Experience: A single-sided Printed Circuit Board (PCB) was designed by the instructor for the purpose of providing a soldering experience to students in the freshman circuits class. The class watches soldering instruction videos and reads solder safety guidelines. Each student gets a PCB, and we go through steps together in class to populate the PCB with components and solder the components to the PCB. The soldering stations used are professional level, containing temperature adjustment of the soldering iron, board holder, tip cleaner, and more. Each student populates and solders their own board and keeps it. The PCB (see picture below) contains familiar breadboarded components which were used in class experiments with the Arduino microcontroller system during the Introduction to Microcontrollers module of the course. Once their PCB is completed and functional operation is verified, the wires soldered to the PCB can be inserted into the Arduino system and code can be developed for simple projects involving the switch, LED, and Potentiometer on the PCB.



Proposal for a Well-Being STEM-Support In-Class Coach

As we try to build math preparedness in this freshman class and provide introductory tooling experiences, we hope to see confidence levels increase. To help support classroom activities, we propose to situate a general well-being STEM-Support person inside the classroom (referred to as the In-Class Coach, ICC). Our school has many tutoring resources (academic support) and counseling types of resources (general well-being support) for students. These support services occur outside of the classroom and often the support is activated when the student solicits help. Having and ICC in the classroom can provide freshman-level help in a real-time environment, and the 'help' can come to them instead, as the ICC, for example, moves about the classroom and checks in with each lab group. The ICC can provide a conduit between the students and instructor for non-academic issues and take a leading role when students are a) repeatedly absent or late, b) being a passive lab group member, c) disengaged, and d) focusing on non-class material.

The ICC would sit in on all classes and meet with instructor before and after class, as needed. The ICC and instructor will spend time prior to the beginning of the semester to develop a cohesive plan for embarking as a team on this endeavor. It will be important for the instructor and ICC to present themselves as a team.
With an increasing population of students in our program who are underrepresented in the engineering field, it is recommended that significant impact can be made by recruiting an ICC who has experience in supporting underrepresented students in STEM areas.

ICC Role in the Classroom The logistics of the freshman circuits course, as well as all technical courses in our program, are favorable to having an effective ICC. There is a maximum of 24 students in the lab, and both the lecture and lab take place in the lab. During Lab Time (approx. 50% of class time), the ICC can actively engage each lab group (walk around), speak informally with each student and/or lab group, assess individual engagement with the lab, group accountability in accessing instructor help when needed, and group accountability in working toward completion of the lab exercise**.** During Lectures (approx. 50% of the time, the ICC can find a stationary location or move about the classroom as desired to best observe student engagement. Based on observations, feedback can be discussed with the instructor.

Conclusion

The freshman circuits curriculum is updated each semester to identify more ways to engage students. Funding is currently being sought to bring a STEM-Support In-Class Coach to the freshman circuits course, which will be taught in the upcoming Fall 2023 semester. Our hope is that the provision of an ICC at this early juncture in our students' technical education can help build confidence, positive study habits, and effectiveness on a technical team. With an increasing population of first-generation students and students traditionally underrepresented in the engineering field, it will be important for the ICC to have experience in delivering support to these student communities.

[1] K. G. Frase, R. M. Latanision, and G. Pearson. Summer Bridge: Engineering Technology Education. NAE.edu. https://www.nae.edu/173075/Engineering-Technology-Education-in-the-United-States-Summary (Retrieved Feb. 24, 2023)

[2] Math Teacher Shortage Crisis: Insight and Possible Solutions. https://yup.com/blog/math-teacher-shortage/. (Retrieved Feb. 24, 2023)