Active Methodologies in the discipline Electrical Installations I of Electrical Engineering: An Experience Report

Marcos Jolbert Cáceres Azambuja
Polytechnic School of the University of São Paulo, Brazil
São Paulo, Brazil
marcosjolbert@gmail.com / mjca@usp.br

José Aquiles Baesso Grimoni
Polytechnic School of the University of São Paulo, Brazil
São Paulo, Brazil
aquiles@pea.usp.br

***Abstract*— During the last centuries, the teaching-learning process had great transformations, especially regarding the relationships teacher/student, student/student, and student/content. This research article has the objective of presenting an experience report about active methodologies, its main characteristics, and present results through literature research, investigation with undergraduate students from Electrical Engineering at USP Politechnical School, in the Electrical Installations I course. Besides this, examples of active learning activities are discussed, in special in this experience report, the Flipped Classroom, the Project Method and PBL as activities that can motivate students regarding an autonomous and deeper learning, based on learning with new methodologies and dynamic activities. A questionnaire was developed and applied to students during the course period in order to evaluate active learning in engineering teaching. Among main results, the significant positivity attributed to the methodologies employed are emphasized. However, data allows the conclusion that active methodology utilization in engineering teaching can contribute to professional and personal student formation, as well as capacitation and updating of teachers.**

Keywords*— *Active methodologies, Active learning, PBL, Flipped classroom, Experience report

I. INTRODUCTION

Society currently demands more from thinking and updated individuals, capable of feeling, acting, and reacting in a broad, deeper, and fast manner. Following this reasoning, the teaching-learning process in the undergraduate teaching also goes through changes, by estimulating the student to search for autonomy, teach him to learn by doing, which means, through reading, abstraction, work group (team), and problem resolution. Thus, through the use of several methodologies the student can have a critical formation that brings him to think with autonomy and form his scientific spirit in an active manner, as a knowledge protagonist.

This research article has the objective of presenting an active learning experience report inserted in the undergraduate course identified as “Electrical Installations I”, from Electrical Engineering at USP Politechnical School, and also present the perception of students regarding the active methodologies applied in the course, having the data obtained through the questionnaire as proof.

This article also presents an opinion research that was taken, through an online questionnaire, with students that took the course in 2018. This course is offered once a year, with groups of approximately 50 students.

It is important to observe that the strategy of using active learning is born from the need to motivate fourth year students from the EPUSP electrical engineering course, and the exploratory interest from the authors of this research, which is very positive. With students whom are more actively involved and motivated, it is possible to predict a higher compromisse with learning and more efficient autonomy, since these students would commit more to the course.

The strategy of using the proposed active learning is a job to be done throughout the course. This work has the intention to foment the achievement of answers and solutions by the students, which places them as a knowledge protagonist, thus requiring more commitment and their involvement.

The student has a certain degree of control over resources and becomes an advisor to himself. However, this does not indicate that he should lose contact with the professor. According [1], student and professor need to have a parnership attitude and corresponsibility for the learning process. Communication with the professor is of great importance, since he should do the pedagogical mediation and then new ideas can come up.

It is interesting to point out that during the course students already face a broad vision of the impact of their future profession in the environment and the world that awaits them.

This article is structured as follows: the first section presents introduction aspects; the second section presents the Electrical Installations course; the third section presents Active Methodologies applied in the course; the fourth section presents a report of the experience and its unfolding subjects. At the end of the article, concepts, benefits, and factors are presented which could reveal a series of activities in which Active Methodologies can benefit Engineering Education.

II. ELECTRICAL INSTALLATIONS I COURSE

The “Electrical Installations I” course is an undergraduate discipline from the EPUSP (São Paulo University Politechnical School), located in the Energy Engineering and Electrical

Automation Department. It is a course offered in the seventh semester, fourth year of the Electrical Engineering course, emphasizing Energy and Electrical Automation, with an abbreviation of PEA3402.

This course offers two class credits and is equivalent to a total hour load of 30 hours and 1 work credit of 30 hours. Classes have 100 minutes per week.

The objective of this course is to develop systemic concepts for electrical installations and their connection with other areas of knowledge from electrical engineering.

The discipline is composed of expository classes, tests, exercises, and individual work that directly involves active learning with the following methodologies: Problem Based Learning – PBL, Project Based Learning, with this work done individually, throughout part of the course. It contemplates the delivery of study reports and analysis regarding a diagnostic of electrical installations in a real residence. Laboratory classes are given in another course, abbreviated PEA3401 – Electrical Installations Laboratory, with 2 class credits (4 classes of 50 minutes at every 15 days), which is offered in the same ideal 7th semester.

A. Active Methodology in the Electrical Installations I course

Introduction of active learning in the course is born from the need to motivate fourth year students from the EPUSP electrical engineering course, foment an interest to search solutions for real problems in the students, placing them as a protagonists of their own learning process, putting them in a commitment position with knowledge and their professional future, and taking them from a position of a simple spectator in the classroom. The exploratory search of the authors from this research and this experience report opens up new perspectives in teaching of EPUSP engineering, pointing to new paths for already existing applications.

The student learning process using active methodologies is more efficient, since students are involved in activities attributed to the course's content, with practical and real situations, in which they will face their professional daily routine in some of these situations.

Authors from this investigation used strategies like the introduction in the course teaching plan of the Flipped Classroom methodology, PBL, and Project Based Learning. In such pedagogical strategies, the students are active and involved in approaching and resolving problems of life real situations. One great advantage of this approach is that students interact with information about their own living space and thus acquire knowledge from their protagonism, so that they develop abilities, attitudes, and behaviors that allow them to better experience a work scenario during their studies.

However, active methodologies involve students in activities that place them as active agents in the cognitive process and make them think about what they are doing and the activity in which they are inserted. Students get engaged, live the active learning process, of facing ever more complex challenges, an spiral growth, of more simple levels to more complex levels of knowledge and competences, in all dimensions of their lives.

During the work, the students must make a diagnosis of consumption of some residence, which can be their own, estimating the demand of electrical systems, analyzing data, and proposing replacements or project reformulations. The student must have knowledge and take energetic efficiency into consideration, energy quality, and costs that involve environmental impacts in a real situation of the professional life.

Active methodology in the course and at work has the objective of developing critical spirit, capacity of analysis and synthesis, proposing student reflexion and conscientization about electrical installations in Electrical Engineering.

III. LEARNING THEORIES

A. The Structure of the Behaviorist Theory

In John Broadus Watson (1878-1958) is considered to be the founder of Behaviorism. The term behaviorism came to mean a concern with observable aspects of behavior [2].

Behaviorism is based on stimulus-response (I-R). Suppose that all responses (behaviors) are impelled by stimuli (conditions that lead to behavior). According to this theoretical line, behavior comprises responses that can be observed and related to other observable events as conditions that precede and follow it [2].

Watson reported that, its objective is to offer conditions that predict and control human beings [3]. It would predict what a subject would do in a given situation; when in action, which type of response would the subject be capable of having that the reaction could provoke.

Thus the objective of behaviorism is to infer laws that explain the existing relationship between external conditions (stimuli) and behavior (responses) [2]. The work of behaviorism is, given the stimulus, predict the response – given the response, predict the stimulus [3].

Watson (1928) [3], Guthrie (1935) [4], Thorndike (1935) [5], and Skinner (1991) [6] believed that behavior changes (that is, for learning to take place) and these two events (S-R) are needed (stimulus-response) several times or more frequently in other situations.

During these events (S-R), there should be reinforcement, for example: it is the teacher's responsibility to propose many exercises for the students in order to strengthen the connections that need to be learned – the practical aspect of the desired results (it should offer the learner positive reinforcement, such as a compliment) and at the same time discontinue the practice of undesirable connections (in this concept, the teacher should use negative reinforcement such as a punishment) [5].

The quantitative factor of repetitions and reinforcement are proportionally related to the performance of the user [5] [6].

Good teaching depends on efficiently organizing stimulating conditions so that the student leaves the learning situation different than they began it. Learning is a conditioning process using reinforcement of the responses that are desired [7].

There are a few principles that behaviorist instructors should follow [8]:

Instruction objectives: a key to the behaviorist Project is good understanding of the final objective of instruction. In behaviorist instruction, the instructor focuses on the objective of instruction and evaluations are based directly on it.

Task analysis: the instruction is analyzed from the final step to the beginning.

Observable stimulus-response association: this is made up of exposing the students to the stimulus that is associated with the desired response. For example, in a classroom the students are exposed to a problem. If most of them get it right, the teacher moves on. If not, the teacher repeats the exercise until the students are able to respond correctly.

Mastery and self-stimulation: Behaviorism requires the student to work continuously until the issue has been dominated.

Reinforcement: In behaviorism, learning must be reinforced.

B. The Structure of the Cognitivist Theory

Use Contrary to behaviorism, which is focused on human behavior, cognitivism analyzes the mind, the act of knowing, as a human develops knowledge about the world.

Cognitive philosophy thus mainly deals with mental processes; it is occupied in the attribution of meanings, of comprehension, transformation, storage, and use of information involved in cognition [9].

For teaching, this posture means that the students shouldn't be seen as a receiver of knowledge, not concerned with how the student stores knowledge and organizes it in their mind. At this moment, the students comes to be considered an agent of a construction that is their own cognitive structure [9].

The main idea is that the product developed by the student be different than that which is presented by the teacher. The emphasis of these learning approaches is on distributing ideas in the student's brain.

This construction isn't arbitrary. It is there that cognitive theories come in, seeking to systemize cognitive construction and explain and predict observations in this area.

In cognitive theory, information that is made available to the receiver serves as a starting point for something that will soon be developed in order to better build cognitive ideas; it's thought that the more different the aspects that are visualized, the better the final products will be. In the content exposed, the learner must have the opportunity to see the same topic more than once at different levels of depth and presented in different ways [7].

In cognitivist, the student becomes the active subject of learning. The student is no longer passive as in behaviorism. He begins to experiment, research, divulge, and develop reasoning. That students assimilate knowledge through the intermediary of tasks because the goal of this approach is to incentivize creativity and motivate learning through activity [10].

The principles for cognitivist education are [8]:

Focus on the main concepts to be learned: This involves guaranteeing that the student concentrates on the main characteristics of the concept that is being learned so that these main characteristics can be used to establish connection with the learner's prior knowledge.

Take advantage of the student's prior knowledge and experience: The objective of learning in the cognitive theory is to make connections between new information and information that is already in long-term memory. Instruction should begin with what the learner already knows.

Aim for deep processing of the information (learning with comprehension): the general idea of deep processing is that students must understand the structure of the information that is going to be learned such as the main ideas, how they inter-relate, and how sub-ideas can be derived from them. The information in long-term memory implies that there are very complex networks of association. The better the organization of this network, the easier it is to remember and use.

Actively involve the student in the selection, organization, and integration of new information: It is fundamental that the student be actively involved in creating the structure through deep involvement with the content.

Develop metacognitive knowledge that allows the students to control their own learning: all of the students should become independent learners that can define and monitor their own objectives and processes."

C. The Structure of the Humanist Theory

The The humanist theory is primarily focused on learning as a person. The student is seen as a whole (feelings, thoughts, and actions) – a holistic vision, not just an intellectual one.

The most important thing is self-realization of the person, their personal growth". In this focus, learning isn't limited to an increase in knowledge. It penetrates, it's visceral, and it influences that choices and attitudes of the student [9].

Rogers and Freiberg [11] give an excellent example of this application, calling it "student-centered learning", which was well-known in the 1970s.

The greatest objective of education is to facilitate learning. Instead of presenting Rogers theory [11], a series of principles for student-centered learning are proposed here.

Human beings have a natural potential to learn: Encourage the act of discovery in the student and increase their knowledge. This is the basic characteristic of Carl Rogers' focus.

Significant learning: The student learns significantly only when they perceive how to maintain and enrich their own "I". Rogers gives an example of two students – one of them develops a project which will require using the content of the course and the other does it only because it's obligatory. Individually, the learning will be different.

When the student notices that content is relevant to reach their objective, their learning is much faster.

Significant learning means acquiring knowledge through acts: One the most effective ways to encourage learning is to place the student in a directly confrontational experience with practical problems (social, ethical, philosophical, and personal) and with research problems.

Responsible participation of the student in the learning process: Learning is maximized when the student chooses their own directions and their own learning resources, when they formulate their own problems, decide on their own course of actions, and live with the consequences of each of their choices.

Independence, creativity, and self-confidence: Students must be given the opportunity to make their own judgments and their own mistakes. Self-criticism and self-evaluation are fundamental in helping the student be independent, creative, and self-confident.

Learning process: The student has to learn to learn. This means to be open to experience and have a continuous posture to seek knowledge.

The teacher a facilitator [11]. The teacher must have the following principles:

Authenticity: When the teacher is an authentic, genuine person, they completely show themselves to the student without needing imposition or authoritarianism.

Appreciation and confidence: The teacher values the student and accepts the student as they find them.

Empathic comprehension: create a climate of lived learning. It's an attitude of putting oneself in the place of the student and considering the world through their eyes. When there is sensitive empathy on the part of the teacher, the reaction of the student is to have better comprehension.

When these behavioral changes are adopted by the teacher, it facilitates lived and self-initiated learning, which increases the chance of significant learning [9].

The teacher begins to become a facilitator. It is the teacher that creates the conditions for the student to learn [11].

IV. Active Methodologies

The concept of Active Methodologies can be explained under the following view, it is an education that presupposes activity, instead of passivity, by the students. In this sense, it can be affirmed that learning by doing would be a good example of active methodology.

The student becomes a protagonist in active methodology, assuming more responsibility in his learning process, he starts to have an autonomy regarding it.

In addition, the student learns what is interesting to him, learns when finds an intimate ressonance with him, next to the development phase in which he is found. Several theoretical researchers like Rogers [11], Freire [13], and Piaget [14], among others, point to a different manner by which each individual learns in an active way, from the context in which he is found, what is significant to him, relevant and close to the level of competences that he has [15].

Deeper learning require practical spaces, environments rich in opportunities. Thus, the motivation of abstraction from theory and valorization of previous knowledge from students, motivate them to new knowledge.

There are three keys to the success of deeper learning: I want to learn, which means the motivation; know how to do it; and have an opportunity to do it [16]. If we don't try to do it, we probably will never learn. It is doing it or trying to that the student will learn how to do it [16].

In this sense, teaching and learning is fascinating when they are transformed in constant research processes, of experimentation and reflexion, of sharing in deeper and broader knowledge areas. The classroom is transformed in a privileged space for learning, in which students and teachers learn from concrete situations, from experiences, from problems, with resources that show up: simple or complex.

It is important to estimulate the creativity of each student, whom can evolve as researchers, discoverers in potential [15].

The role of the teacher as an advisor gains relevance. He helps students to overcome themselves, to encorage autonomy, guide, and motivate. After motivation, reading of texts and practice, with mediation of the teacher, students learned how they could reach a better development in their learning through the autonomous learning project.

Autonomous learning is when the apprentice realizes his individuality and assumes control over his experiences, choices, and tasks [17]. The student has more autonomy when he knows what he does and what is for, having a certain control over the goals of his learning activity [18]. He has consciousness about his learning process and becomes responsible for its improvement. The student has a certain degree of control over resources and becomes his own advisor. However, this does not indicate that he should lose contact with the teacher, since student and teacher need to have a partnership attitude and corresponsibility regarding the learning process [1]. Communication with the teacher is of great importance, since he must do the pedagogical mediation and then new ideas can come up.

Autonomous learning must be composed in one single process, with the folllowing principles [18]:

Capacity to act;

Capacity of having responsibility and reporting data from the chosen options; and

Capacity to construct student learning and learning self-regulation.

Because these principles and both practices have one objective: student development; if he is an autonomous apprentice or not.

In order for all of this to happen, chosen active methodologies applied in the Electrical Installations I course –

PEA 3402 were: Flipped Classroom, PBL, and Project Based Learning, which will be explained below.

A. Flipped Classroom

The There are several strategies to implement active methodologies. One of them is the Flipped Classroom. It can be classified as a teaching modality or as a teaching methodology [19] and [20].

The idea is not new, since the practice of reading texts before classes is already common, for example, classes that involve presentations and discussions from students, which is, classes less centered on the teacher.

With the advancement of Information and Communication Technologies – TIC, the Flipped Classroom proposal is coming out in a moment of great opportunities. Most students have these technologies available and are using them, correctly or not, in their learning processes.

During the Flipped Classroom approach, the content and instructions received are studied online, before the student enters the classroom, using TIC, especifically in virtual learning environments [19]. The classroom becomes a place to work the contents already studied, having practical activities such as problem resolution and projects, group discussion, and laboratories.

In the Flipped Classroom model, the time hour/class is totally restructured. Students still need to ask questions about the content that was transmitted to them through the video [20].

Let's take an example of the time use in the Flipped Classroom methodology and the function of the teacher in the methodology. The class starts with a session of questions and answers. Students ask about the viewed video that was made available in the learning virtual environment, and the professor clarifies doubts and possible misconceptions. After this beginning, the professor instructs the students regarding the resolution process of practical problems. He conducts the students to other problems and new topics. Teacher mediation at this point is fundamental, since all students receive a timely feedback in order to clarify doubts and correct mistakes.

Basic rules for a Flipped Classroom, according to the Flipped Classroom Field Guide, are:

- Activities in the classroom must involve a significant amount of questioning, problem resolution and other active learning activities;
- Students must receive feedback immediately after the completion of presential activities;
- Students must be motivated to participate in online and presential activities, with them being considered in the student's formal evaluation, which is, they are worth a grade;
- Both the material to be used online and learning environments in the classroom must be highly structured and well planned.

The Flipped Classroom has been a solution implemented in renowned universities, such as Harvard University and Massachusetts Institute of Technology (MIT) [20].

Technological advancements, educational technologies, and active methodologies have a potential to minimize evasion and disapproval levels.

V. EXPERIENCE REPORT AND ITS UNFOLDING

During The objective of the course is to bring the student to evaluate an electrical installation in a real residence. In addition, it is expected that students motivated about autonomous study can evaluate technical impacts, be capable of planning electrical installations, study the demand of electrical systems, among other actions, according to the course ongoing status.

The following main objectives are also defined:

- Allow the student to evaluate the energetic consumption of a residence and estimate the demand for electrical systems of buildings;
- Develop notions about energy quality with the student, automations in electrical installations and energetic efficiency; and
- Allow the student to have notions regarding grounding systems, have clarity on the importance of norms, as well as comprehend and apply graphic representations of electrical installations.

The course work was divided in five steps. At each step the students must make an invididual report, regarding each phase of study done in the residence. This report mut be consolidated, containing data about his studies, analyses, comparatives and comments about the reseearch done. In addition, one presentation is shown to the classroom regarding these studies.

Step 1: Data collection and detailed survey

Students must collect data regarding the electrical instalations through a detailed survey of the consumption points, characterized by several types of plugs, ilumination points and the manner to activate them, by the measuring system at the residence entrance, and the boards of distribution with their internal elements, such as phase bars, neutral and grounding, circuit breakers, residual differential switches (IDR) and/or integrated circuit breakers with residual differential switches, Protectors against outbreak, electroducts, and cables.

Step 2: Electrical Network Drawing

Through collection of information using an adequate symbology, the students can draw the electrical netwok over the civil scheme. They can make an estimate of the possible traject for electroducts and cables from circuits that leave the distribution boards and go around the residence in slabs, walls or floors, to each plug, ilumination point, and switches that command these ilumination points. Students also survey data, through visualization and pictures of the distribution board internal part, of devices, such as nominal currents for circuit breakers and DRs. Then, they estimate mm² sections for cable gauges. In addition, students make a check-list of fundamental

components that must exist in a well designed and constructed board. With all of these data it is possible to analyze if a project is done correctly, which is, if the number of circuits are adequate, if there is no overcharge in each circuit, and if the gauges and circuit breakers are adequate to the type of cable and number and type of plugs. The work principle and main characteristic of devices, such as circuit breakers, DRs, electroducts and cables, are presented to the students during the classes.

Step 3: Videos about best practices in Electrical Installations

Some short videos of approximately 10 minutes were recorded as part of the information regarding best practices on electrical installations of a residence, and how to dimension cables, DRs, and circut breakers.

Step 4: Verification of application for Active Methodologies

The reports delivered by the students on several steps of the diagnosis work showed an evolution in quality and understanding of the contents approached. Results of performance in the tests and exercise lists also showed an evolution in understanding and application of concepts connected to the themes discussed in the course. The students also reported a higher learning degree with this active strategy, since concepts were more solid, due to their direct involvement with a real system from an electrical installation connected with their routine. This increased their motivation in performing the activitiy, finding out real problems, and searching for solutions.

VI. Final Considerations

In the context of active methodologies, several strategies have been employed to facilitate and favorably influence autonomous attitudes and student's practical performances. Teaching-learning based on active methodologies allows an exchange of experiences and knowledge, allowing the students to live new challenges and also innovation, which points out to basic values of recognition in large institutions of superior teaching.

Currently it is not easy to compete with technology and facility of information spreading, access to information and content from digital devices, which brings the teacher to research and elect the best or the most adequate methodology that seems pertinent regarding the efficiency of his own didatic practice, in function of his course and/or his students.

The use of active methodologies in the course "Electrical Installations I" was more efficient, since it allowed the students to get involved with a problem connected to their routine, which is the case of a diagnosis of electrical installation in their own residence.

Finally, it is necessary to emphasize how valid were all efforts from the authors, in search of a more innovative education, critical, reflexive and human, which focus is to develop complete individuals, competent, and conscious of their role in society, as creative engineers, inventive, articulating, proactive, capable of transforming their surroundings and making a better world with their professional knowledge.

Acknowledgment

Special thanks to CNPq, National Council for Scientific and Technological Development (CNPq), for the doctoral scholarship of Marcos Jolbert Cáceres Azambuja.

References

[1] Masetto, M. T. Competência pedagógica do professor universitário. 1. ed. São Paulo: Summus, 2003

[2] Lefrançois, G. R. Teorias da aprendizagem: o que a velha senhora disse. 5. ed. São Paulo: Cengage Learning, 2009

[3] Watson, J. B. The ways of behaviorism. New York: Harper & Brothers, 1928

[4] Guthrie, E. R. The psychology of learning. New York: Harper, 1935

[5] Thorndike, E. L. The psychology of wants, interests and attitudes. New York: Appleton-Century Crofts, 1935

[6] Skinner, B. F. The behavior of organisms: an experimental analysis. New York: Copley Pubblishing Group, 1991

[7] Ostermann, F.; cavalcanti, C. J. DE H. Teorias de Aprendizagem. 1. ed. Porto Alegre: Evangraf; UFRGS, 2011

[8] Newstetter, W. C.; svinicki, M. D. Learning theories for engineering education practice. 1. ed. England: Cambridge University Press, 2014

[9] Moreira, M. A. Teorias de aprendizagem. 2. ed. São Paulo: Editora Pedagógica e Universitária, 1999

[10] Morais, L. DA S. Teorias de Aprendizagem e Arquiteturas Pedagógicas: a relação entre ambas no ensino a distância. EAD em Foco, v. 2, p. 111–126, 2014. http://eademfoco.cecierj.edu.br

[11] Rogers, C. R.; freiberg, H. J. Freedom to learn. 3. ed. [S.l.]: Pearson, 1994

[12] Mattar, J. Metodologias Ativas Para a Educação Presencial Blended e a Distância. 1 ed. Penso, 2018

[13] Freire, P. Pedagogia da autonomia: saberes necessários à prática educativa. 27. ed. São Paulo: Paz e Terra, 1996

[14] Piaget, J. Psicologia e pedagogia. Rio de Janeiro: Forense Universitária, 2006

[15] Moran, J. Bacich, L. Metodologias Ativas para uma educação inovadora: uma abordagem teórico-pedagógica. Porto Alegre: Penso, 2018

[16] Murphey, T. Learning to surf: structuring, negotiating, and owning autonomy. In: Barfield, A. & Nix, M. (Orgs.). Autonomy You Ask! (p. 2-10) Tokyo: The Learner Development Social Interest Group of the Japan Association for Language Teaching, 2007

[17] Usuki, M. Learner autonomy: learning from the student's voice. CLCS Occaional Paper, 60. Dublin: Centre for Language and Communication Studies, 2002

[18] Rué, J. El aprendizaje em Autonomía: possibilidades y limites. São Paulo: EdUSP, 2009

[19] Valente, J. A. Blended learning e as mudanças no ensino superior: a proposta da sala de aula invertida. Educar em Revista, n. 4, p. 79-97, 2014

[20] Bergmann, J.; SAMS, A. Sala de Aula Invertida. Uma Metodologia Ativa de Aprendizagem. 1 ed. LTC. 2016.