Research skills R+D+I and industry 4.0, STEM and TRIZ and their application in the professional skills of applied physics students

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The advancement of science and technology requires that future professionals in all fields of study have developed certain professional and investigative skills. The impact of the industrial revolution 4.0 has included the education sector. For these reasons, we designed a chart based on five competencies that are essential for the professional improvement of future graduates of the Engineering career. These competencies were: industry 4.0, TRIZ, STEM and research competencies in R+D+I projects. A didactic material was prepared to be applied to 225 basic level students in the subject of Applied Physics together with a rubric that determines the skills that the participants have developed during their study from the upper secondary level to the basic level of the career. engineering. The quantitative analysis of the study was carried out with inferential descriptive statistics, in which we found that the students have not developed certain skills: social skills, leadership, cooperative work, assertive communication, demotivation, lack of interest in contributing ideas in group work, no they know how to assign roles. A qualitative technique of motivational didactic development (survey of previous motivations, prejudices and feelings) and the inventive TRIZ were applied to promote the development of certain skills in students. The qualitative analysis of the study was carried out with the Chi Square technique, the results of our research confirm that the didactic-pedagogical-experimental technique has a significant impact on the improvement or development of professional skills in students regardless of the skills acquired in previous years' levels.

Keywords: R+D+I investigative skills; Industry 4.0 skills; STEM skills; TRIZ; Motivational support technique; professional skills.

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1. Introduction

Currently, the labor field in all its sectors is aligning itself with Industry 4.0, which requires future professionals to have already developed certain professional skills (proactivity, collaboration, innovation, creativity and problem solvers) to cover an activity in particular, aligning itself according to the professional profiles in the field of work [1,2]. That is to say, those in charge of selecting personnel need a certain "quality technique or method" that allows identifying the dynamic and weak points of each one of those chosen, in order to "filter the best talent" [3]. Therefore, future engineers are required to acquire a set of knowledge, aptitudes and skills necessary to practice their profession in the field of engineering. Also, they will be able to provide solutions to the problems that arise in their autonomous profession and flexibly, at the same time, have the ability to assist in the professional and organizational context in their workplace; all this is called "professional competence". However, in this conceptualization of generic or transversal competences skills are included. In agreement, with the Educational Sciences among the transversal generic competences we highlight: the instrumental (investigative skills), intrapersonal (social skills - communication) and systemic (autonomous learning, inventive ability, leadership, adaptation to new situations). These competencies are the common cornerstone of the profession as well as of the specific environments of professional practice that require complex responses [4,5].

Therefore, when we talk about professional or work skills, we refer to the sum of knowledge and skills acquired to solve a certain activity in the company or industry. Among the skills to develop in future engineers is the TRIZ methodology; which is defined as the method of Theory to Solve Inventive Problems (TRIZ). A suggestive formula that encloses the attribute of this pedagogical didactics applied to the business field. Its three essential indications of this methodology are: blocking points and possible solutions, technological development and scientific knowledge [6,7]. However, TRIZ as a tool focuses on "technical problem solving" [8,9] and in the university educational field, on problem solving from a didactic point of view, which are broader. To this last expression, Altshuller [10], indicates that this has a lot to do with "the inventive principles of conflict resolution and focused his attention on more stimulating problem-solving techniques" [11,12]. Didactically speaking, TRIZ has much to do with the systematization of knowledge. Berdonosov [13], indicates that "human knowledge can be estimated as a specific system, and if we transfer the rules of development of the system to that knowledge, it is right there that the TRIZ laws are developed". That is, it can be developed from the contradiction to the resolution of contradictions by applying the law of system evolution, and the principles of conflict resolution, all through inventiveness [13].

Many authors who have applied this inventive TRIZ technique describe that this technique and its tools applied correctly in students manage to train in basic concepts of TRIZ systematization applied to different contexts in the field of engineering or educational sciences [13,11]. On the other hand, the STEAM method (Science, Technology, Engineering, Arts and Mathematics) is also promoted; It is aimed at solving problems and investigating needs that arise in the workplace, mainly using technology and digital skills. With both TRIZ and STEAM methodologies, the 4.0 industrial revolution is joined, where professionals who merge both methods are required. However, to align future engineering graduates, universities must implement strategies and procedures to adjust the study curriculum to the requirements of the new industrial revolution [2]. In this same context, the social and industrial sector presents challenges that need greater attention and interest in professional skills (ability to solve problems, produce and evaluate scientific evidence, teamwork, simulations, computational technology), and above all, understand the world and the phenomena that establish it [14]. Everything described has the purpose of providing solutions to the inconveniences that are collectively externalized in the different areas of labor action [15]. We reflect that yes, it is eager to complete this barrier, it will be necessary to renew the teaching-learning processes that are applied in the classrooms; not only at the undergraduate level, has it also implied the levels of basic and secondary education [16]. The refutation of these assumptions is found in the new educational construct "Science Technology Engineering and Mathematics" (STEM) which proposes among its activities the development of certain skills that students must acquire from initial levels [5,17].

But, what other skills should students entering engineering careers have developed? Or in turn, what other skills should be improved in their professional skills? Skills based on Research, Development and Innovation, known by the acronym R+D+I require advanced creativity that allows future engineering graduates to generate new ideas that provide solutions to problems that arise in their area of expertise worked. Other skills that are related to inventiveness are the TRIZ, which generate innovative ideas that focus their effectiveness on deducing and solving the real needs of society, industry and technology. The TRIZ is the most suitable method for students who start engineering careers since it is a technique and a set of tools that allow the inventive process to be approached in a logical and systematic way. Identically, Industry 4.0 joins this group of skills; these skills allow future graduates to connect with leadership, teamwork and assertive and effective communication without neglecting knowledge in technology and programming [7]. Therefore, the purpose of this study is to apply "Active Learning Techniques" in combination with the STEM didactic model to improve professional competence in R+D+I projects according to the requirements of industry 4.0 in an Applied Physics course. [18]. Therefore, we consider the model as an ideal didactic methodological resource for the construction of knowledge [19,20] developing certain necessary skills in students for their personal and professional development [21,22]. Next, we will explain the process to select the professional competences based on STEM, TRIZ and Industry 4.0 together with those of R+D+i for students of the Physics course in the engineering career [23,24].

1.1. Exploration of the skills to be developed

Among the conceptualizations on "teaching and learning" Leamnson [1] states that teaching comprises the deliberate act that creates the ideal environment for students to assimilate content, experiences within the classroom. At the same time, it is the activity that has the reflective purpose and the potential that arouses learning [17]. On the other hand, learning is a comparatively unscathed change in knowledge or behavior due to the student's experience" [25,26]. In other words, the change in the subject occurs by acquiring new learning methods and techniques that facilitate the development of skills and knowledge that strengthen systemic thinking [27]. In this sense, if we intend to improve or enhance a certain skill in future engineers in a specific competence according to the area of work, we propose the following conjecture: What skill do you want to enhance from a didactic, pedagogical perspective? At all educational levels, it is proposed to develop skills through learning (practical, experiential); that is, students at the undergraduate level should have developed these skills through the passage between basic and secondary education (Table I).

TABLE I. Skills to be developed at the different educational levels.

Skill to develop	Skill to improve
Abstraction	Idea management
Acquisition and management of information	Organize - analyze
Complex systems	Ability to understand and perceive Interrelation of things and the effect
Experimentation	Inquiring ability to propose conjectures Evaluate and interpret outcome data
Cooperative collaborative work	Flexibility positive interdependence

Source: Integral Human Development Guide [28]. Adapted by the authors. Indeed, if we want to improve or enhance these skills, we must have subjects predisposed to be taught [29]. That is, "attitude" plays an important role by having a good predisposition to be instructed, positive proactive attitudes can be established that affect the apprehension of scientific knowledge through an assertive didactic technique. In this same context, the level of higher education must strengthen and generate positive and proactive attitudes, reproduce perceptible models, promote practice and evaluation (pros and cons) of the consequences accompanied by commitment, in every act of reinforcement [30]. In this sense, it is about intrinsically motivating and positively affecting the interpersonal and intrapersonal intelligence of the students to promote satisfaction for being educated and aspiration in their professional area of study (spontaneous curiosity, fulfillment and personal success). As described above, learning has reciprocity with abilities, skills, and attitudes, with professional competence being part of the set of skills that an undergraduate graduate must have [31]. This is how the STEM model promotes some learning strategies-skills-techniques at different educational levels. Berkeley [23] states that the characteristic skills of a student researcher specialized in their specialty are: ability to develop a project (which does good or bad research), work in a team; social skills, creativity and innovation, emotional intelligence, ability to improvise and find ways to overcome difficulties [17]. However, the STEM model has a holistic approach to teaching-learning by not segmenting or dividing study disciplines, this allows students to integrate into different interdisciplinary areas of the curriculum [17,32]. This model examines the impact of these interdisciplinary subjects in the professional field and prepares future engineers to be the workforce induced to the demands of Industry 4.0 [14,22]. In other words, universities must guarantee that engineering graduates have alternative techniques and instruments to function in: interdisciplinary projects in their area of work, laboratory practices in industry 4.0, use of technological tools (big-data, simulations) that be in harmony with science and technology [33]. The STEM model and the competencies of Industry 4.0 together with the TRIZ techniques are linked to critical-systemic thinking with learning stimuli [2]. The implementation of these models allows the student to have an experience of knowledge grounded in innovation and experimental practice [34]. STEM skills that are related to Industry 4.0 and research skills in R+D+I projects; chosen for the students of the basic engineering career is based on the cognitive skills that are developed at all educational levels (basic, Middle), which are applied according to age and cognitive level and according to the level of complexity of the problem [35,36] as well as gradually building a series of shared meanings with the teacher and society supported by the content and guidance of the teacher [37]. That is to say, the role of the teacher is paramount, he becomes not only the learning guide but also the one in charge of detecting the student's needs, adjusting it to the guidelines required for Industry 4.0 in the different disciplines throughout the duration. of the race [21]. The skills proposed in the methodology section designed for this study are based on the didactic, pedagogical and scientific. Focusing on the study of the constructivist theory regarding the resolution of authentic and real problems [38] of industry [39]. Some authors such as G. Yakman, and Y. Lee [38], denote a learning-oriented relationship between engineering and art. That is to say, engineering contributes as an investigative technological innovator while art in the social and creative context. From that follows, the emotional, experiential and collaborative part for formal and non-formal environments. Let's consider this hypothesis: How to distinguish STEM skills that are related to research skills from interdisciplinary R+D+I projects according to industry 4.0? It is likely that the answer lies in using a didactic inventiveness that is based on the pedagogical, didactic and scientific. Active learning techniques are more efficient and systematic to provide solutions to inventive problems, which not only occur in technical areas but also in social areas [40]. Likewise, the STEM model requires the use of certain inventive and optional instruments for instruction and learning, among them: interdisciplinary projects, laboratory practices, handling of technological tools and simulations that are in accordance with science and technology [27]. According to what was stated by Becker [22], the STEM model would allow students to develop critical thinking and be more receptive to learning stimuli both in experimental practice and creative innovation [19,34]. In short, we believe that in order to develop these skills, the emotional part of future professionals in the engineering career must be positively and significantly affected [31,41], which generates internal skills of self-knowledge [42]. To do this, we will seek to answer the following research questions:

1. To what extent can the professional skills and competences of the students be enhanced from the didactic and pedagogical point of view?
2. Can R+D+I, STEM, TRIZ skills be related to professional skills from a didactic, pedagogical, scientific perspective with the labor area (Industry 4.0)?
3. Is it possible to improve some level of the students' professional skills?

From this systematization of questions, we consider a possible assumption in the event that students do not have developed certain skills at the undergraduate level in which they are at the time of applying the study. We formulate our assumption considering the possibility of applying a didactic-pedagogical-experimental technique that significantly affects the improvement or development of professional skills, regardless of the skills acquired at previous levels. For this, we propose to make a table of combination or relationship of these skills described: TRIZ, STEM, Industry 4.0 and R+D+I research skills. Next, we present the methodology or procedure carried out in this study and give answers to our systematization questions and possible assumptions.

TABLE II. Participants demographic.

Gender		Age			Socioeconomic level		
Man	Woman	18 - 20	21 - 24	25 - 30	Low	Medium low	Medium
141	84	126	49	50	117	78	30

2. Methodology

Due to the mixed nature (qualitative-quantitative) of our study, we focused on a non-experimental, exploratory - cross-sectional descriptive - longitudinal design, that is, applied research in the classroom [43,44]. The population participating in the study involved 225 students, which corresponds to 25% of the students of the Industrial Engineering career, of the Faculty of Industrial Engineering of the University of Guayaquil (UG), Ecuador. The selected sample was for the convenience of the researcher [45], the study participants belong to the subject of Applied Physics. Table II shows the demographic characteristics of the participants.

2.1. Process

To be successful in this type of educational experiment requires a combination of "special teaching skills" [46]; which will differ slightly from the didactics of STEM, Industry 4.0 and TRIZ to be applied at an educational level. As a first step, based on the literature and the concepts of each of these methods, it focuses on creative imaginative development and conflict resolution. As a second point, we observe the need to have certain special skills acquired at previous levels of previous study and as students assimilate the fundamental notions of research skills at the University, they also require other skills such as: STEM, TRIZ, Industry 4.0 and R+D+I [47]. As a third point, it is necessary to substantiate from the perspective of pedagogical models the combination of each skill required by Industry 4.0 together with TRIZ and STEM, in turn identify the didactic technique or didactic strategies that

TABLE III. Relationship between STEM, Industry 4.0 and investigative skills of R+D+I projects, TRIZ.

Industry 4.0	STEAM	TRIZ	Research R+D+I	Professional Competence for	Didactic basis Engineering Career Course	Teaching strategy	Base pedagogical Model
(Mystakidis, Papantzikos and Stylios, 2021; Blández, González and López, 2006)	(Pane, Andra and Distrik, 2021)	(Berdonosov and Redkolis, 2015; Bukhman, 2021; Ni, Samet, and Cavallucci, 2021)	(Haryani *et al*., 2021; Coello, Hidalgo and González, 2018)	(Arena, Medina and Callejas, 2021; Ministry of Education of Ecuador, 2018)	(Coello, Flores and Venegas, 2016; Coello and González, 2018)	(Román, 2006; Monarrez, 2016; Silberman, 2013; Demirkesen and Zhang, 2021)	(Ramos *et al.*, 2021; Gómez *et al.*, 2019)
Critical thinking, Work in multidisciplinary teams and in multilingual environments	Critical reflection, Problem and conflict solver	Interdisciplinary critical reasoning	Holistic thinking, decision making, Effective communication -assertive- multi-languages	TO KNOW: It stimulates your cognitive abilities. Develop your ability to solve problems creatively	Cooperative learning - collaborative and self-regulated, meaningful	Processing and use of information	Cognitive-developmental (Piaget, 1978; Castro, 2021)
Creativity	Creativity	Creative thinking	Development of ideas together (Brainstorming)	KNOW TO DO: They project their imagination and their desire to create new things	Active learning	Metacognitive and self-regulated	
Implementation of innovations	Innovative	Innovative thinking	Openings to new expectations	CAN DO: They learn through first-person experimentation	Self-regulated learning		
Emerging technologies	Information technology	Analytical-technical tools	Critical and functional thinking skills related to information technology	TO KNOW: They more easily retain the concepts learned	Self-regulated learning	Components affective	Constructivist educational (Yakman, 2018)
Effective-assertive communication Leadership	Communication, Group work	Psychological tools (brainstorming, intuition, creation, brainstorming)	Flexibility and adaptation Social and intercultural skills (Emotional Intelligence)	WANT TO DO: Improves your self-esteem	Emotional intelligence Intrapersonal intelligence Interpersonal intelligence Social skills	Motivational and affective	

Prepared by the authors.

go in harmony to solve the problems. problems that students may have in developing certain skills related to the specialty of study in their chosen career [48].

Continuing with the idea, in order to answer the research questions and in accordance with the reviewed literature, a table of skills and abilities was designed (Table II): STEM, Industry 4.0, TRIZ and research capabilities of projects R+D+I. In addition, these skills or competencies were based on the pedagogical models and the types of teaching techniques that are applied at all educational levels [49]. To verify to what extent the skills and competencies of students can be enhanced and the level of competency they have, an instructional task based on an interdisciplinary classroom project was proposed, together with a rubric for teachers in the Physics and Physics area. Applied that I evaluated the competencies that the participants should have. Both instruments aimed to identify the predominant "knowledge of Physics" in the students and what skills they have developed at the level they are at, if any. The dimensions of the classroom rubric were to measure knowledge in: Communication skills, drawing, design and construction, (Geometric skills); use of differential and integral calculus (mathematical tools) and contents in Physics (Mechanics), effective and assertive communication and teamwork (collaborative - cooperative) and inventive techniques [50-52]. It is worth mentioning that all these skills are related to conflict resolution [11,13,53]. To answer our third question, it is necessary to apply the proposed instructional task and rubric to determine whether or not there are developed skills in students and thus verify our assumption that if some didactic - pedagogical - experimental technique can be applied that contributes to the improvement of skills and competencies in at least one level in the students. The time of application of the technique had a duration of a partial (three months) with the purpose that the students can develop the projects requested by the teachers; In the first month, students present their group work and proceed to make the respective grade based on the rubric proposed by the teacher. The results of the works were not very encouraging, for this purpose a second attempt was made to deliver the works. Where, the ideal pedagogical - didactic - experimental technique for its application in students is analyzed.

2.2. Data analysis procedure

To evaluate the reliability and internal consistency of the instructional task and rubric, the KR-20 statistic and Cronbach's Alpha were applied. The responses to the rubric were measured for internal, content, and construct evaluation with teachers from the pedagogy and didactics area of the Faculty of Philosophy, Letters, and Educational Sciences of the University of Guayaquil (UG). The results were analyzed descriptively (through analysis of frequencies and percentages) and parametric techniques.

The assumptions of the study were analyzed qualitatively through the Chi Square statistic and the Friedman test [54-57]. Next, the validation phases of the rubric and the selection process of the pedagogical didactic technique are explained to improve undeveloped skills or abilities according to the results obtained from the study. The application time of the experiment was three months.

TABLE IV. Reliability of the questionnaire and rubric according to the statisticians applied.

Dimension	Statistician	Punctuation	Interpretation
Industry 4.0		0.914	
Research R+D+i	KR-20 (Dichotomy)	0.923	Correlation coefficient
STEM		0.899	Very
TRIZ		0.982	Strong
Motivational technique	Alfa de Cronbach (Like)	0.875	(valid)
Degree of acceptance of the methodology		0.911	

a) Phase 1: Validation of the internal consistency of the rubric and questionnaire

Table IV shows the statistics that were applied to validate the internal consistency and reliability of the instructional instrument and rubric. Where values close to 1 indicate a strong and reliable level of our teaching material to be applied in the treatment of identifying skills and competencies acquired or developed in students.

Therefore, our instruments are reliable and consistent to be applied in the study.

b) Phase 2: Selection, evaluation of the R+D+i project

As a second phase, a didactic material based on a problematic situation of design and construction of a "hydraulically actuated cardboard robotic arm" is provided. The participants had to identify, show and support their answers based on the physical principles and mathematical tools involved in their construction. In this phase, creativity and innovation skills are analyzed [27,58]. To check what skills the students had at this basic level, a Likert-type rubric was created with the following values (Table V).

TABLE V. Weighting and description of the result of the rubric.

Score results	
Percentage (%)	Interpretation
0 - 25	Overall dissatisfaction
26 - 50	Dissatisfaction with respect to certain characteristics
51 - 80	Neutral arrangement
81 - 100	Satisfaction

TABLE VI. Competencies to improve in the Physics course according to the skills proposed in the study.

Knowledge in Physics	Skills		
	STEM - R+D+I research	Industry 4.0 - TRIZ	
TO KNOW	Geometry Pascal's principle in a hydraulic arm Structural characteristic of fluids lever system	Identifies physical principles in the proposed problematic situation. Understands the physical principles of the problem effectively	It stimulates your cognitive abilities. Expands your ability to solve problems creatively Retain learned concepts more easily (inventive thinking)
KNOW TO DO	Pressure applied to an incompressible fluid (liquid). Mathematical analysis Design models and interpret graphs	Proposes possible modeling and interpretation of graphs according to the problem raised Build models or designs according to the physical parameters that must be met in the process of developing the experiment	They project their imagination and their desire to create new things (Innovation - create)
CAN DO	Hydraulic arm, hydraulic press or hydraulic hand	Understand and expose possible failures and identify where to correct them from the physical and mathematical point of view	Assimilate through first-person experimentation
WANT TO DO	Assertively communicates his physical and mathematical knowledge Provides solutions to the proposed proposals of the R+D+I project	Increases their potential for leadership, teamwork and assertive communication of the physical knowledge acquired	Boost your self-esteem

In the second month, the respective errors or complaints of each member of their group are socialized with the students. According to the socializations, a table of skills to be developed in the students to improve their professional competence is elaborated. According to the results obtained, the design of the competencies or skills is applied according to Table III, which has active, self-regulated and collaborative learning as a pedagogical and didactic basis. Also including the suitable formal and non-formal environments to apply the correct learning techniques [2,59,60], which is detailed in table III.

The process of implementing a technique based on the "motivational support of skills" to influence the collaborative activity of the participants and investigate the skills acquired in previous levels or their deficit; a problem based on an interdisciplinary R+D+i project that can occur in a work context is applied, which allows technique for the training of the participants. Next, we explain the selection of the applied didactic technique.

c) Phase 3: Selection of the didactic-pedagogical-experimental technique

The third phase consisted of selecting the active demonstrative technique (experimental didactic-pedagogical) as a participatory phase. This technique "support for motivational learning" or "probing of motivations, prejudices and previous feelings" was proposed by A. Herrán [61]. Let's consider this teaching technique because it aligns with STEM, research, and Industry 4.0 skills (Table VI). The purpose of being applied in a group is for students to intervene with their agreements and knowledge about the difficulty posed [62].

3. Results

In light of the results regarding oral and written communication, it was found that 16.44% gave a coherent conclusion. 20.44% were able to express themselves clearly and assertively with the other members of the group. 33.33% correctly wrote the project study, 12.89% contributed positively

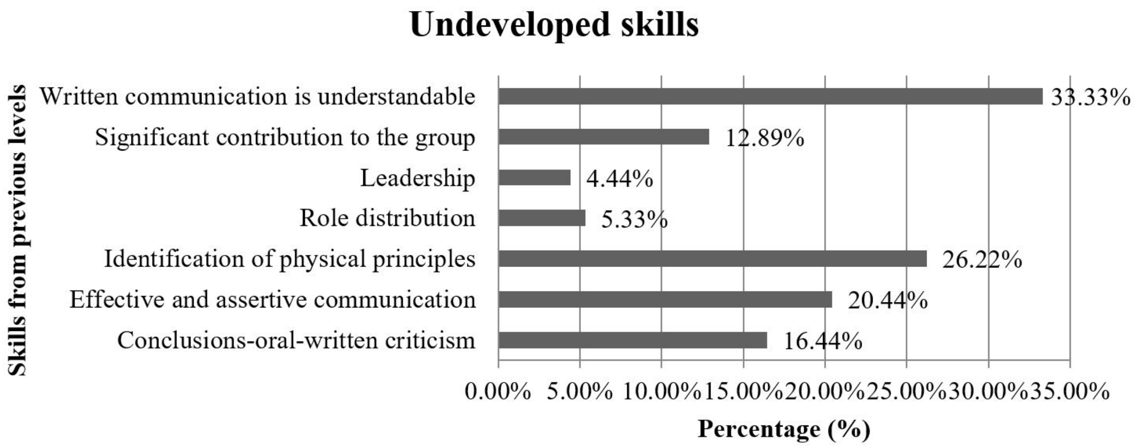

FIGURE 1. Shortcomings found in the basic competence - average of the participants.

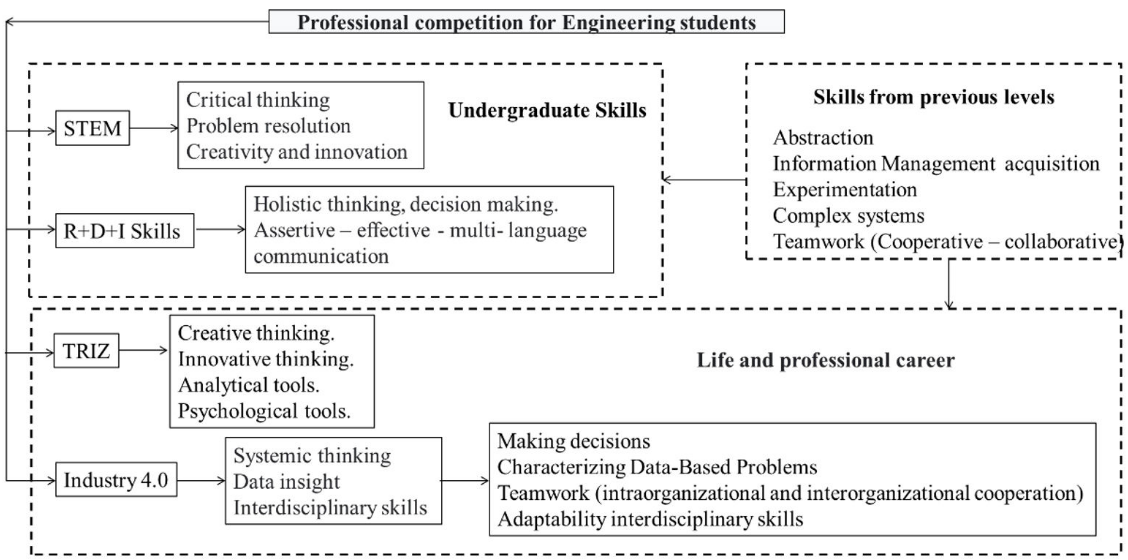

FIGURE 2. Professional competences of basic level students and progressively to levels of professionalization of the Engineering career.

to teamwork and the distribution of roles was scarce with 5.33%, which implies that leadership did not occur where only 4.44% made decisions regarding to the proposal of the given problem. We visualize in this graph 1 that each dimension of the professional competence of the students is very scarce among the participants, who indicates that the practice of the given situation for the groups was worked independently and with a lot of information there is no decision-making concession decisions. This is reflected in the discussion on the foundation of the study from the scientific-critical point of view; identification of the problem in terms of physical principles to be applied is "unsatisfactory in general" with 73.78% who failed to understand the information and express it correctly (oral-written).

The results obtained according to the didactic-pedagogical-experimental technique (Table II) allow us to merge certain skills to improve the professional skills of engineering graduates and the development of new R+D+I research skills [23] in at least one basic level whose process is shown in Fig. 1.

In this conceptual chart we indicate the skills or competencies that basic level students should have when entering undergraduate (basic and secondary education). Therefore, such skills are connected to the needs of the higher level, supporting us with the STEM, Industry 4.0, and TRIZ model. STEM skills consist of five dimensions: Ability to abstract (creativity and innovation, critical thinking and conflict resolution), Collaborative and cooperative work (Affective communication, collaboration with others) [27] and professional competence (Life and career) (Fig. 2).

We work on a didactic-pedagogical treatment that relates the emotional-affective intelligence of the subjects to optimize the interpersonal and intrapersonal relationships of the groups. It is necessary to develop a learning strategy of "motivational support" and with the technique of "Survey of mo-

TABLE VII. Table of association of expected values.

Use of the Technique	STEM	R+D+i	Industry 4.0	TRIZ	TOTAL
YES	49.64	59.37	56.45	53.53	219
NO	1.36	1.63	1.55	1.47	6
TOTAL	51	61	58	55	225

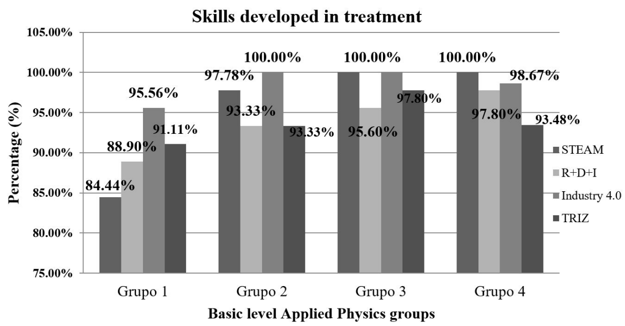

FIGURE 3. Level of satisfaction of the skills to be developed in the participants.

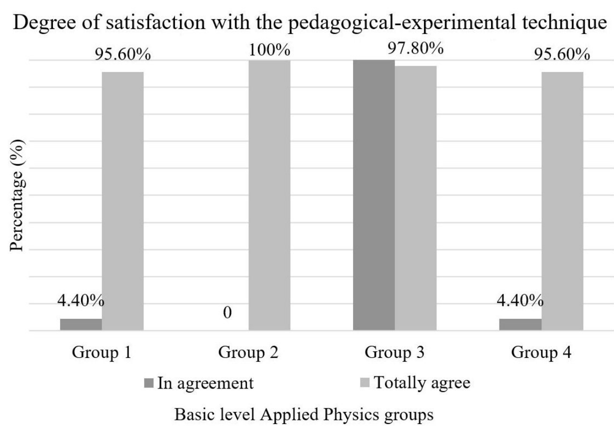

FIGURE 4. Statistics of the attitude regarding the academic experience of the participants (Degree of satisfaction with the methodology).

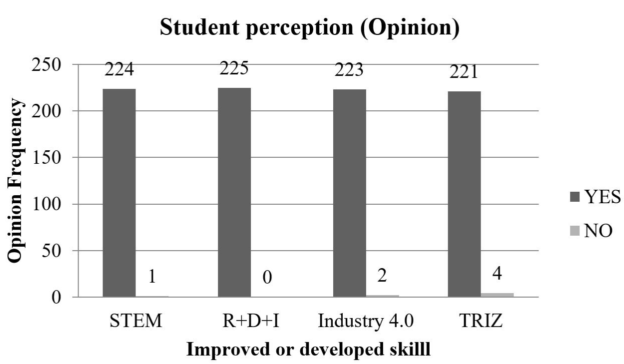

FIGURE 5. Analysis of development or improvement of skills from the perspective of the participant.

tivations, prejudices and previous feelings" it was achieved that social skills significantly affect professional skills.

The effects were that the proposed dimensions rose to an average of 98.89% for industry 4.0 (Conflict Resolution), 93.91% for R+D+I project, and 95.56% for STEM skills and 95.01 for TRIZ (Inventiveness and creativity) which indicates a very satisfactory result for the participants (Fig. 3).

It is important that when applying new methods, the approval of the students is obtained, according to this dimension on the degree of satisfaction, it was averaged from the four groups that 97.25% of the participants totally agree to apply the technique, a 2, 75% agreed.

Figure 4 shows that 97.33% of the participants in the pedagogical-didactic treatment have perfected at least some skill (creative-inventive R+D+I) proposed in the study. Only a minority of 2.67% considers that they have not reached the objective in one dimension of the treatment.

Regarding the dimensional structures of the rubric, the Chi square statistician was applied, obtaining a calculated Xi less than the critical one. Based on the results obtained from Fig. 5 (observed values) and Table VII where the expected values are found.

Table VIII contrasts the assumptions of the study to assess whether there is a significant positive incidence between the applied motivational technique and the professional skills of the participants. We obtain a Chi squared of $X_{\text{calculated}} = 0.01552$ for three degrees of freedom with an associated probability of 0.05 giving $X_{\text{critical}} = 7.81$.

In short, the null hypothesis is accepted. That is to say: The didactic-pedagogical-experimental technique significantly affects the improvement or development of professional skills in students regardless of the skills acquired at previous levels.

Therefore, $X_{\text{calculated}} < X_{\text{critical}}$, so $0.01552 < 7.81$. The statistical decision is that the experimental pedagogical didactic technique positively affects the students, improving their professional skills and abilities at least by one level.

TABLE VIII. Validity of the dimensions according to STEM, Industry 4.0 and R+D+i, TRIZ.

Hypothesis test statistic	$n = 225$
Chi square	0.01552
gl	3
Sig. Asintót	0.999
Test Friedman	

4. Discussion

The instructional phase was carried out in the classroom; the groups at the end of the proposed classroom project had to impart the solutions of the same. The evaluations made of the student work were very low in terms of the dimensions selected by the teachers in the area of Physics. It can be argued, what the researchers Qureshi, Khaskheli, Qureshi, Raza, and Yousufi [63] indicate, where they highlight that the education curricula at all levels highlight that current competency-based learning does not observe substantial changes in learning practices intervention in the classroom [64]. In this observation phase, the limited availability of cooperative-collaborative participation (POWER DO) and leadership of the students is appreciated [65]. The results of the observational phase imply that since there are no roles in the student teams, decision making is more difficult; which has as a consequence, that communication between students is not clear and assertive [66,76].

Hence, for engineering education, the way of instructing and applying discernment affects the student's cognitive abilities (KNOW); consequently, some authors suggest creating teaching spaces in which discernment and ability become objectives of teaching [67, 68]. For this reason, communication is essential between the work groups, it is there where the decision-making of how the problem will be solved is decided based on the techniques or methodologies applied by the teachers in the classroom [69]. However, communication has a lot to do with the emotional part (social, interpersonal and intrapersonal skills), it is required that students at this level of higher education in which they are [68]; be able to participate and understand ideas, using a variety of representations to externalize those ideas and be more receptive to perspectives that are dissimilar to their own (KNOW HOW TO DO). This implies that educational centers must align themselves with the demands of Education 4.0; from the beginning levels to the middle level. Thus, when entering universities, high school graduates will better profile what the Industrial Revolution 4.0 demands [70,71]. With the above, we propose a treatment based on dramatization using the technique of "Survey of motivations, prejudices and previous feelings" [72] to channel the motivation for learning and training of the participant from the "zone of the next development" in a group way [17,40,73]. The core of the model is the "mutually supportive learning strategies", which have proven not only to be useful to achieve conceptual understanding or to represent the problems that the future engineer faces in the exercise of his profession, but also to improve his professional and emotional competence (wanting to do); in our case adapted to Applied Physics courses and the competence to develop [18,19,74].

With this motivational strategy, it is possible to improve the professional skills that engineering students should have (Graph 1). We can limit that the experimental didactic-pedagogical technique based on motivational learning has managed to perfect and develop certain skills that are required in the work of interdisciplinary R+D+i projects together with Industry 4.0 and the inventive-creative technique TRIZ (Tables II and IV) [65,75,77]. The methodology applied to the 225 students of the basic level of engineering had a satisfactory acceptance, which indicates that the construct and the validity of our instrument (rubric) were suitable; which were validated with the statisticians described in Table IV. The assumptions made for this study based on the Chi-square inferential technique (Table VIII), is to reject the null hypothesis. In summary, the didactic-pedagogical-experimental technique used does significantly affect the improvement or development of professional skills of students. The competencies that were improved were: affective components, context control strategy, social interaction and resource management, information processes, self-regulated metacognitive strategies [18,34]. We can state that in this study many timeless skills are useful in the processes that determine organizational behaviors in terms of developing professional skills while the career lasts and in turn we contribute to implementing changes, both in the attitudes and behaviors of students to the job placement currently required by Industry 4.0 [78,79]. However, these professional skills do not imply the need for engineering graduates to be "super-engineers". With this result, we limit that not all the professional skills described will be acquired by all future engineers to the same extent, but this will depend mainly in the area of specialty and what you want to promote in the graduates according to their professional context in which they are going to perform [79 - 81].

5. Conclusions

Future engineering graduates who enter the labor field for Industry 4.0 should have a slightly broader vision of other disciplines. Therefore, the skills described (R+D+i Projects, TRIZ) in this study contribute to adaptability in their work area. These methodological and interdisciplinary skills, especially systemic and critical thinking, will allow them to work and make decisions autonomously and as a team, as well as the ability to learn and adapt in critical or crucial situations. In this experimental treatment, it is possible to conceive the importance of strengthening the transversal skills that usually appear as a barrier in labor insertion. This happens when it comes to working in a practically technological environment (skills gap) or the difference between the skills required for an area or task and the skills that workers actually possess. Many companies and industries confirm that this is an impediment they encounter at the time of personnel selection. The competence of "learning by doing" that we promote through didactic techniques accompanied by the STEM method and industry 4.0 makes students consider that the problems they propose may have different paths of development, thereby promoting their innovative and self-sufficient Spirit in investigative skills of R+D+I project. Therefore, we recommend the curricular pedagogical managers and teachers of the different undergraduate chairs to update themselves in the new didactic pedagogical techniques so that they integrate this teaching-learning model in their classrooms as well as verify the professional skills that go in harmony with the scientific and technological progress of Industry 4.0 and unequivocally in educational regulations.

6. Recommencations

Therefore, we recommend the curricular pedagogical managers and teachers of the different undergraduate chairs to update themselves in the new didactic pedagogical techniques so that they integrate this teaching-learning model in their classrooms, as well as verify the professional skills that go in harmony with the scientific and technological progress of Industry 4.0 and unequivocally in educational regulations.

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