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Proposal for a relationship between educational paradigms and engineering teaching-learning techniques

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Abstract— For centuries, engineering teachers have used educational paradigms and teaching strategies or techniques that are primarily associated with the repetition of teaching practices based on successful models they have seen, without understanding them more fully. The internationally renowned normative framework ABET has redefined the role of engineering education, including professional skills, such as leadership, communication, understanding of ethics, the ability to work in teams and engineering professionalism in a context. global and social, promoting lifelong learning, and knowledge of contemporary issues. These competencies demanded by these organizations, it is necessary to use teaching-learning teaching techniques in the classroom. As a result, the need to analyze the role and purpose of engineering educators is essential in the context of this research, guiding to understand the complex teaching and learning process of their students. This bibliographic review provides the engineering teacher with a guide of what teaching technique can be applied in the classroom, according to the skills and abilities that they want to develop in their students.

Keywords— education; learning; teaching techniques; competencies; engineering education.

Propuesta hacia una relación entre paradigmas educativos y técnicas de enseñanza-aprendizaje en ingeniería

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Resumen— Durante siglos, los docentes de ingeniería han utilizado paradigmas educativos y estrategias o técnicas de enseñanza que se asocian principalmente a la repetición de prácticas de enseñanza basadas en modelos exitosos que han visto, sin comprenderlos de manera más exhaustiva. El marco normativo de renombre internacional ABET ha redefinido el papel de la educación de ingenieros, incluidas las habilidades profesionales, como el liderazgo, la comunicación, la comprensión de la ética, la capacidad de trabajar en equipo y la profesionalidad de la ingeniería en un contexto global y social, fomentando el aprendizaje permanente, y el conocimiento de temas contemporáneos. Estas competencias que exigen estas organizaciones, es necesario utilizar técnicas didácticas de enseñanza-aprendizaje en el aula. Como resultado, la necesidad de analizar el papel y el propósito de los educadores de ingeniería, es algo esencial en el contexto de esta investigación, proporcionando una guía para comprender el complejo proceso de enseñanza y aprendizaje de sus estudiantes. Esta revisión bibliográfica, brinda al docente de ingeniería una guía de qué técnica didáctica se puede aplicar en el aula, según las habilidades y destrezas que desee desarrollar en sus alumnos.

Palabras Clave— Educación, aprendizaje, técnicas de enseñanza, competencias, educación en ingeniería.

1. Introduction

During the first half of the twentieth century, in the United States the Engineers' Council for Professional Development, defined engineering as the creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation and safety to life and property [1]. Years later, this same organization (now renamed as Accreditation Board for Engineering and Technology - ABET) redefined engineering as a professional who is more involved in the problems which affect and concern society: "Engineering is the knowledge of the mathematical and natural sciences, gained by study, experience, and practice, applied with judgment to develop ways to economically utilize the materials and forces of nature for the benefit of mankind" [2]. As can be seen, the association with the natural sciences remains within this definition, but a new link to mathematics has also been added [3]. In this new definition, it also highlights that engineering needs to be beneficial for humankind. In this sense, the key point of promoting that engineers behave ethically based on knowledge and rationality, shows how they must deal with questions like: which social systems are affected by the projects; the people involved, their interests or purposes; and how scientific knowledge must be used to legitimize these goals or purposes [3].

Notwithstanding this, ABET has currently redefined education and the role of the engineer, including professional abilities like leadership, communication, teamwork and the understanding of engineering ethics and professionalism in a global and social context, encouraging permanent learning and knowledge of contemporary matters [4]. Preparing, in this way, an engineer who is trained to identify, formulate and solve society's real problems [5].

The prestige of engineering in general, is undoubtedly the result of the extensive and successful trajectory of construction works and

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projects, mainly in the infrastructure setting. These have decisively contributed to reaching lifestyle standards, which were unthinkable until only recently. However, society's evolution, rapid scientific advances, the appearance of new values and patterns of social conduct and the spectacular development of communications, demand profoundly reexamining certain aspects of engineering, both in academic and professional education [3,6,7].

On the other hand, the challenges facing education in engineering today are not always easy to solve in practical terms, because often engineering problems and their solutions tend to be poorly structured [8], or even as Rittel and Webber [9] declare, such problems can be "wicked", which means that they do not give definitive answers simply by following rules. However, from the perspective of the educator, it is also possible that the participation process and commitment can be defined as single, double and triple-loop learning [9, 10]. Single-loop learning refers to the development of skills, practices and actions that allow answering the question: are we doing things right? i.e. procedures and rules. Double-loop learning facilitates to evaluate assumptions and underlying models regarding why something works, allowing answering the question: are we doing the right things?, i.e. insights and patterns. Finally, triple-loop learning allows reflecting, changing values and norms, that is the basis to answer the question: how do we decide what is right? i.e. principles. This leads to the principle that engineering involves reconceptualizing a complex situation to facilitate analysis; including the definition of the problem, and not just the solution of it [11]. In other words, for Argyris and Schön [12], learning does not appear when an educational problem is invented and solved, but rather learning must be linked to action; it happens when you act to achieve the desired objectives.

As a result, different universities around the world are teaching and reinforcing service-learning and different teaching or technical strategies focused on stimulating active learning in engineering education [13-16]. To prepare an engineer able of identifying, formulating and solving real problems, in a world in which knowledge, technology, communication and globalization grow exponentially [4,17,18].

Having said this, one of the failings overtime of the study programs for this subject has been a predominantly traditional learning-teaching methodology, where out-of-context teaching and memory learning prevail [19,20], which is why different factors are having an impact on this traditional learning. These include the demands of the study plan, the base study material, the methodology, teaching strategies, among others. These are linked to the students when they begin their degree studies, where the prior preparation the youngster has to face the profession, as well as the professional motivation, play an important role [21-23].

It is for this reason that an urgent need for change has arisen, not just in the content, but also in the educational methods and approaches in engineering, where the teaching staff must look at the way of creating settings, which support learning, adapting teaching processes to the needs and characteristics of each student [24].

Therefore, it is necessary to face what has been an obstacle up until now, namely modifying or improving educational practices, overcoming the lack of confidence and knowledge about different pedagogical approaches and teaching strategies, a challenge that a high number of educators feel is not so easy to face [25].

Therefore, due to the obstacles that engineering education faces today, questions arise such as: are the methodologies used by educators to teach effective? Are such methodologies related to the type of learning that educators want to achieve? What teaching techniques or methodologies are used most frequently in engineering? Are strategies oriented towards teaching or learning? These questions will be discussed throughout this manuscript.

Said the above, then in Fig. 1, a flowchart with the research methodology is shown, to carry out the bibliographic review from an integral perspective.

2. Educational paradigm

Knowing a pedagogical movement, a learning model, a teaching theory is not reading this in a student's manual, it is not even an article published in a professional journal. Knowing something in depth is heading to the sources, to the most representative authors, to the trains of thought these are supported by. Only in this way it is possible to discover the origin and the generation of theories, approaches and models that these present [26,27].

A paradigm is a general thought of the theme of the study of science, of the problems that must be studied, of the method that must be used in the research and of the ways to explain, interpret or understand, as is the case, the results obtained through the research [28]. For Patton [26], the paradigm indicates and guides its followers in terms of what is legitimate, valid and fair. Namely, it allows the researcher to be able to see the reality from a certain perspective and, as a result, will determine largely, how they carry out their research process and how they will acquire knowledge.

As a result, paradigms become patterns, models or rules for the researchers to follow in a determined field of action. Many authors refer to three forms of approach to the educational reality (paradigms) with some inspired by positivism, by constructivism (sometimes called interpretative or symbolic), and finally by the socio-critical paradigm [29,30]. However, recently a new learning approach is being studied and researched. This is the Critical Communicative approach. It contributes to overcoming educational and social inequalities, encouraging the social inclusion of groups in the least favorable situations [31]. These educational approaches will be shown in Table 1.

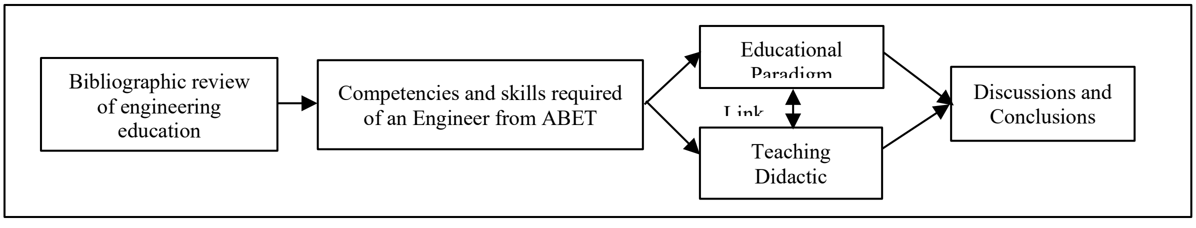

Figure 1. Research Methodology: A comprehensive vision from ABET.
Source: Elaborated by the authors.

Table 1.
Comparison of research educational paradigms

Dimensions	Positivism	Constructivism	Socio-Critical	Critical Communicative
Pioneers and seminal authors who developed the paradigm	Auguste Comte, Saint-Simon, David Hume, John Stuart Mill	Jean Piaget, Lev Vygotsky, David Ausubel, Jerome Bruner	Theodor Adorno, Max Horkheimer, Jürgen Habermas, Karl-Otto Apel	Jürgen Habermas, Ramón Flecha, Lidia Puigvert, Aitor Gómez, Jesús Gómez
Epistemology	Based on objective realities	Based on social and subjective construction	Based on dialectics	Based on a communicative and consensual construction
Methodology	Quantitative: experimentation, observation	Qualitative: interpretation, hermeneutics	Socio-critical: dialectics	Critical Communicative: encourages consensual dialogues
Social orientation	It finds to represent and explain facts	It interprets social reality	It transforms social organizations by practicing	It transforms the society using communicative action
Method of construction of meanings	Deductive-inferential	Inductive	Dialectic	Dialogic
Relationship of subject-object study	Independent relationship, where the subject discovers the meaning of the object	Interdependent relationship, where the subject interprets the object	Dialectic relationship, based on reflexion and action	Dialogic relationship, based on reflexion and intersubjectivity, breaking the epistemological imbalance
Information gathering technique	Quantitative	Qualitative	Quantitative and qualitative	Quantitative and qualitative, with communicative orientation

Source: Data from [27,29,31]

In positivism the student is a receiver and assimilator of knowledge, solving engineering problems individually and objectively, seeking to observe, verify and justify the knowledge acquired, through empirical sciences [32]. In the constructivist paradigm, learning is essentially active, where the student creates and develops new knowledge; it interacts with the object of study and with his/her partners, interpreting reality together [33,34]. On the other hand, in the socio-critical paradigm, students solve engineering problems reflexively, critically and collectively to transform social reality, by using both quantitative and qualitative techniques [35-37]. Finally, the critical communicative paradigm builds knowledge through critical and reflexive dialogue [31]; covering not only real engineering problems, but also social problems, where both expert and non-expert knowledge is validated [38].

These four educational paradigms have the purpose of clarifying and offering solutions for the challenges laid out by education over the centuries, where each paradigm has: (1) a way of seeing and understanding the educational reality; (2) an epistemological different dimension, that is to say, a different relationship model between who researches and said reality and, (3) a different methodological dimension, namely, these differ in how knowledge is obtained. Due to the advent of these currents of learning or educational paradigms, teaching techniques arise to improve the teaching-learning process of students.

3. Teaching techniques in engineering

Teaching techniques are organized, formalized procedures oriented towards obtaining a established goal. Said in another way, this is the planning of the teaching-learning process for which the educators choose the strategies and activities they can use to reach the proposed goals, along with the decisions they can consciously and reflexively make [39-43].

Brown and Atkins [44] make a categorization of the different teaching strategies or techniques (see Fig. 2), following this criterion: on the left, one would have the master class where the participation and control of the student are minimal. Here you have the explanatory classes, where the educator's control dominates the learning strategies. While on the opposite polar end, one finds an individual or autonomous study where the educator's control and participation are minimal.

Over the years, new teaching methodologies and techniques have arisen that promote greater participation of the student in the classroom rather than the teacher. An example of these innovative initiatives is the Flipped Classroom (FC), a pedagogical model with a constructivist approach, which transfers the work of certain learning processes outside the

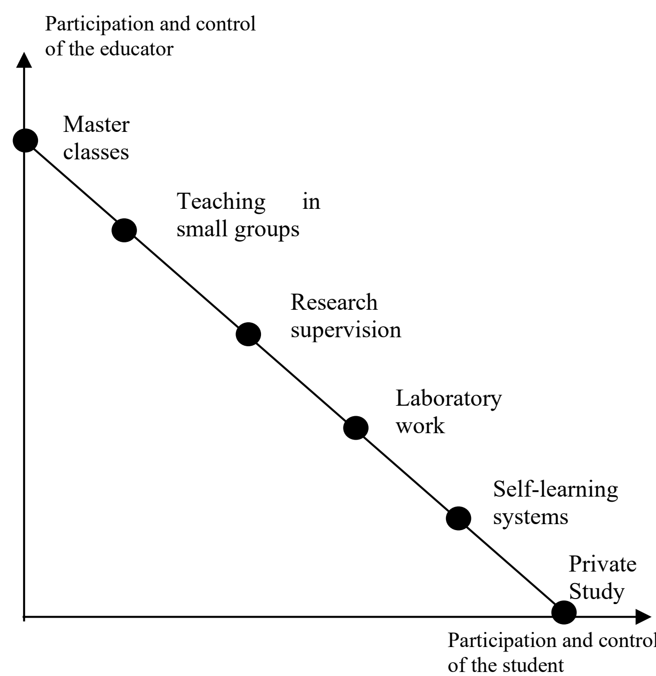

Figure 2. Learning classification: Control-autonomy core.
Source: adapted from Brown and Atkins [44].

classroom and use class time, along with the experience of the educator, to facilitate and enhance other processes of knowledge acquisition and practice within the classroom [45]. On the other hand, new Information and Communication Technologies (ICT) have been developed, becoming naturally part of university teaching, in line with different motivations and academic competencies that students require [46]. However, ICT does not replace the educator, but rather they have become a powerful resource, whose incorporation includes new platforms and capacities to record, store and disseminate knowledge, allowing the development of new content, study methodologies and ways to evaluate, where the educator is now a knowledge facilitator. In this sense, new innovative initiatives have emerged. Just to mention an example, Rapid Prototyping is a manufacturing technique that allows fast manufacture of 3D computer models, achieving functional prototypes, shortening design time, and leading to successful final products [47]. In summary, during the last few years, engineering educators have taken on the challenge of reforming engineering education, by using new tools and techniques to significantly improve the teaching-learning process.

In line with the above, didactic techniques are classified into three main groups: a) focused on educator participation, where the knowledge is delivered to the student in a closed and controlled scenario, through master classes, which leads to limited construction of knowledge, and less understanding on the part of the student; b) focused on student participation, where he/she is who builds his/her knowledge, being the protagonist of the learning process. This technique responds to the new competencies that students need to develop and strengthen, as well as the demands of the labor and social market; and c) focused on the shared participation between educator and student, helping the student to learn significantly and solve problems, according to the academic demands in conjunction with the educator. This allows the educator to provide and teach the student the tools and resources necessary to facilitate a deeper process of knowledge acquisition, getting the learning will last over time. In other words, the educator must guide, support and motivate the student in his/her learning process. Below is a brief explanation of the main teaching strategies used in engineering under the precepts mentioned above.

3.1. Participation and control of the educator

- Traditional Teaching: The educator is the provider of already prepared and studied knowledge. The student is only the receiver of this knowledge, which is presented in an objective manner that is rarely questionable [48,49].
- Educator Tutoring: The students are guided to support their learning process, performing a personalized follow-up on the weaknesses and strengths that appear in the subjects taught [50].
- Demonstration: Practical or theory verification of a concept that is not easily understood, to provide evidence or convince when doubts may arise, covering a need for demonstration [51].
- Symposium: A team of experts successively demonstrates to the audience, different aspects of a subject or problem, supported by empirical research data. Finally, time is given to ask questions and answer them [52].

3.2. Participation and control of the student

- Case Study: This focuses on the students investigating a real, specific problem, which allows them to acquire the basis for an inductive study [53].
- Discussion 66 or Phillips 66: Consists of forming groups of 6, looking to discuss or analyze a topic, trying to give a common response in six minutes to the topic that was initially proposed [54].
- Round-table: Communicative method where groups of students meet to discuss a topic in particular. There is a coordinator per group, who introduces the topics and keeps order for the conversation. At the end of the sessions, the students conclude and ask questions to the other groups to get feedback about what has been learned [55].
- Conceptual Map: The students must hierarchically connect and record concepts. It is characterized by starting from the main topic, making branches, which indicate the relationships between concepts [56,57].
- Mind Map: Graphical way of expressing the student's thoughts following the knowledge that has been stored. Its application allows generating, organizing, expressing the learning and associating the ideas more easily [58].
- Cooperative Learning: This considers an interaction philosophy that is broadly used in different teaching strategies, where students work together in small groups to guarantee that all the group's members reach the targets that have been set [33,59,60].
- KWL (what we know, what we want to know and what we learn): This allows exploring the prior knowledge the students have, inquiring what they know (K); what they want to know (W) and finally, what they have learned (L) [61].
- PNI (Positive, Negative and Interesting): This allows generating a large number of ideas about an event or observation, leading the students towards listing all the points that are relevant to a situation and ordering them into positive, negative and interesting points [62].
- KPSI (Knowledge and Prior Study Inventory): This provides the students with a tool for their self-regulation, where the answer options are: (1) I do not know or I do not understand; (2) I am not sure if I know; (3) I think that I know what it means, but I could not explain it to anyone; (4) I know and understand this; and (5) I can explain this and teach it to my classmates [63,64].
- Ideogram: This consists of the synthetic or schematic description of a piece of text through the prioritization of concepts and the definition of their relationships [65].
- V Diagram: A "V" is drawn, where the question being reviewed is put in the middle. The right side of the "V" indicates the methodology to compile, interpret and evaluate the information needed to answer the core question. On the left side, the related concepts are defined [66].

- Learning by Discovery: The students must explore via didactic experiments and research, following the objectives that the educator presents them with. This promotes meta-cognition in the learning process [67].
- Student seminar: This is characterized by the active participation of small groups that are educator-led, using dialog and flexible research. This develops the participant's reasoning and metacognition [68].
- Survey: This is a strategy where the students fill out a survey about a sample of subjects that represent a large population, using standardized questioning procedures. The objective is to obtain quantitative and qualitative information about a large variety of subjects [69].

3.3 Shared between the educator and the student

- Explanatory Teaching: The student's participation is limited but is not zero. This is evident as they ask questions or make comments to the educator, activating the learning process [70,71].
- Workshops: The students apply their knowledge, abilities, skills and attitudes in practical learning experiences, helping them solve problems and develop critical thinking [72].
- Project Learning (POL): This is based on the application and integration of knowledge. The students plan, implement, evaluate and solve real projects outside the classroom, developing long-term interdisciplinary learning activities [73,74].
- Problem-Based Learning (PBL): It was developed and implemented during the sixties at the Medical School of McMaster University in Canada. Its application has spread in other disciplines, such as engineering, in countless universities around the world. This consists of obtaining knowledge as a result of an exploration process towards new concepts via problem-solving, aiding the professional knowledge acquisition [20,75].
- Simulation: The students learn via participation in activities that simulate real situations, using a series of tools that allow creating multiple scenarios of different complexities [75,76].
- Debate: Here they learn to exercise and receive affective-social interaction, within a setting of respect and cordiality. They develop communicative, cognitive and social abilities [77].
- Critical questioning: This consists of the preparation of questions that stimulate the students to examine ideas, notions and problems related to a case provided by the educator, stimulating an in-depth reflection about the problems [78].
- Portfolio: This is a compilation of activities and works done by the students, which allows the educator and student to reflect on the achievements and difficulties found throughout the training period [79,80].
- Journal or Logbook: This comprises research done by students through books, lectures, news, events and research experiences. It does not last as long as the portfolio, with the progress and its results being reported to the educator [81].
- Interview: Scientific research technique that uses verbal communication to compile information related to a given purpose, through a precise reciprocal exchange conversation [82,83].
- Brainstorming: This is a group technique which looks to generate original ideas in a relaxed setting, where the best ideas are then chosen by the participants [84,85].
- Virtual Forum: This facilitates the creation of settings that stimulate learning and critical thought, where everyone virtually forms part of the group dynamic and learning process, which then will serve as the basis for relevant analysis [86].
- Role-Playing: The students take on roles within a task or situation that has been set out, allowing them to discover new facets of their imagination and helping them to think about multiple alternatives for a problem [87].
- Observation Technique: This requires that the students look, from a descriptive perspective, at objects, processes, phenomena or behaviors, whether natural or social, to then apply the knowledge acquired to solve real problems [88].
- Service-Learning: Educative proposal which combines learning and community service processes in a single well-articulated project, where the participants learn while they work, about the real needs of the setting, looking to improve these [89,90].

It is because of this, that to facilitate the student's repetitive learning while learning (storing, assimilating, integrating, transferring information, creating, innovating and experimenting), it is necessary to flexibly use different teaching strategies for engineering. In this way, the use of new teaching strategies influences the educator's role in the teaching-learning process as a facilitator, as it is the learning and development which provides the student with the necessary abilities to solve real problems in a globalized world. A world where these are required, not just as an engineer, but also as a citizen, seeking a social transformation, through critical and reflexive communication.

4. Relationship between educational paradigms and teaching techniques

Next, a table will be provided that guides the educator about how to train students of engineering, according to the paradigm that predominates in his/her teaching, in order to identify the most coherent strategies regarding with his/her way of conceiving reality and learning. The paradigms that have built an educational reality for years are linked to teaching techniques for engineering education, classifying these techniques or strategies in terms of whether the control or autonomy is in hands of a) the educator; b) the student; or c) shared between both of them. This allows the educator to know if his/her role will be:

- To be a protagonist, who aspires to explain and control;
- To be a mediator and facilitator of knowledge in the classroom, promoting active learning with the goal of understanding and interpreting;
- To promote equal dialogue with students for the construction of knowledge, aspiring to emancipate and criticize, using promoting a balanced and shared path between student and educator;

To evaluate the learning process-oriented either to the process or the result, in an objective, subjective or intersubjective way.

Table 2 shows the relationship between educational paradigms and the most common teaching techniques in Engineering.

As each didactic strategy is part of an educational paradigm —which has sought to build an educational reality throughout history— these were linked to provide a guide for engineering educators that allows them to determine which paradigm they relate to the didactic strategies they are using. Thus, as previously mentioned, the educator can decide if he/she wants to be the protagonist in the classroom or rather a mediator and facilitator of knowledge; if he/she aspires to explain and control; or understand and interpret; or emancipate and criticize; or if he/she aims to promote egalitarian dialogue for the construction of knowledge. Therefore, the educator must know which paradigm dominates in his/her teaching process or in which one he/she feels more comfortable to teach, applying then the teaching strategies according to the paradigm that he/she promotes in the classroom.

As an example, if the educator enters Table 2, he/she realizes that he/she teaches strategies with a positivist approach and if he/she wishes to migrate towards the constructivist approach - that students are protagonist in the classroom and interact with the object of knowledge and with their peers - then he/she must apply strategies such as PBL, case studies, portfolios, workshops, simulations, among others. On the other side, if the educator wants to develop the critical and reflective thinking of students to find concrete solutions for a social transformation, that is, the socio-critical paradigm, then he/she should apply strategies such as debates, critical questions, round tables, expository teaching, etc. Now, if the educator wants to contribute to overcoming educational and social inequalities, promoting social inclusion, that is, the critical-communicative, then he/she should apply strategies such as service-learning. In this way, the map is drawn and the educator must choose the way throughout it.

Table 2.
Relationship between educational paradigms and teaching techniques — Part 1.

Teaching techniques	Positivism	Constructivism	Socio-Critical	Communicative Critical
Teacher-centered participation				
Traditional teaching	X			
Teacher tutoring	X	X		
Demonstration technique	X			
Symposium	X			
Shared participation between the teacher and the student				
Expository teaching		X	X	
Workshop		X	X	X
Project oriented learning		X		X
Problem-based learning		X		X
Simulation		X		X
Student debate		X	X	X
Critical questions		X	X	
Portfolio		X		
Logbook		X		
Interview		X	X	X
Brainstorming		X		
Virtual forum		X		X
Role play		X		X
Observation technique	X	X	X	
Service-learning		X		X

Source: Elaborated by the authors.

Table 2.
Relationship between educational paradigms and teaching techniques — Part 2.

Teaching techniques	Positivism	Constructivism	Socio-Critical	Communicative Critical
Student-centered participation				
Case study		X	X	X
Discussion 66		X	X	X
Round table		X	X	X
Conceptual map			X	
Mental map			X	
Cooperative learning		X		X
K-W-L		X		
PMI		X	X	
KPSI		X		
Ideograms		X		
V-Diagram		X	X	
Learning by discovery		X		X
Student seminar		X	X	X
Survey	X	X	X	X

Source: Elaborated by the authors.

5. Discussion

Education is a process where the participation of the different agents, namely the educator and the student is fundamental. In a series of studies and investigations, it has been seen that the students as active agents, assume the responsibility of their training process, and generate skills and abilities that allow them to consolidate concepts for the solution of practical cases for engineering. However, the commitment of the educators and the students are required [91, 92, 93, 94]. Today, and even more in the future, it is expected that engineers not only perform as good professionals, but also as citizens in search of a social transformation, through a critical and reflective communication with the different stakeholders that constitute the society.

Positivism is the paradigm which covers those strategies where participation and control in the classroom is the educator, promoting the passive, static and repetitive learning, with a limited or zero interaction with the student. Notwithstanding the above, it should be noted that positivism is not used less in the classroom; on the contrary, it is the one that has been used the most in engineering education for centuries. What happens is that some fewer authors and researchers write about this paradigm, since who can be interested in investigating some educational experience that has been used for generations and is not very innovative? In other words, the fact that various researchers looking for new teaching techniques to improve the teaching-learning process of the students does not mean positivism is less used today.

On the other hand, constructivism has a better relationship with teaching techniques, promoting the control and autonomy of the student and in a shared manner with the educator, where new ideas or concepts based on present and prior knowledge are actively developed. The participation shared between the educator and the student is also stimulated to a greater degree, evidence in this way, that knowledge may be subjective, and not purely objective like positivism. In this sense, in a large part of the literature related to the teaching of engineering, educators research and apply in the classroom techniques such as: PBL, Project-oriented Learning, Case Studies, Simulations, Cooperative Learning, or Service-Learning; teaching techniques that encourage the student to discover knowledge and apply it in the real world. It is for this reason that, a large number of researches aim to promote constructivism in the classroom, whose premise is that what students learn by themselves lasts over time, significantly modifying in educators the way of delivering and actively sharing knowledge.

Academic programs require a change, involving the student in real engineering problems, by interacting with the environment and with his/her classmates, and by using new resources, teaching techniques and innovative tools that improve the comprehension of contents, where the educator plays a role as a mediator and facilitator of knowledge. However, it is not possible to achieve a successful strategic redesign of contents and curricula, without recognizing that there may be physical and even institutional problems to develop learning techniques with a constructivist approach, and without recognizing the various mediating functions played by tools and resources which improve student understanding [95]. On the other hand, literature has often exposed the need for consistency and coherence of approaches across a curriculum, and that learning approaches —where students are actively involved— should be encouraged as long as possible, but not changing abruptly from a traditional teaching (in which the students are accustomed) to a new teaching approach [95, 96, 97]. Learning, therefore, must be driven by action, including time for reflexive thought, allowing for individual reflection and, what is more important, collective reflection [95]. Through collective reflection, both students' and educators' perspectives can be considered by taking into account previous experiences, and new points of view can emerge and be articulated with academic programs used.

In this way, constructivism is an epistemological conception, which gives importance to the individual's contribution in knowledge acquisition, through interaction with the environment and between the educator and student, allowing the educator to choose multiple teaching strategies to reach some target in particular or to efficiently plan his/her student's teaching-learning.

As a result, the socio-critical paradigm arises in response to the positivist and constructivist traditions, covering strategies that propose the integration of all participants, including the researcher, stimulating the critical and reflexive thinking, through a social transformation. Giving the grounds of the critical communication perspective, which advocates for the participation of the subjects in the learning investigation process.

Saying this, these teaching techniques or strategies and educational paradigms will provide the educator with solutions to the challenges set out by the current education and understand how to improve the teaching-learning of the future engineers, in a world where knowledge grows exponentially and one that demands the abilities, attitudes, knowledge and competencies needed to look for new engineering solutions. This involves the development of skills such as: the ability to lead, plan, design, implement and operate real engineering projects; to possess communication and collaborative work skills that allow the future engineers to play important roles within multidisciplinary organizations; to behave as trustworthy people and committed to the analysis and solution of the problems of their environment; and that they feel called to continue their academic training throughout their professional life.

In this same sense, in strategies that are part of the constructivist paradigm, socio-critical and critical communication, the student will not be a mere spectator and assimilator of the knowledge, as he/she was for centuries. His/her protagonism, along with his/her need for new knowledge, is what leads to a change in the learning process. It is for that reason, that the role of the engineering educator needs a change, and thus, the class itself must be different. The role of the professors moves from traditional teaching to a facilitator of the learning process. The traditional classroom becomes a workshop, to take the student, little by little, into the real world. It is under this idea that the professor must be a facilitator of the new tools, with new actors, in a new scenario. For this reason, the engineering educator must understand what the industry and the international market ask from a future engineer, from the language that they use to how the knowledge is transmitted, to thus motivate the student and manage that learning occurs effectively.

Therefore, it would be then beneficial to ask ourselves, which techniques are today the most appropriate to achieve the necessary competencies for engineers of the future? and perhaps more importantly, which of such techniques will be able to mobilize those engineers so that they recognize their achievements and to be capable of self-managing them? The answer to these two questions, although it might seem easy after studying different paradigms and strategies in engineering education, is far from being categorical or fundamentalist, since the analysis presented shows that all teaching techniques are necessary for the acquisition of skills in the training of engineers. That is, it is not possible to abandon traditional lectures, because they play a fundamental role in teaching engineering students in science subjects, where they have to develop the ability to hear and understand phenomena, from explanations oriented to processes preferably of logical-deductive reasoning.

6. Conclusions

However, the foregoing also needs to consider that academic programs have to be relevant, attractive and connected, preparing students for lifelong learning. That is why engineering training should not only provide knowledge, but also flexibility, technical capacity, and an understanding of the social context in which they find themselves. It is also necessary for engineering education to provide students with a deeper cognition and understanding of teamwork, since one of the learning outcomes for a graduate student in the ABET Engineering Criteria is the ability to work in multidisciplinary teams [98], where it is unlikely that students acquire a high level of knowledge of teamwork, if they only work with their peers in one or two subjects throughout their study programs. Also, the emergence of new engineering services and the use of technology as an essential tool for the learning process should be incorporated, so that future engineers understand what they have been taught, so that they can contribute to the development of engineering products and implement them, i.e., focused on the practice of engineering.

For that reason, this investigation does not intend on being a categorical and absolutist vision about the educational paradigms, but rather more to reflect and re-think the purpose of the education in the engineer's professional development, being a guide for educators in the complex way of understanding how the engineers are taught and how the different teaching techniques can help to improve the learning of the engineering students.

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