

On a New Hybrid Laboratory Approach: Remote Learning and Face-to-Face

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Abstract: A new hybrid approach to the realization of laboratory experiments has been implemented in the current academic year. The new approach was realized out of necessity due to the pandemic of Coronavirus disease (COVID-19). The hybrid approach consists of two approaches: The Remote Learning experiments and the Face-to-Face experiments. The experiments were performed successfully using either approach. The students reported satisfaction of the outcomes, getting both topical and practical experience and preparing a Laboratory Report. The experiments consist, in most cases, of three parts: the analytical, the simulation, and the experimental.

Introduction:

Due to the current pandemic situation face to face classes and laboratories were canceled immediately after its appearance in the middle of the Spring 2020 semester. Instead of returning to classes after Spring Break, it was extended for an additional week and preparations were made to move to online teaching. The online learning system in use was Blackboard. Blackboard is an online Learning Management System (LMS). The remaining laboratories were canceled. But the author, due to his expertise and his own electrical and electronic laboratory developed remote learning experiments for most of the remaining Engineering Physics II laboratory and for all the remaining Electric Circuits laboratory. The experiments of Engineering Physics II not be able to perform was due to lack of specialized equipment.

The communication medium during the Spring 2020 and Summer 2020 was Blackboard Collaborate. The major disadvantage of the system is that only four people can be seen out of the whole population of the class. The communication medium during the Fall 2020 and Spring 2021 changed to Zoom. Zoom is a platform for video and audio conferencing, chat, and webinars. The respective communication medium was used for the Lecture/Recitation and Laboratory.

Organization of the Laboratory course:

The following two menus are the main menus for each of the laboratory courses. The two courses under consideration are:

- *ENGR 2151 Introduction to Electrical Engineering / Engineering Physics II (Laboratory),*
- *ENGR 2621 Linear Circuit (Laboratory)*

They are opening another folder that contains the topics of the laboratory. There are fifteen laboratory topics “Topic 01” to “Topic 15” corresponding to the weeks of the semester, plus one introductory, the “Topic 00 – Prolegomena”. In addition, there are Appendices “Appendix – xx”.

Figure 01 shows the laboratory selection for each of the courses while Figure 02 shows the typical parts of a laboratory topic.

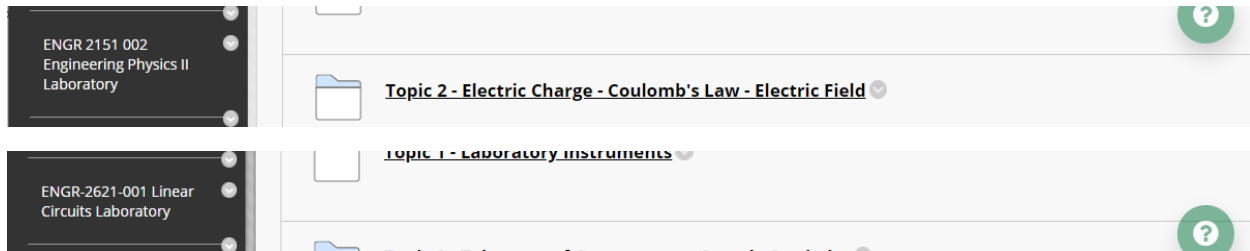


Figure 01. The selection menu for the list of Laboratory Topics.

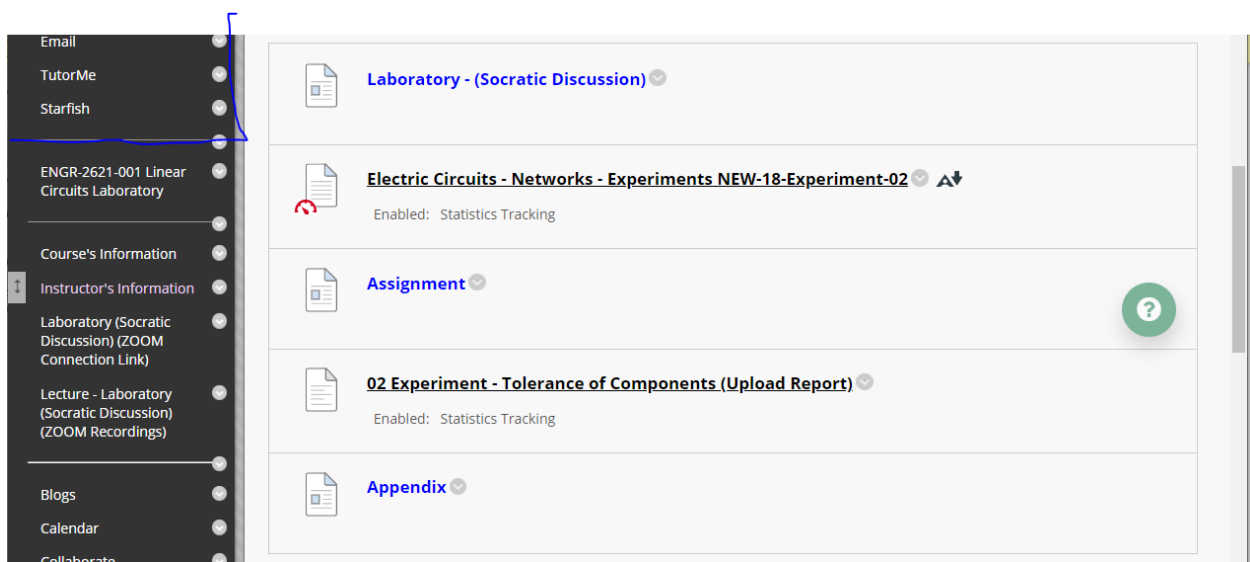


Figure 02. Typical organization of a Laboratory Topic.

Every Topic includes the Laboratory (Socratic Discussion) that provides the laboratory experiment handout, the Assignment through which the student will upload the Laboratory Report, and Appendix which includes additional reference material.

The Remote Laboratory:

The remote learning experiment approach consists of fully contacted experiments by the instructor in his laboratory station (remote location). In this case, the remote location is the author's personal electrical/electronic laboratory fully equipped with instruments (DC power supply, function generator, dual channel oscilloscope, electronic multi-meter, analog multi-meter) and electronic components (Resistors, capacitors, inductors, transformers, transistors, switches, relays, motors, leads, proto-boards, jumper wires, etc.). The laboratory serves as the place to contact the experiments. The equipment used is similar but not necessarily the same model as the ones at school. For a few experiments in Engineering Physics II (Electricity and Magnetism), the instructor borrowed in the Spring 2021 some of the needed equipment from the College's Laboratory. The laboratory session starts with the instructor introducing the subject

followed by a demonstration. After that the instructor and the students following the step in the laboratory handout, work together although physically separated. They proceed step by step to perform the experiment. While it is the instructor who performs the experiment, the students are active participants by watching the setting of the meters, the connection of the equipment, the method of measurements, collecting the data themselves by reading the instruments on their computer screen. The students collect the data and complete the appropriate Tables in their laboratory handout. The processing of data is done by the students either individually or in teams. An external camera is used to record video and audio and record in the learning management system. The recordings are available afterwards to the students by posting the corresponding link in the Blackboard page of the laboratory. The Zoom [1] and Blackboard [2] services have been used for direct communication. The personal preference of the instructor is to use Zoom for the lecture, presentations, Socratic discussions, and remote laboratory experiment, because he can see the whole class in a second monitor located behind his laptop screen that he shares for the discussion part of the laboratory. The Blackboard is used for the overall organization of the Laboratory course as the Collaborate communication module of it, is considered inadequate and was replaced by Zoom as described earlier.

Students can review the recording of the experiments, clarify processes, extract data, ask questions through email, video conferencing, discuss with other students, etc. Afterwards, student work as a team to prepare a professional Laboratory Report. The Laboratory team consists of two to three students. Writing a Report cooperatively and under current pandemic environment closely mimics the current industrial environment. The Professional Laboratory Report includes all the parts and requirements found in a professional environment [3]. The topics selected are from Physics II (Electricity and Magnetism) [4] and Electric Circuits, [5]. Figure 03 through Figure 07 present snapshots from the video of two recordings. The experiments have been developed by the author, [6], [7]. The Laboratory Report is uploaded to Blackboard for grading.



Figure 03. Experimental setup of a remote learning experiment (Gauss Law – Electric Charge Distribution). Grounding of the proof plane.



Figure 04. Experimental setup of a remote learning experiment (Gauss Law – Electric Charge Distribution). Measurement of electric charge.

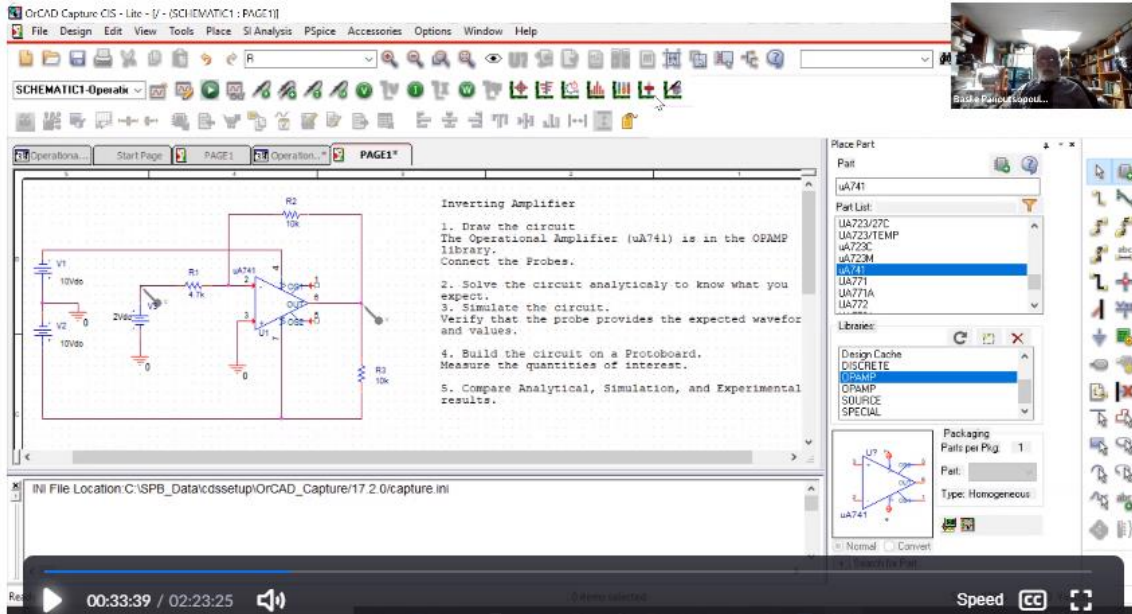


Figure 05. Simulation of an electronic circuit (inverting amplifier) in remote learning.

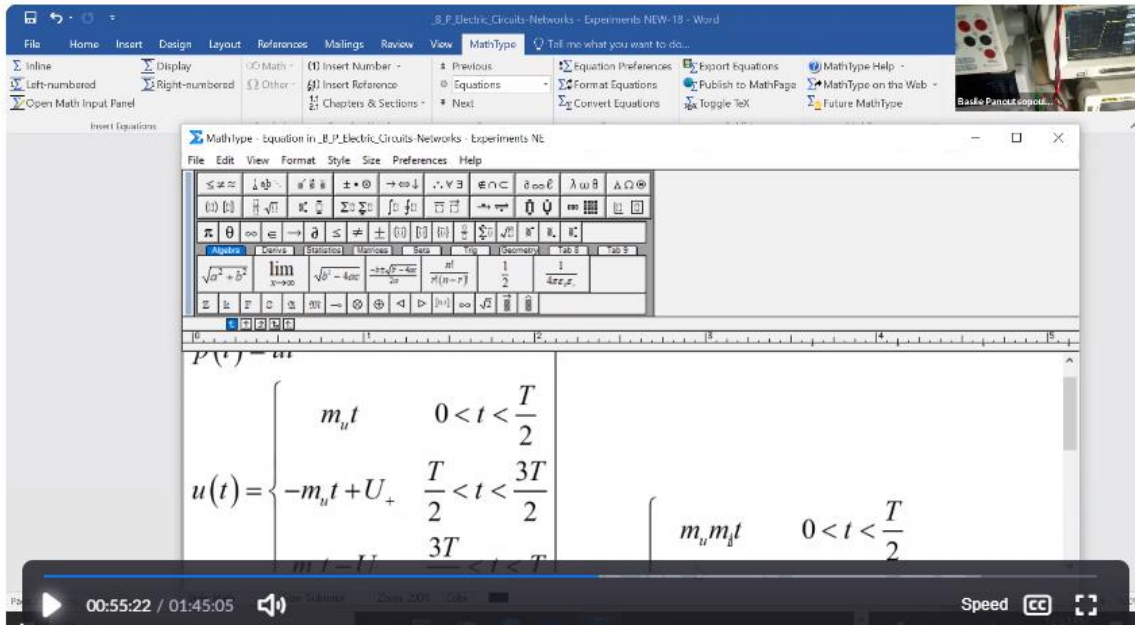


Figure 06. presentation of the material before the experiment. Mathematical description of signals or functions.

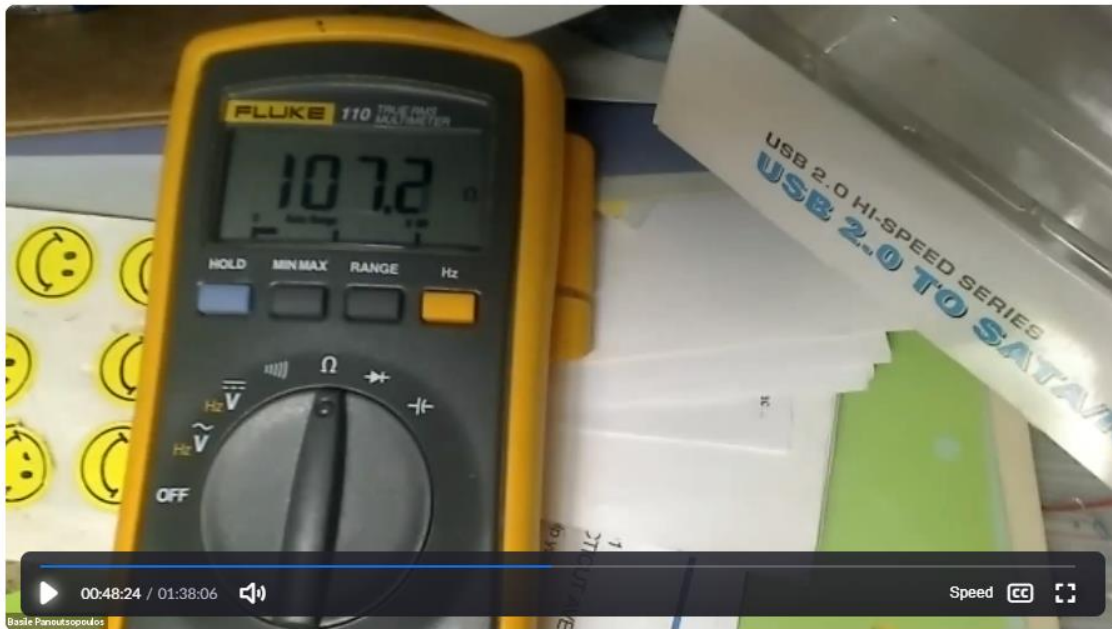


Figure 07. Measurement of the resistance of a resistor using a multimeter.

The Face-to-Face Laboratory:

The face-to-face experiments part of the laboratory course, consists of fully contacted experiments by the students at the College's laboratory under the direction and supervision of the instructor.

The students work individually and in teams. This approach fully reflects the industrial approach where engineers work either on a specialized part of a project, alone or on a part of a big project along with other engineers. The approach prepares them for industrial employment. The laboratory consists of one experiment in a three-hour time once a week. The experiment is fully related and integrated with the topic discussed in the lecture-recitation/Socratic discussion. Figure 08 is a snapshot from the presentation of the laboratory material and Figure 09 is a snapshot from the demonstration of the laboratory experiment.

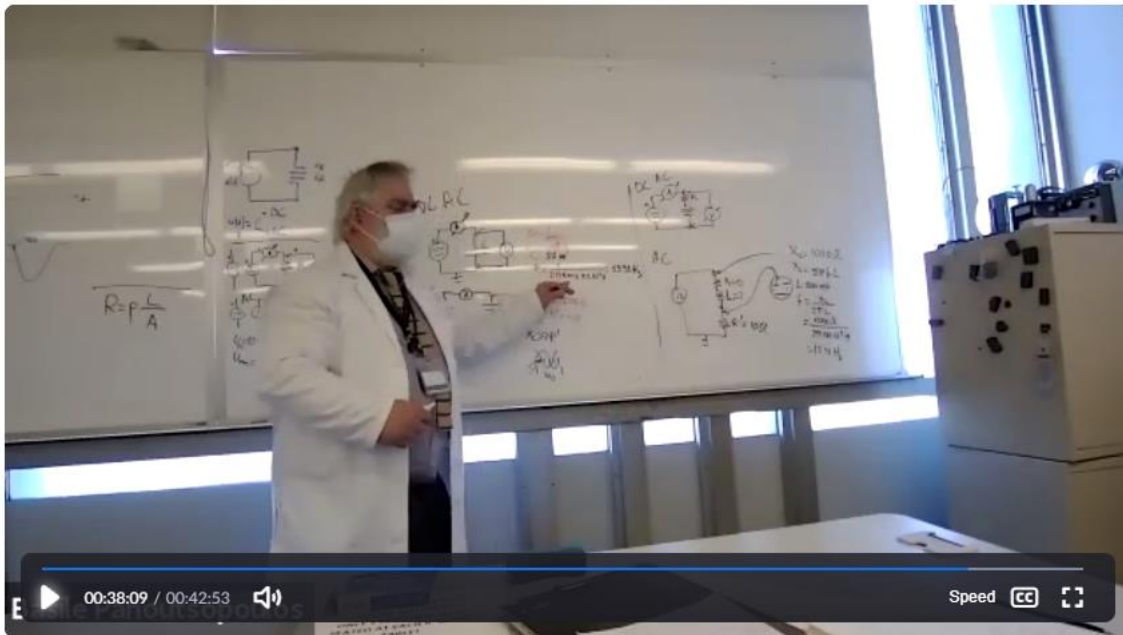


Figure 08. Presentation of the topic before the experiment. Behavior of R-L-C under DC and AC excitation – Phase difference. Method of measurement.

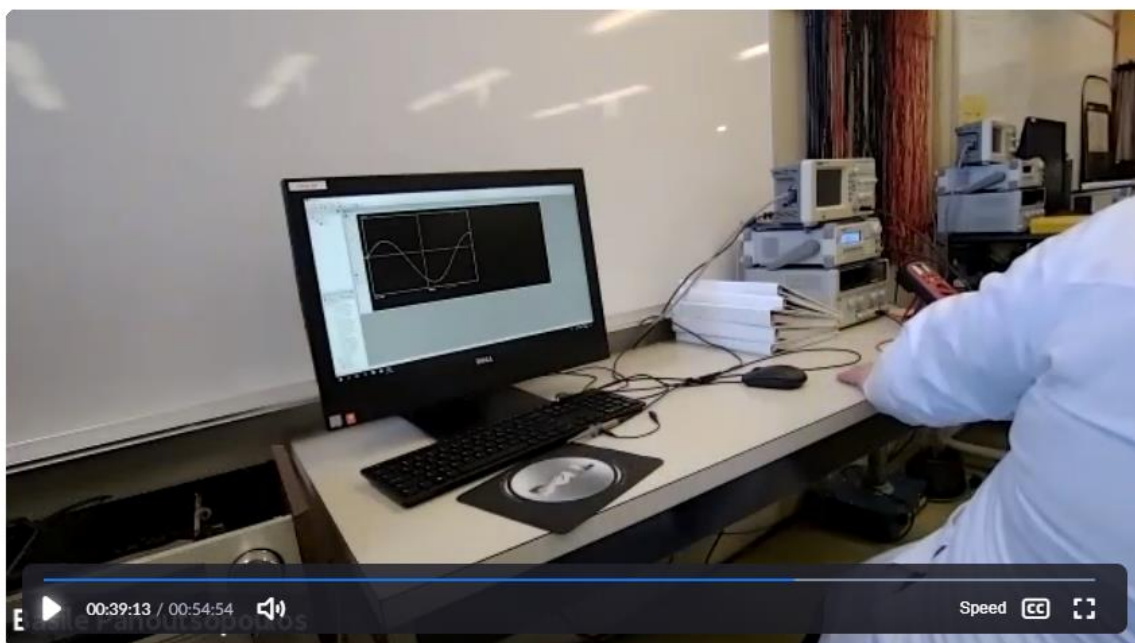


Figure 09. Demonstration on using electronic instruments in the face-to-face laboratory.

Organization of Experiments:

The typical laboratory experiment consists of a problem that is solved in three parts: The theoretical-analytical, the simulation, and the experimental-practical. It should be noted that before the experimental there is a short presentation and demonstration to the students intended to transmit experience from a senior colleague (the instructor) to a junior engineer in training (the student). The students will have the opportunity to investigate on their own during the various parts experiment. The three parts approach parallels the approaches used in the industry. The students are in their formation years in their path to become engineers.

The students provided with the laboratory assignment that clearly spells out the three-part approach with the steps, needed to be completed. The result of every experiment is a Laboratory Report. The report is a professional prepared document in all its aspects, text, tables, equations, figures, overall organization. The required typical organization of a report is based on the instructor's industrial and research experience.

The above-described approach was implemented in the laboratories of two engineering level courses taught by the author: Engineering Physics II (Electricity and Magnetism) and Electric Circuits. The final product, the Laboratory Report, reflects the level of mastering of the material. In both approaches, remote and face-to-face, the Laboratory Reports, were of equal quality as the previous years, based exclusively on face-to-face instruction. Furthermore, at the end of the semester there was a written practical examination with questions from the practice of the laboratory of Engineering Physics II and Electric Circuits.

One disadvantage of the remote approach is the final practical examination in which a student is asked to build a circuit and use instruments to perform measurements. This may be rectified by requiring the students to buy a student's basic component kit and one or more instrument. The disadvantage of this approach is the cost: an inexpensive kit will contain instruments of low quality with limited capabilities, while a high quality and high capability instruments will increase the cost prohibitively and may be out of the scope of a student's laboratory financial reach. A partial solution to this dilemma may be the selection of experiments: the simple ones required inexpensive equipment to be contacted remotely while the more involved that require expensive equipment to be contacted face-to-face at the College fully equipped laboratory. Again, a disadvantage of this is that the experiments must be tight to the lecture while the laboratory for face-to-face instruction are available specific days. Further consideration will require optimization considering the boundary conditions, in this case mandated restrictions. But this is engineering: compromises to get the best outcome which is the best practical education of the students.

Conclusion:

The current Coronavirus pandemic state has influenced the approach to teaching. Teaching of the laboratory parts of Engineering and Technology courses has been challenging. The proposed approach of a mixed laboratories: remote learning laboratories and face-to-face laboratories looks to be successful. The students perform six face-to-face experiments and seven remote learning. The reaction has been positive, without any complains.

Further Work:

Upon return to normality many lessons learned, material developed, and used under the current pandemic state, can be adapted to be used as tutorials for future classes.

References:

- [1] Zoom. <https://zoom.us/> (Last Accessed March 1, 2021).
- [2] Blackboard. <https://www.blackboard.com/> (Last Accessed March 1, 2021).
- [3] NUWC-NPT Administrative Publication 11,787 10 July 2007. Publications and Presentations Guide Information Technology Department. Naval Undersea Warfare Center Division. Newport, Rhode Island.
- [4] David Halliday, Robert Resnick, Jearl Walker. Fundamentals of Physics. 10th Edition. Wiley. 2015.
- [5] James A. Svoboda and Richard C. Dorf. Introduction to Electric Circuits. 9th edition. Wiley. 2013.
- [6] Basile Panoutsopoulos. Experiments in Engineering Physics II (Electricity and Magnetism). 2021.
- [7] Basile Panoutsopoulos. Linear Systems and Electric Circuits. Analysis and Synthesis. A Laboratory Manual. 2021.

Appendix: Description of Blackboard Menu

The author created an online resource for all his courses that has identical menus for all courses taught by him. Figures A through Figure D show the single page web menu as it stands during the Spring 2021 semester. The menu is presented in parts because cannot fit in a single page.

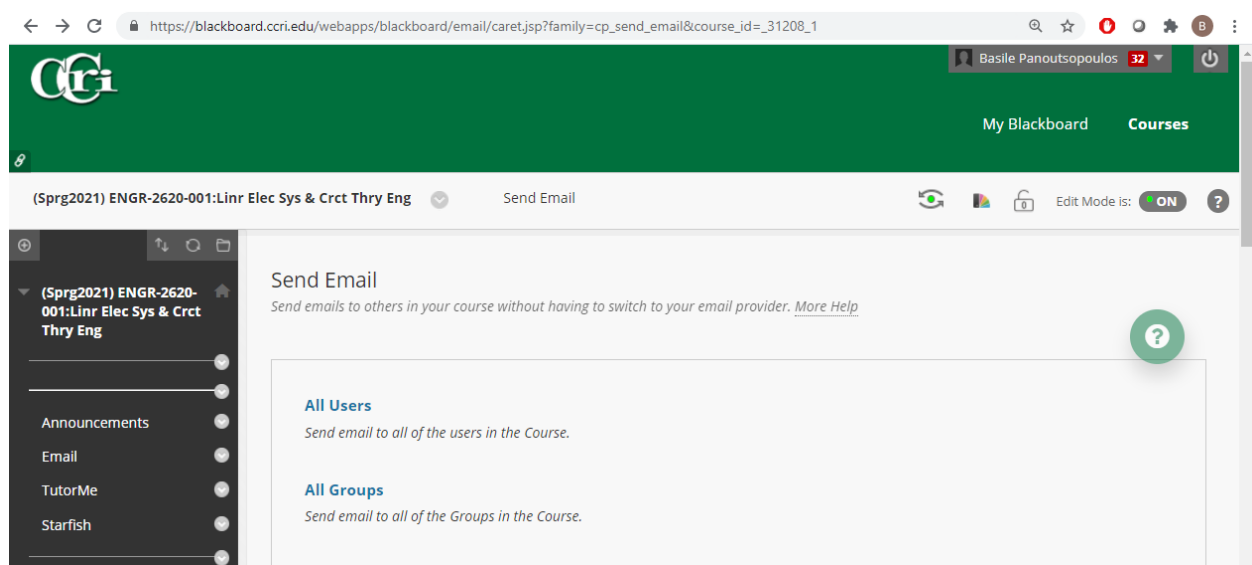


Figure A. The first top part of the menu.

The Announcements menu selection points to the various announcement from before the semester starts, during the semester, to after the conclusion of the semester.

The Email menu selection points to the various options of email communication in the system. This is useful in communication of the instructor with the students, the students with the instructor, and the students with the students.

The TutorMe menu selection points to a service that is available to the students asking for tutoring.

Starfish menu selection provides a central place to connect to the people and services that will help a student to be successful at CCRI.

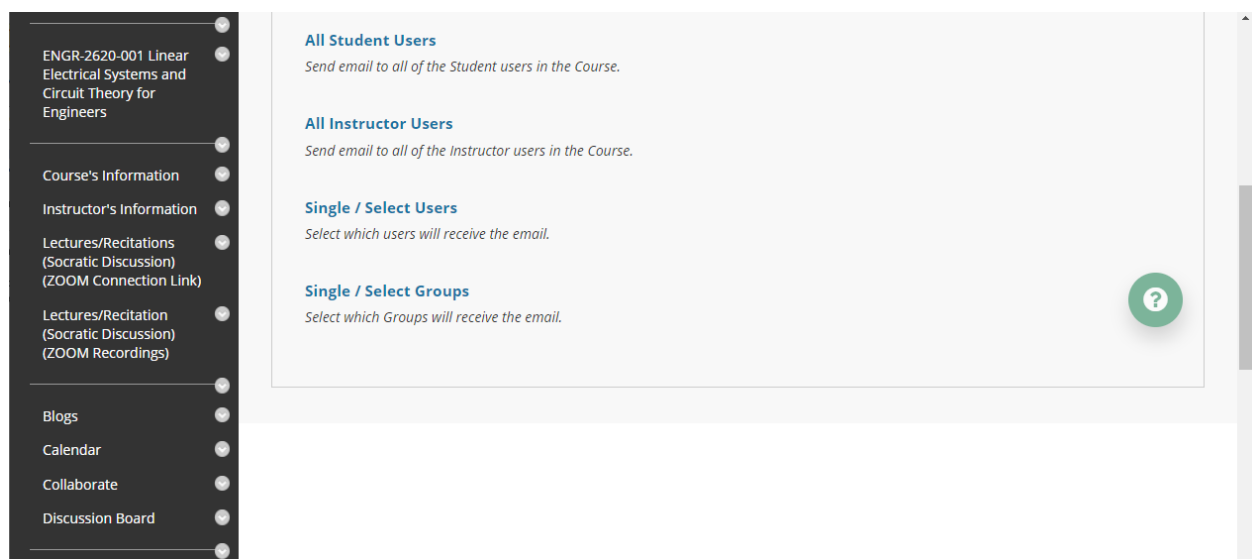


Figure B. The second and main part of the course menu that open the course (top) and sub selections below.

The “ENGR 2620 Linear Electrical Systems and Circuit Theory for Engineers” is the main part of the course that includes submenus for the various experiments of the course.

The Course Information selection provides information for the course.

The Instructor’s Information selection provides information for the instructor.

The Lectures-Recitation (Socratic) Discussion (ZOOM connection link) selection provides access to the meeting dates and the connection link.

The Lectures – Recitation (Socratic Discussion) (ZOOM Recordings) selection provides information link of the recording of the laboratory meetings.

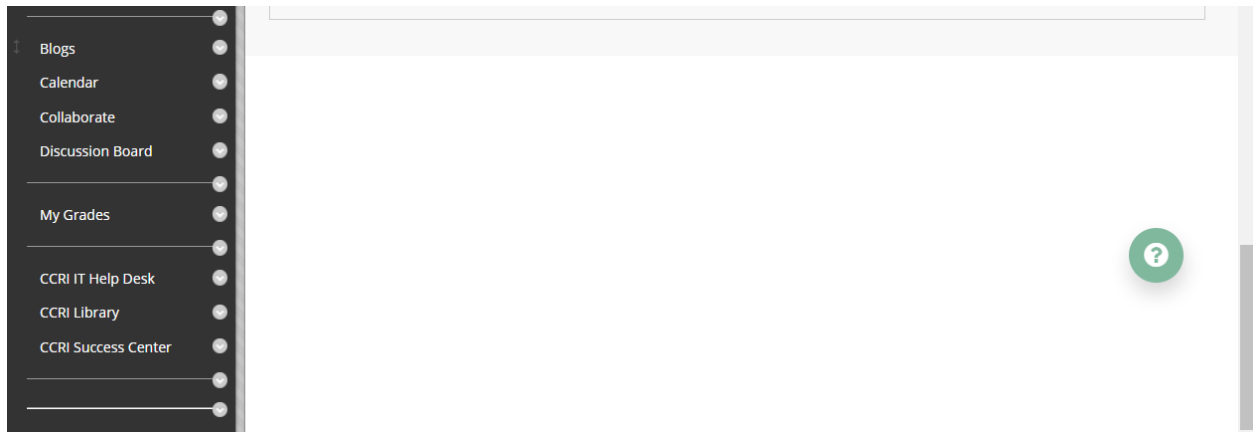


Figure C. The third part of the menu.

The Blogs selection provides students with the ability to create Blogs.

The Calendar selection provides a view of the calendar of the student.

The Collaborate provide a remote selection using Blackboard but is used only for Office hours face-to-face connection. Currently collaborate displays only up to four live images of the class.

The Discussion Board Selection provides an avenue for discussion among the students and the instructor. Unfortunately, students prefer other Social media.

My Grades provides a view to the status of a student's grades.

CCRI IT Help Desk provides a link to computer Desk Help.

CCRI Library provides a help to the Library.

CCRI Success Center provides a link to the Success Center, a tutoring College service.



Figure D. Organization of a typical laboratory course using the Blackboard management system.

The Course Management is used by the Instructor and it is not seen by the student.