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SIMPLE WAYS TO FACILITATE ACTIVE LEARNING IN HANDS-ON ELECTRICAL ENGINEERING TECHNOLOGY COURSES

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SIMPLE WAYS TO FACILITATE ACTIVE LEARNING IN HANDS-ON ELECTRICAL ENGINEERING TECHNOLOGY COURSES

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Abstract

The traditional way engineering and engineering technology courses are taught is based on traditional lecture and laboratory experiments, which are still the most frequent teaching methods used nowadays around the world. On the other hand, active learning methodologies grounded in scientific research in education have been attracting considerable attention over the past years with numerous research studies indicating the efficacy of such learning styles.

In this article, the author addresses the main challenges and shares active learning strategies used to encourage active learning and engagement among students in face-to-face Electrical Engineering Technology (EET) courses. The implementation of active learning, cooperative learning and problem-based learning in EET hands-on courses is discussed. The assessment results have indicated that the instructional approaches used have been successful in meeting the teaching goals, which once again serves as evidence for the effectiveness of active learning as research studies have indicated.

Keywords: electrical engineering technology, active learning, Bloom's taxonomy, learning styles, teaching methodologies.

1. Introduction

The traditional way engineering and engineering technology courses are taught is based on traditional lecture, which is still the most frequent teaching method used nowadays around the world.¹ On the other hand, active learning has been attracting considerable attention over the past years with numerous research studies indicating the efficacy of such learning style. In recent years, both universities expectations and students' expectations of faculty have increased. Not only is a professor expected to teach effectively, but also manage other responsibilities such as maintaining certain levels of research and other scholarly activities. Most university professors were not taught how to teach prior to their first faculty position, which in turn leads to many of us learning by trial and error. Since there are already numerous studies on what makes teaching effective, the "how to teach" learning curve can be more effective just by studying the literature available in the subject.^{2, 3, 4, 5, 6} One of the challenges when learning "how to teach" is the large number of terms, usually unknown to engineering faculty. These terms are introduced, explained and debated in many articles in educational conferences and journals such as the Journal of Engineering Education and the American Society of Engineering Education (ASEE) meetings. For instance, in an article presented at the Annual ASEE Conference,³ the author makes a summary of the jargon, which served as a good reference document to many engineering and engineering technology educators.

One could argue that the structure used in engineering technology courses already incorporates problem-based and active learning methodologies since technology courses usually have a hands-on component. The author of this paper doesn't disagree with this argument. The goal of this article is to provide additional insights and definitions of the active learning approaches used in face-to-face electrical engineering technology (EET) courses, offer suggestions for implementing additional active learning methods, cooperative learning and problem-based learning, as well as encouraging learning and engagement among students in EET hands-on courses. The reality is that in many cases, EET faculty members apply their own version of active learning methods without the knowledge of the terminology, research in education, and body of literature available on the subject.

The suggestions provided in this paper, while confirming principles and practices described in the literature, provide new insights and ideas. So far, the methods applied to EET courses taught by the author can be considered successful due to the positive and encouraging feedback provided by the students. Assessment results have indicated that the instructional approaches used have been successful in meeting the learning goals, which once again serve as evidence for the effectiveness of active learning as research studies have indicated. The use of these methods has also helped faculty to manage their teaching and scholarly expectations by providing tools to improve student learning and more efficiently manage course development and time once these methodologies are mastered and implemented. In addition, effective teaching is a component used as metric for tenure promotion and reappointment. While some of these findings are anecdotal (i.e., based on the authors experiences), several research works point in the same direction on teaching effectiveness.^{2, 3, 4, 5, 6}

2. Active Learning

Active learning is usually defined as any instructional method in which students are actively engaged in the learning process as opposed to passive listeners in a traditional lecturing setup. The Active Learning Continuum is presented in Fig.1,⁷ where any learning activity that has students doing something in class other than listening to lectures and taking notes has strong evidence of success.

A commonly cited definition from Bonwell and Eison⁸ states “involving students in doing things and thinking about what they are doing.” While EET course are traditional hands-on with the “doing” part well emphasized – the “thinking” part quite often is not well explored. An instructor informed and educated in active learning can incorporate teaching mechanisms to explore the “thinking” and additional engagement of students.

2.1 Student's Preparation for Active Learning

It is a good practice for instructors to talk to students in the beginning of the course to briefly explain the type of active learning approaches that will be used in class, setting up instructors' expectations, and emphasize that the active learning approaches used in class will be reflected in quizzes, exams, homework, lab reports, and other assignments.⁹ One suggested starting point is to add information on active learning in the syllabus, in addition to clarifying learning objectives and course expectations up front. However, the importance of active learning techniques needs to

be frequently reinforced throughout the course. Unfortunately, quite often students resist the student-centered type of approaches. Other authors have investigated the reasons why students often resist to active learning approaches and have suggested ways to deal with these unfriendly responses.^{10, 11} The suggestions include: explaining to students that their active participation will increase their learning, lead to higher grades, and reinforce critical job skills. Another suggestion was to share teaching-learning philosophies in the course syllabus, which is not necessarily a good solution since students have the tendency to not read a lengthy syllabus. “Transparent teaching” is also suggested as an efficient way in which instructors explain their methods and motives for specific assignments and activities.¹²

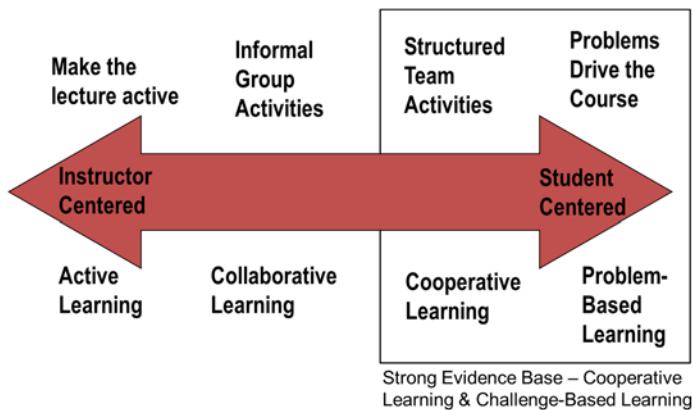


Fig.1 – The Active Learning Continuum. (Prince, M., 2010, NAE FOEE)

2.2 Active Learning Approaches

Active teaching and learning is the introduction of student activities into the traditional lecture. One example of how that can be accomplished is for the lecturer to pause two or three times during an hour-long lecture and have students clarify their notes with a partner. Studies have shown significant results in student retention by using this approach.^{13, 14} Numerous studies suggest that student attention span during a lecture is roughly 15 minutes.¹⁵ Breaking up the lecture might work because students' minds begin to wander and activities provide the opportunity to start fresh again, keeping students engaged.⁵ It is important to highlight that the activities to engage students must be designed in line with the course learning outcomes. Students should be encouraged to think about what they are learning. Adopting instructional practices that engage students in the learning process is the key feature of active learning.⁵ Other active learning approaches include:

i. Thinking-Aloud Pair Problem Solving (TAPPS)

Students pair with one designed as the explainer and the other as the questioner. The explainers outline the assignment goal (solve case studies, complex problems, or interpret text) and then begin detailed descriptions of how they should work on the assignment. The questioners listen and can also ask questions. At a given point, the students reverse roles and the process continues until the assignment is concluded.¹⁶

ii. Think-Pair-Share

The instructor poses a problem and has the students think about it individually for a short time. The thinking time can also be used to write the response. The students then form pairs and share their solutions. During the third stage, students' responses can be shared within learning teams, within larger groups, or within the entire class during a follow-up discussion.⁶

iii. Visible Quiz or Clickers

Ask a multiple-choice (A, B, C, D) or True/False question about a course-related concept. At a given time (30 seconds or more), each student or one student in each team (if small groups are formed) should display the answer using either visible quiz cards (with a different color for each answer letter) or electronic clickers. Then, display the histogram of the responses. Following that, have the students get in pairs or groups again and try to reconcile their responses and vote again. Finally, call on some of them to explain why they responded as they did and then discuss why the correct response is correct and the distractors (incorrect responses) are not.¹⁶

iv. Minute Papers, Direct Paraphrasing, Application Cards, and Lecture Summaries

These are examples of individual approaches. In **minute papers** or clearest/muddiest point, the instructor should stop two minutes before the class period ends and ask students to write main point(s) of the lecture and the “muddiest” or least clear point(s). Collect the papers and use responses to plan the next lecture. In **direct paraphrasing**, the students should write a definition in their own words. In **application cards**, students should provide a specific real-world application for the topic covered in class; and finally in **lecture summaries**, students should write the key points of material covered in the lecture.⁶

2.3 Collaborative and Cooperative Learning

According to Prince,⁵ because different authors have interpreted some terms differently, it is not possible to provide definition universally accepted for the vocabulary of active learning, but it is possible to provide some generally accepted definitions and how common terms are used. Among the terms and definitions, **collaborative learning** is defined as any instructional method in which students work together in small groups towards a common goal, which encompasses all group-based methods, including cooperative learning. **Cooperative learning** can be defined as a structured form of group work where students pursue common goals while being assessed individually. Thus, collaborative learning is a core approach in hands-on lab projects commonly used in electrical engineering technology courses.

2.4 Problem-based Learning (PBL)

Problem-based learning (PBL) is an instructional method where students work on an open-ended, real-world problem and work in teams to identify learning needs and develop a solution. Typically, it is introduced at the beginning of the course and provides the context and motivation for learning additional material. In PBL, instructors are usually facilitators as opposed to the main source of information. Successful PBL should start with well-designed problems in order to “guide students to use course content and methods, illustrate fundamental principles, concepts, and procedures, and perhaps induce the students to infer those things for themselves instead of

getting them directly from the instructor; and engage the students in the types of reflections and activities that lead to higher-order learning.”⁴ An example of PBL commonly used is the final class project.

3. Actions Taken

Teaching freshman and sophomore engineering students is crucial because it is during this initial period that students are more likely to change majors or drop out of college.^{17, 18} Many studies stress the importance of first-year college experience, and indicate the first-year GPA as the best predictor of attrition. The adoption of an active learning format whereby student participation is highly encouraged has the strongest impact on students’ academic performance and their attitudes towards the engineering profession.¹⁹ Despite of the fact that many students may have been academically prepared and motivated to study engineering, 50% of students who enter engineering programs as freshman do not earn an engineering degree.^{17, 18} The gap between engineers needed annually and the number of graduates available to fill positions is still wide.^{20, 21} A change in motivation is perhaps the key factor in a students’ decision to earn an engineering or engineering technology degree. Positive experiences in introductory electronics courses, for instance, can influence both EE majors and non-major students in their career path and in some cases even influence them to change majors. These courses can greatly influence whether a mechanical engineering student will pursue further studies in robotics, or control mechanisms, much needed in the automobile industry and any other automated industry. Thus, a challenge for individual faculty and engineering departments collectively is to find ways to build on these positive experiences and enable students to acquire some knowledge in electronics related fields. However, there is no general agreement on how best to serve diverse student audiences in any discipline and, in some cases, no formal consensus about desired learning outcomes.²²

The traditional order to teach EE is that one must learn about semiconductor junctions before common emitter amplifiers. According to Wolaver, et al.,²³ instruction should follow an order that starts with the broad uses and system components and only then delve further down into the details. This methodology is known as “outside-in” or “top-down” approach and is widely applicable and is practiced in many fields, especially by engineers. The advantages of the outside-in approach includes the motivation to students. Students, especially non-majors, want to appreciate why they are putting effort into learning a specific material that at first doesn’t appear related to their majors. They need a better answer than, “Because you will need it later.” The author has to follow an approach consistent to the top-down approach, where the application is briefly discussed first and the teaching of the basic principles follows. For instance, to tailor a given topic to Computer Network and System Administration students, the author talks about the need for different cables to carry out binary data at different data rates before talking about specific characteristics of transmission media.

Special attention needs to be paid when choosing appropriate course content, its learning objectives, and the corresponding levels of learning. Discuss real-world applications that are straightforward extensions of fundamental ideas. Show students why electrical engineering is relevant to their careers, and involve them in lecture demonstrations. Emphasize “transferable skills” and their relevance to future careers in robotics or information system management. The use of examples relating electronics to their field, for instance, a mapping correlating the

electrical circuit of an automobile and an electrical circuit diagram helps students to make a connection between the classroom and their major in the case of Mechanical Engineering students, or the need for electrical cables with different proprieties to carry out binary data at different data rates for the case of Computer Network and System Administration students. Students in electronics courses only master a small fraction of the material with which they are presented. Therefore, focus on fundamental concepts and keep the math simple.

To motivate students, three key questions that should be answered in every lecture: Why, What, and How. Students must understand: “Why” do we need to study a specific topic? “What” is the relationship between this specific topic and other topics covered in that class or even in other classes? “How” do we reach a given result or derivation? Properly addressing these questions and other related questions is crucial to keeping students attention and maximize their learning experience.

The author also actively pursues the engagement of the students in the classroom by frequently asking them questions and stimulating them to ask questions. The author also motivates students to study on a weekly basis through the application of frequent quizzes, consistently assigning a reasonable load of homework, and carefully designed exams. A combination of lectures, laboratory experiments, and course management software is used. The author uses a balanced combination of electronic media and traditional lectures on the whiteboard in which the author often demonstrates how to apply the theory to solve practical problems. This is a way to help each student develop problem-solving skills. To support classroom activities, the author has extensively used learning management system, such as Canvas®.

Some active learning approaches the author used in EET hands-on courses include:

1. Syllabus:

Syllabus improvement: the course educational objectives were restated based on Bloom's taxonomy² and Bloom's revised taxonomy.²⁴ Bloom's taxonomy is based on six levels of the cognitive domain: knowledge, comprehension, application, analysis, synthesis, and evaluation. Bloom's taxonomy uses a multi-tiered scale to express the level of expertise required to achieve each measurable student outcome. The summary of these main domains is from the Appendix (pp. 201-207) of Taxonomy of Educational Objectives.^{2, 25}

- **Knowledge** “involves the recall of specifics and universals, the recall of methods and processes, or the recall of a pattern, structure, or setting.”
- **Comprehension** “refers to a type of understanding or apprehension such that the individual knows what is being communicated and can make use of the material or idea being communicated without necessarily relating it to other material or seeing its fullest implications.”
- **Application** refers to the “use of abstractions in particular and concrete situations.”
- **Analysis** represents the “breakdown of a communication into its constituent elements or parts such that the relative hierarchy of ideas is made clear and/or the relations between ideas expressed are made explicit.”
- **Synthesis** involves the “putting together of elements and parts so as to form a whole.”

- **Evaluation** engenders “judgments about the value of material and methods for given purposes.”

The revised taxonomy adds a more dynamic classification for educational objectives, using verbs and gerunds to label their categories and subcategories as opposed to nouns of the original taxonomy. The action words describe the cognitive processes by which learners deal with knowledge.

- **Remember:** recognizing, recalling.
- **Understand:** interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.
- **Apply:** executing, implementing.
- **Analyze:** differentiating, organizing, attributing.
- **Evaluate:** checking, critiquing.
- **Create:** generating, planning, and producing.

In Table 1, the author makes a comparison of course learning objectives for an Electronic Communication course. Courses learning objectives before and after the use of action words from Bloom’s taxonomy.

Spring 2013 Upon successful completion of this course, students should be able to understand:	Spring 2014 Upon successful completion of this course, students should be able to:
<ul style="list-style-type: none"> • How noise and bandwidth affect the operation of communication systems, including noise designation (SNR, BER, noise figure); • Importance of frequency domain analysis (FFT) for communication systems; • Principles of oscillators and its use in communication systems; • Fundamentals of AM: percentage modulation, overmodulation, high percentage modulation; • Operation of AM generators and transmitters; • Operation of AM detection and receivers; • Fundamentals of FM: Bessel function analysis, narrowband/broadband FM, FM noise analysis; • Operation of FM generators and transmitters; • Operation of FM detection and receivers; • Superheterodyne principles in AM and FM receivers; • Single side band (SSB) communication. 	<ul style="list-style-type: none"> • <u>Explain</u> how noise and bandwidth affect the operation of communication systems, and <u>calculate</u> noise metrics (SNR, BER, noise figure); • <u>Explain and use</u> frequency domain analysis (FFT) for communication systems; • <u>Design and build</u> oscillators for communication systems; • <u>Explain</u> the fundamentals of AM: percentage modulation, overmodulation, high percentage modulation; • <u>Design and build</u> AM generators and transmitters; • <u>Design and build</u> AM detectors and receivers; • <u>Explain</u> the fundamentals of FM: Bessel function analysis, narrowband/broadband FM, FM noise analysis; • <u>Design and build</u> FM generators and transmitters; • <u>Design and build</u> FM detectors and receivers; • <u>Explain and use</u> the superheterodyne principle in AM and FM receivers; • <u>Explain</u> single side band (SSB) communication.

Table 1: Comparison of courses learning objectives for an Electronic Communication course. Courses learning objectives before (Spring 2013) and after (Spring 2014) the use of Bloom’s taxonomy.

2. Promoting Teamwork Skills:

In order to promote teamwork skills and to use student teams effectively, the author devoted a large amount of time to design good team assignments, construct teams carefully, teach teamwork skills, and assess student teams effectively. The author teaches teamwork skills in the first lecture or in the first lab session of each course. Students are also asked to develop a team contract template that would serve for any team work assignment, including final class projects and senior design. The author explains the team logistics, which includes teams and roles

assigned by the instructor as: coordinator, recorder, monitor, and checker. Homework, lab experiments, and other class assignments were assigned in teams. Also, in the first class meeting, the author discusses:

- Why teamwork skills are necessary.
- Characteristics of effective teams.
- Key stages: forming, storming, norming, performing.
- Establishment of ground rules.
- Managing group dynamics.
- Why teams fail.
- Types of conflict typical to group assessment tasks.
- Resolving conflict.
- Strategies for having a successful teamwork experience.
- Team contracts: team's purpose, roles for each member, norms of conduct, meeting times.

3. CATME Website:

“CATME SMARTER Teamwork prepares students to function effectively in teams and supports faculty as they manage their students’ team experiences.”²⁶ The instructor used CATME to help with team work assignments and assessment. CATME provides tools for assigning students to teams (especially important for large classes), self and peer evaluations, gather student information and provide feedback, team management, among others.

4. Homework Teams:

Students’ teams are formed to work on weekly homework assignments instead of working individually. The teams and roles of each student are assigned by the instructor. The roles are rotated for each homework and have the following tasks:

- **Coordinator:** organizes work sessions, makes sure everyone knows when and where to meet and what they are supposed to do, keeps everyone on task and makes sure everyone is involved during the meeting;
- **Recorder:** prepares final solution to be turned in;
- **Monitor:** checks to make sure all team members understand both the solution and the strategy used to get it;
- **Checker:** double-checks and submits the final solution.

Students must also:

- Agree on a common meeting time and what each member should do before the meeting;
- Do the required individual preparation;
- Meet and work. Agree on next meeting time and roles for next assignment before you end;
- **Checker** turns in the solution with the names of every team member who participated actively in completing it;
- Review returned assignments. Make sure everyone understands why points were lost and how to correct errors;
- Consult with your instructor if a conflict arises that cannot be worked through by the team.

5. Think-Pair-Share (TPS):

The author created assignments for lecture periods using the think-pair-share approach. For instance in an electronics communication course, the author developed several assignments using the TPS approach such as having students analyze a circuit diagram for a commercial FM broadcast transmitter. Another example of a shorter assignment would be to have students apply Kirchhoff's voltage law (KVL) and other circuit laws to a small circuit diagram.

6. Clickers:

The author also uses i-Clickers® for classroom short quizzes based on multiple choice problems to review material taught on previous lectures. Students have the tendency to lose their concentration just by looking at slide upon slide in the classroom. Incorporating breaks into the monotony of slides is very important in getting students to be more engaged and thereby more willing and able to learn the material. Furthermore, the exclusive use of PowerPoint (PP) during a lecture makes students more tempted to skip a lecture, in particular if the instructor makes the PP presentations available to students afterwards.²⁷

7. Collaborative Learning:

In EET, course collaborative learning is based on laboratory team work. The instructor selects all the partners for the entire semester. Students work with a different partner for each lab section forcing them to change their role instead of constantly doing the same type of task, such as only taking notes or only taking measurements. This is a practical way to train students to the workplace since they usually will not be able to choose the co-workers they will be working with on different projects. Team members are usually chosen based on the type of project, individual skills, among others.

It is a common understanding that the laboratory must serve as a learning resource center in which the students not only perform formal lab assignments, but also have the opportunity to use the equipment and computers to strengthen their understanding of the concepts presented in the lecture section.²⁸ We cannot stress enough the value of hands-on learning. The laboratory adds realism and solidity to the large number of topics that are covered in an EE course for non-majors. Students usually enjoy laboratory work, especially as it can be related to some of their own major interests. Therefore, it is imperative to choose experiments that provide students with real-life applications that are challenging but achievable, and most importantly that the lab experiments are tightly coupled with the lecture. We also receive input from our Industrial Advisory Board for experiments that would be beneficial for the students in their professional careers. Therefore, undergraduate laboratories require constant updating and development of new and innovative experiments each semester, which requires a fairly large amount of time on the instructor's side. The author frequently re-designs laboratory experiments and laboratory manuals, and updates/develops new teaching materials. In addition to well-chosen experiments, students' data should be checked before they leave the lab to make sure that it is at least acceptable to complete the lab assignment.

It is also of great use to have a computer on each bench that can be used for instrument control and data acquisition, data processing and plotting, and circuit simulation. The author encourages students to simulate simple circuits using software such as Electronics Workbench Multisim® by

assigning them simulated lab homework prior to the hand-on lab experiment. The simulations provide a link between the theory learned in class and the actual lab experiment. Computer-based lab experiments speed up student progress in hands-on experiments and make the learning experience in the lab more efficient. However, careful attention should be paid to avoid the use of simulation as a substitute for thinking, as can be the case for some students. Students are also stimulated to make circuit analysis of the lab experiment prior to the lab section.

8. Problem-based Learning (PBL)

The author frequently applies PBL final class projects. Examples of final class projects are:

- Design and build a FM transmitter/receiver pair for an electronic communication course;
- Design and build a function generator using Op-Amp circuits and discrete components for an Op-Amp class;
- Design and build a multistage BJT amplifier.

9. Learning Management System (LMS)

LMSs such as Canvas®, aTutor®, Blackboard®, Desire2Learn®, Moodle®, eCollege®, among others can be of great aid in active learning as it can be used to guide students to take a more active role in their learning. LMSs have a large number of functionality including: course content delivery (for self-service and self-guided services), portability, content personalization, reporting, tracking, grading, etc. It is a key mechanism for e-learning in colleges and universities worldwide. The practicability to allow course material delivery to be accessed by students at any place and time makes LMS strategically useful in active learning. LMS should be paired with traditional active learning techniques as much as possible. The author has been using LMS, in particular Canvas, to post lecture and non-lecture videos covering the course material, and to guide students on a variety of activities. Students activities include: watching videos and answering short quizzes, reading material before lecture, posting questions and discussions, working on pre-lab simulations, among others.

Discussions and Active Learning Methods Comparisons

The author has been applying active learning methods in EET and EE courses for the last eight years. From the author's own experiences, some methods yield better results for student's learning, easy to implement, class time, among others.

Think-pair-share: The author is particularly fond of this technique, which has proven very effective in inducing students' productive discussions in class and improved learning. The lecture time required depends on the type of problem, but the author usually selects problems that can be solved in five minutes or topics for discussion with a duration of five minutes. Students have demonstrated to like this approach as well. It doesn't require any use of technology, so it is "easy and cheap." Sometimes the author decides to give a problem or topic for discussion on the fly during the lecture depending on the student level of engagement or learning of the material.

Clickers: The author has used electronic clickers in several courses. It is an excellent method to test basic level of material retention and build lecture flow based on clicker results. The author has used the clickers in the beginning of lecture to test material covered in previous lectures. Any

question/material with less than 70% of correct answers is covered in class again for at least a few minutes. The problem with clickers is that it takes lecture time. The last time the author used i-clickers®, they required an additional receiver box for the classroom and would take a few seconds to display the histogram results for each problem. This resulted in taking more class time than the instructor wished. Another issue with the i-clickers was the cost. Students would be fine in buying the i-clickers if they had to use them in multiple courses rather than just one or a few. Unfortunately, this was the case in the author's department since very few instructors were using the same technology. More recently, the author has been giving short review quizzes in the beginning of class using paper clickers and visually counting the number of correct answers, which is fine with a class of less than 40 students.

Homework Teams: This method was used by the author for a few semesters. In general, the students positively accepted to work in teams, the overall grades increased, and visits to the office hours decreased. However, the need to find time to meet weekly generated a major issue for some of the students. Students quite often complained about conflicts to setup meeting times which was the major drawback with this method.

Collaborating Learning: The core of technology hands-on courses is based on collaborating learning, more specifically cooperative learning as most of the lab experiments are performed in groups, not individually. When it comes to lab experiments, working in teams is by far the most preferred practice by students. Students especially learn when lab experiments are well paired with the material covered in class during this period of time. Some of the students' comments in a recently taught course:

"Having a lab that correlate directly with the material covered in class helped significantly."

"I like how we went over the circuits in class, analyzed them and then constructed in the lab."

Problem-based Learning: This is another method very popular and applied by many instructors, especially in hands-on technology courses. The author uses a variety of problem-based methods in every single class in both EE and EET. Final class projects are always problem-based and comprehensive requiring knowledge of material covered during the entire semester. The results using this type of approach are always positive from the student learning perspective, hands-on, and positive comments from students. Example of comments:

"Keep the project (function generator)."

"The project is awesome. I loved every bit of it."

Use of Learning Management System (LMS): The author extensively uses LMS in every single course. Most of the instructors in U.S. colleges and universities are familiar with LMS and use some sort of system. I cannot stress enough the importance of pairing active learning techniques with LMS. The use of LMS has proven efficient in course teaching and a time saver.

5. Assessment

The assessment results have indicated that the instructional approaches used have been successful in meeting the teaching goals, which once again serves as evidence for the effectiveness of active learning as research studies have indicated. The success indicators were based on direct and indirect quantitative measures such as homework, short quizzes, exams,

written lab reports, class participation, hands-on-projects, and student surveys. In Table 2, the author compares the average results for main direct measures used in the course during Spring 2013 and Spring 2014. The results in Table 2 are based on students' assignments average in scale 0-100. In general, the feedback for the new approaches were positive. For the "team-based homework," students liked the opportunity to discuss in a group before submitting their final answer. However, several students reported on the difficulty to find a meeting time that wouldn't conflict with their busy schedule.

	Spring 2013	Spring 2014
Homework	80.1	91.8
Midterm	76.3	77
Lab reports	76.7	83.4
Quizzes	68.2	76.8
Final Exam	80.7	89.6

Table 2: Comparison of course direct assessment averages. Course direct assessment before (Spring 2013) and after (Spring 2014) the use of active learning methods.

5. Conclusions

The main goal of this paper is to share active learning strategies used to encourage active learning and engagement among students in face-to-face Electrical Engineering Technology (EET) courses. Active learning is a well-tested approach but not necessarily broadly applied by engineering faculty. They are usually encouraged to push through as much material as possible in a given session, while students remember more content if brief activities are introduced to the lecture.⁵ Engineering faculty should be aware of these methods and be encouraged to adopt what has proven to work.

The assessment results indicated that the instructional approaches used have been successful in meeting the teaching goals. Since the author has been implementing some of the additional active learning approaches discussed in the paper for only a few semesters, more data needs to be considered for more conclusive effectiveness of these methods in EET courses. The author strives for continuing improvement. In order to continue the teaching methods improvement cycle, direct and indirect assessment statistics will be constantly considered and used as feedback for courses modifications.

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