A Comparative Analysis on The Educational Perspective of Students and Professors in Stem Courses Regarding Industry 4.0 Competencies

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Abstract

This work consists of an investigation in the form of a comparative analysis between students and professors from the STEM field (Science, Technology, Engineering and Mathematics), about their educational perspective in the context of the current industrial revolution - Industry 4.0 (I4.0). This research aims to investigate, in particular, how professors and students from a Control and Automation Engineering (CAE), Information Systems (SI) and Mechatronics Engineering perceive the educational process in relation to the development of skills needed for the upcoming job market. As future professionals, students need technical knowledge to deal with emerging trends, such as Big Data, Internet of Things (IoT) and Robotics. In addition, social skills, such as solving complex problems, dealing with conflicts, creativity, innovation and communication, leadership and collaborative work, are paramount. The research methodology adopted in this work is based on mixed methods, quali-quant research. Data collection was carried out through research based on questions related to three categories: intrapersonal, interpersonal and didactic. The study found that, although students claim to be prepared for Industry 4.0 challenges, professors think otherwise. There seems to be a pedagogical challenge to fully achieve the requirements for the development of future I4.0 professionals. In addition, this research identified that active learning methods, focused on the development of 21st century skills, are poorly applied by professors, which may indicate that students are not being exposed to real life situations necessary to better prepare themselves for the future challenges of I4.0.

Keywords: Industry 4.0; Competencies; Student training; Student-centered learning;

1. Introduction

The reality of today's Industry is rapidly changing. The Internet and the multitude of new approaches arising from Information and Communication Technology (ICT) have penetrated the industrial world, bringing disruptive potential. Innovations linked to the Internet of Things, Data Science, Cloud Computing, 3D Printing, Artificial Intelligence and Robotics have become part of the range of possibilities to bring more agility, economy and productivity to the industrial world - a new industrial revolution (Freeman et al ., 2014).

Industry 4.0 is characterized by advances in ICTs throughout the supply chain (Rüßmann et al., 2015). Allied to ICT innovations, a boost in additive and hybrid manufacturing technologies as well as the integration of horizontal and vertical systems in intelligent supply chains (Huba & Kozák, 2016). The combination of Materials, *Big Data*, cyber-physical systems, results in the formation of "smart factories" (Assunção Pereira et al., 2018, p. 1).

The impact of Industry 4.0 goes beyond the processes associated with production and distribution, going through a more complex form of innovation based on the combination of multiple technologies, encouraging companies to rethink the way they manage their businesses and processes. From this perspective, new business models can emerge: the reformulation in production, consumption (customized products in a shorter time) as well as transportation and logistics systems. According to the National Confederation of Industry (CNI, 2016, p. 12), in these "smart industries", machines and inputs "talk" throughout industrial operations with scale and flexibility in the manufacturing process, which, in turn, occurs in a relatively autonomous and integrated fashion. Therefore, there are great challenges ranging from investing in these technologies, changing processes, as well as in the relationship between the production chain and the development of new skills in employees.

Despite the revolution taking place in the industry, the same movement cannot be affirmed from the standpoint of the teaching-learning process in higher education. Still rooted in the traditional model of education, which inherits several historical practices (Freeman et al., 2014), the current higher education system (professors, students, management) remains, for the most part, far from the reality of companies and industry. Thus, it is necessary to promote initiatives to change education so that it adapts to this new model of work. The latest report from the world Economic Forum, called "*The future Jobs Report*" (WEF, 2018), lists the skills that will be valued in the coming years, and many of them are behavioral.

Thus, university-industry dialogue is essential to seek integration between those in the academic world, which possess a strong scientific and technological structure, along with those in the market, whose bias is more pragmatic. Thus, the focus of education becomes the development of the so-called 21st century skills in the training of students (Rugarcia et al., 2000). As a result, it might be possible for students to experience situations of their future work environment, bringing authenticity to the teaching-learning process and creating relevant bridges between the job market and the academic environment.

Alarcon et.al. (2018, p. 2) claims that education must be connected with the realities of the industry, technology and social innovation, as we live in a networked society (Castells & Spain, 2007).

Corroborating with Alarcon's ideas, there is a need for several initiatives including industry and academia. Thus, it is necessary to train future professionals and requalify the current ones, according to the new demands of the world of work. Therefore, it is necessary to think about the learning processes focused on the formation of 21st century skills, such as: “creativity, innovation, communication, problem solving and technical knowledge” (AIRES et al., 2017).

In order to develop 21st century skills, a focus must exist during their academic training. In this context, we raised the research question: “how do professors and students from the STEM field perceive academic training in the face of the new Industry 4.0 context?”

The challenges raised by I4.0 involve multidisciplinarity and extensive use of innovative technologies: robots, artificial intelligence and additive manufacturing. With an IT infrastructure based on Cloud and information distributed among numerous devices, the Internet of Things promises to be a great ally within the scope of I4.0. Thus, it is clear that technical training is important, but interpersonal, intrapersonal and cognitive skills are equally important and must be developed during your training.

Based on this context, the work aims to verify how the students are doing in the STEM field for this new industry, based on the comparison between their perspective and the professors.

Thus, the rest of this article is divided as follows. Section 2 presents a theoretical basis for this work. In section 3, student education and the role of universities and professors are discussed. Section 4 describes the results and discussions from the questionnaires applied to the research subjects. Finally, in section 5, the final considerations are presented.

2. Background and Related Work

This section presents fundamental concepts regarding competencies and their relationship to the I4.0 professional demands.

2.1 The Competence Concept

The concept of competence has reappeared in the literature in areas as diverse as Medicine, Nursing, Computing and Engineering (Burnette, 2016). There is a strong movement towards *Competency-based Education / Learning (CBE / CBL)*, where the fundamental premise is that students must demonstrate mastery of certain competencies in order to progress in their field of study and become a professional. Thus, instead of organizing learning around credit / hour, as it is traditionally done, CBE makes time flexible and fixes what should be effectively mastered: skills (Henri et al., 2017).

According to Perrenoud (2013, p. 13), “the definition of competences is not new, but lacks precision, often varying according to the scope of a discipline or field”. Thus, several researchers have provided different definitions over the years, causing a debate that is still ongoing. The first definition of competencies emerged in the 1970s, within a debate in the area of human resources, challenging the efficiency of intelligence tests for professional selection and entry into higher education (McClelland, 1973). Competence was then defined as a personal trait or set of habits that lead to a more effective or superior job performance, which could not be captured by tests widely used at the time. McClelland's research developed a list of managerial competencies, assuming that competencies are stronger predictors of managers' future performance than traditional psychological tests widely applied at the time to measure intelligence(Van Klink & Boon, 2003).

In later years, this definition had been criticized for focusing too much on learning isolated behaviors, neglecting professional performance as a whole, in addition to not paying attention to specific elements in the context of a profession, making this perspective extremely behaviorist.

A more succinct and pragmatic comparison on the evolution of the competence concept can be found in (Van Klink & Boon, 2003). Table 1 summarizes three perspectives on the concept of competencies:

Table 1 - Three perspectives on competences

Perspective		Differences observed in the definition
Geographical	USA	Competences referring to performance excellence
	United Kingdom	Competences referring to the performance standard defined by consensus of a group
	Germany	Competences referring to action programs that include the adoption of new developments and transfer to other professions
Learning Theory	Constructivist paradigm	Focuses on norms, values and beliefs as important elements of competences; pays attention to the participation of professionals and their daily situations for the development of competency-based systems; questions the transferability of skills to other contexts
	Cognitive paradigm	Links skills with performance; “top-down” development of competency-based systems
Field of Application	Training and Education	Competencies are defined as groups of skills and knowledge that can be learned through

		training
	Selection for employment	Competencies are defined as partially trainable
	Performance Evaluation	Performance (output) is perceived as a substitute for competencies

Source:(Van Klink & Boon, 2003)(adapted)

Thus, we see that geographically, there are clear differences, since each country has historically different educational policies and different types of relations between education and labor market. In the British approach, competence refers to the ability to meet performance standards for roles and professions. In the USA, competencies refer to the skills, knowledge and characteristics of people: traits, motives and self-concept, which contribute to the excellence of professional performance. This differs somewhat from the German perspective, where the notion of competence refers to a person's ability to perform various tasks within a given profession. More than in the UK or the USA, the German perspective emphasizes a holistic view of competence: it’s not just a random collection of skills and knowledge. Competencies are defined as integrated action programs that allow individuals to perform adequately in various work contexts within a specific profession.

When analyzed from the point of view of learning theories, there are clear disagreements. As stated earlier, having an essentially behaviorist origin in the 1970s, which had been discarded due to its limitations, the concept of competence evolved within the constructivist and cognitivist paradigms. The second source of conceptual disagreement stems from the theory of learning. The constructivist paradigm emphasizes the importance of values, motives and beliefs and questions the premise that competencies are transferable to other contexts, including work contexts. The cognitivist paradigm is based emphatically on *top-down* development in an organization and the application of competencies or competence systems. There is a tendency in the cognitive approach to link competences with observable performance (thus having behaviorist elements), while in the constructivist view the subjective perspective and the individual preferences (attitudes and values) of the professional receive more attention in the development and assessment of competences (Simons, 2000).

When viewed from the point of view of practical application of skills, there are different views, in line with what was initially said by Perrenoud (2013). The definitions differ with respect to the elements that are highlighted. For example, applications of the competence concept to education and training assume that competencies can be considered as a set of trainable skills, knowledge and attitudes. Competency definitions for job selection procedures generally define competencies as individual capacities for future jobs, which may be partially trainable. In addition to knowledge and skills, selections often also include individual characteristics and traits, such as intellectual skills and abilities, beliefs and self-concept, which are immutable or very difficult to change. In the accepted definition of performance appraisal, the focus is not so much on the elements of competencies according to observable output. This presupposes a close relationship between competencies and results, and competence operates roughly as a substitute for performance.

Thus, it should be noted that these three perspectives are not mutually exclusive. In practice, the definitions of competence commonly used in the literature combine the various perspectives within a specific perspective. In this work, when we refer to the concept of competence, we adopt the definition as being a set of knowledge, skills, attitudes and values (Figure 1) (Weinert, 2001)

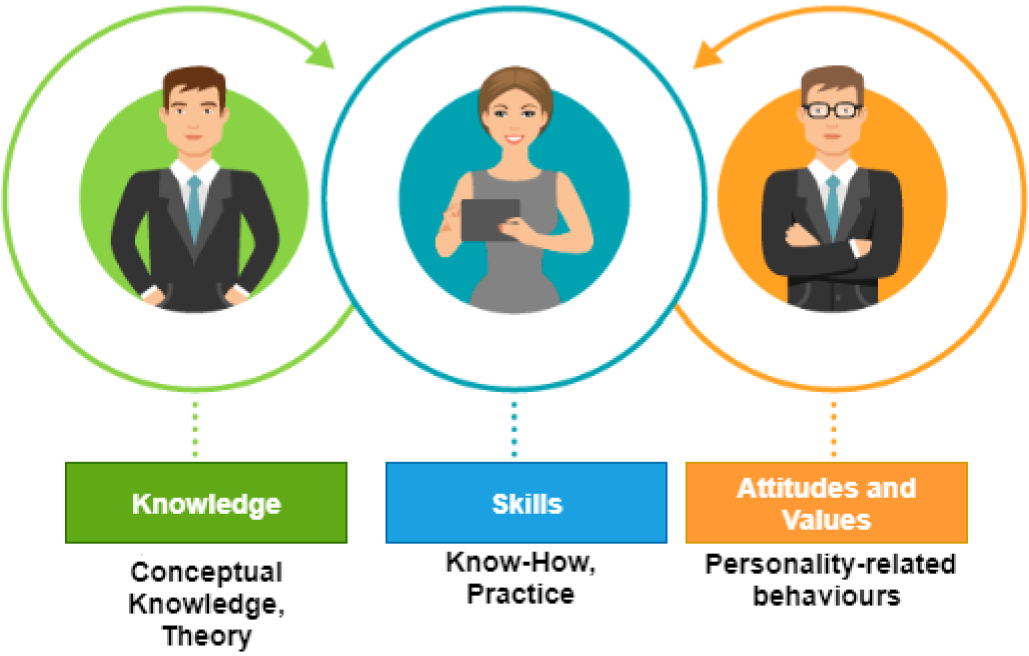

Figure 1 - Competence concept definition

Source: Authors themselves.

Therefore, we follow in line with Perrenoud (2013) where a competence is composed of resources (Figure 1) to be mobilized in a given situation in real life. This set of situations is known in the literature as *competency frameworks* or competency models. Such a concept has been used to establish competency-based curricula in areas as diverse as veterinary medicine (Vandeweerd et al., 2014). Considering the context of Industry 4.0, it is necessary to list the set of skills for this scenario, which has already been proposed in the literature (de Souza Silva & de Andrade Morais, 2018; Huba & Kozák, 2016; Prifti et al., 2017).

Finally, it is important to highlight how competencies should be embedded in current higher education educational systems and what types of pedagogical strategies can be implemented with a view to their development and evaluation. Lectures and exams hardly fit the central concept of competence defined here - real life situations - focusing too much on the theoretical elements of learning and lacking the authenticity necessary to develop competencies.

To acquire skills in areas such as in engineering, educational models must be reformulated with a view to learning real-world situations (Brown et al., 1989) . To solve a real problem, it is necessary to generate a solid learning environment, which includes techniques, methodologies and resources that develop the necessary skills in students to face the problems in the world of work. Approaches such as Problem-Based Learning (PBL) (Barrows, 1986), Project-Based Learning (PjBL) (Kokotsaki et al., 2016) and Challenge-Based Learning (ChBL) (Clegg & Diller, 2019) are methodologies that have been shown to be appropriate to educate within this perspective. In addition, these approaches are directly related to Competency-Based Education (CBE) (Burnette, 2016), which we mentioned at the beginning of this section and is one of the drivers seeking alignment of the academic world and the world of work.

2.2 Industry 4.0 Competencies

At the beginning of the 21st century and the development of the Internet there was a new revolution and transformation in the industry: the improvement of smaller and more powerful sensors, *software* and *hardware* increasingly sophisticated, the use of artificial intelligence and the ability to gather and filter a huge amount of data (*Big Data*). Erik Brynjolfsson and Andrew McAfee of the *Massachusetts Institute of Technology* (MIT), in their book "*The Second Machine Age: Work, Progress, and Prosperity in a time of Brilliant Technologies"* published in 2014, stated that the world is at an inflection point in which the effect of these digital technologies will be manifested with "full force" through automation and "unprecedented things" (Brynjolfsson & McAfee, 2014). This revolution will profoundly change the way we live, work and relate: it is the fusion of various technologies and the interaction between the physical, digital and biological domains. Figure 2 provides some skills needed by professionals for the 21st century.

Fig 2 - Professional skills for the 21st century
Source: authors themselves

Industry 4.0 describes the growing digitalization of the entire value chain and the resulting interconnection of people, objects and systems through the exchange of data in real time. This can also be described as the advent of “cyber-physical systems” (Davies, 2015; Liu & Xu, 2017). Digitization gradually increased in manufacturing is optimizing the fabric floor with integrated technologies and communication technologies. The Internet serves as a common point of all these technologies, as an information exchange platform, allowing the communication of an unlimited number of devices, gving birth to the Internet of Things (IoT - *Internet of Things*).

In this new industrial revolution, extensive use of technology in the labor markets will cause a decline in routine jobs and intensive tasks. Some professions will disappear and others will emerge. Thus, professionals need to qualify for such a change. According to Assunção Pereira et al. (2018, p. 1), "we know that this new industrial revolution brings to life smart factories, allowing the customization of products with the optimization of a large part of the production processes, interfering in professional competences and in work relations". Thus, professionals inserted in industry 4.0 will have to seek new skills and qualifications, as they must have a more strategic vision, be versatile, agile and mainly know how to deal with the new technologies. Thus, students will have to work and develop these new skills, while professionals already in the market will need an adaptation phase. This professional will need to know how to work with computers, applications and robots, in a collaborative way, to add to the organizational productivity. For Tozzi (2010), the professional of this new market that opens must have eight successful attitudes: communication; meaningfulness (the subjective importance of work); analysis skills (knowing how to interpret different variables, relate them and create a plan); didactic (knowing how to share what you know with your team); connection with the world (knowing how to deal with different fields of work and with different people and cultures); optimism (facing crisis situations with positive attitudes); high energy (working with liveliness); and engagement (believing and committing to the objectives inherent to work activity and being able to mobilize your team).

Thus, considering the perspective of the teaching-learning process to prepare for the above mentioned challenges, this work considers three dimensions (Grzybowska & Lupicka, 2017), defined as follows:

- **Intrapersonal :** deals with questions of how a subject (professor or student) sees himself as well as how one relates to communication, creativity, problem solving and conflicts are observed;
- **Interpersonal:** seeks the subject's interaction with the parties involved in the learning process, collaborative work and leadership;
- **Didactics:** analyzes how the professors’ methodology variables, ICTs, theory / practice relationship, extra-class activities (seminars, extension projects and research) influence the formation of the subject for this new job market.

The Future of Jobs from the World Economic Forum (WEF, 2018) brings several statistics related to redundant roles, new professions and also the division of labor man versus machine professional profiles. In addition, it reports on emerging and declining professions in the 2018 - 2022 range in various areas, such as: automotive, aerospace, supply chain, transportation, aviation, travel and tourism, chemistry, biotechnology, energy, financial services , medical, infrastructure, mining and metals, oil and gas. Table 2 synthesizes the jobs that will continue, the new ones and the ones that will be redundant in all sectors.

Table 2 - Stable, new and redundant roles in all sectors

Stable	New roles	Redundant roles
• Managing directors and chief executives • General and operations managers • Software and application developers and analysts • Data analysts and scientists • Sales and marketing professionals • Sales, Wholesale and Manufacturing Representatives, Technical and Scientific Products. • Human Resources Specialists • Financial and Investment Consultants • Database and network professionals • Supply chain and logistics • specialistsRisk Management specialists • Information security • Analysts • Management and organization analysts. • Electrotechnology engineers. • Specialists in Organizational	• Data Analysts and scientist • Experts in AI and Machine Learning. • General and operations managers. • Big Data Experts • Digital Transformation Experts • Sales and marketing professionals. • Experts in new technologies • Specialists in Organizational Development • Software and application developers and analysts • Information Technology Services • Experts in process automation • Innovation professionals • Information security analysts • Specialists in e-commerce and social media • User experience and human machine • Interaction designers • Training and development • Specialists	• Data Entry Staff • Accounting, Bookkeeping and Payroll Staff • Administrative and Executive Secretaries • Assembly and Workers • Information and customer service workers • Service managers and business administration Accountants and Auditors. • Employees for material registration and stock maintenance • General and operations managers • Postal service employees • Financial analysts • Cashiers and clerks • Mechanics and machine repairers • Telemarketing operators • Electronics and telecommunications installers and repairers • Banking and related employees • Car, van and motorcycle drivers

Development ● Operators of chemical processing plants ● University and Higher Education Professors ● Compliance Directors ● Energy and Petroleum ● Engineers ● Engineers and robotics specialists ● Operators of oil and natural gas refining plants	● Engineers and robotics specialists. ● People and Culture Experts ● Information and Customer Service Workers ● Service and Solution Designers ● Specialists in Digital Marketing and Strategy	● Sales and purchasing agents and brokers ● Door to door sales workers, street and street vendors and related workers ● Statistical, financial and insurance employees ● Lawyers

Source: (WEF, 2018, p.21, adapted)

This report emphasizes that the requirement for future professional skills is multifaceted. On the one hand, it demands an understanding of new technologies and their applications within the scope of I4.0. On the other hand, it demands a set of technical skills, such as data analysis, processing and interpretation, as well as interpersonal (soft) skills: teamwork, collaboration and constant learning. The impacts on organizations' professionals demonstrate that Industry 4.0 will bring a new reality to work relationships, through new forms of interactions between humans and machines. The result of this may be greater efficiency in the industry, provided that professionals are in fact prepared for these new challenges.

Current companies look for skilled professionals, predisposed to teamwork, with a macro view, who have initiative, an entrepreneurial, responsible, creative and disciplined spirit. For this to happen, higher education institutions need to prepare this citizen for the job market.

A research carried out by (AIRES et al., 2017, p. 12), brought a set of skills, such as: basic skills (content and process) and transversal skills (social, systemic, complex problem solving) , resource and technical management), which were related based on the authors (Chen & Zhang, 2015; CNI, 2016; Voronina & Moroz, 2017; WEF, 2018). Considering all the skills cited by the authors, the most frequent ones were: creativity, innovation, communication, problem solving and technical knowledge. For Pires da Costa (2018, p. 75) transversal competences "are basically associated with socio-emotional and behavioral competencies, such as: time management, assertiveness, initiative, teamwork, planning or stress tolerance".

According to Aires (2017, p. 13), it is evident that in addition to technical knowledge, professionals need to know how to put their knowledge into practice, solving problems with creativity and innovation, generating value for the organization in which they are working, contributing to the construction of necessary competitive advantage for organizations of the fourth industrial revolution. These skills must be developed throughout the student's academic life, with more student-centered methodologies, such as project-based learning, flipped classroom, problem-based learning, gamification, among others(Prince & Felder, 2006).

All these transformations both in the use of technologies and in the development of skills affect the reality of organizations and work, impacting on the education systems and social life.

3. Student training: the role of universities and professors

The problem of student training can be considered as multifactorial. Curriculum, physical structure, methodologies, interpersonal and intrapersonal skills, different work environments, as well as the involvement of projects between industry and academia are factors that have been considered for years in the literature(Cruz et al., 2019).

Higher education institutions, together with business and industry, need to find common solutions so that these students can qualify for I4.0. Learning should become active, interactive, where practice is present, and didactic content can be shared, using information and communication technologies. For Pires da Costa (2018), "the integration of new technologies and pedagogies needs to be placed at the center of the teaching and learning strategies of institutions, and these must become an integral component of everyday institutional methods".

Schools and universities will demand, according to Fava (2017, p. 263):

> [...] an adapted academic system, with strong use of the *just-in-time* methodologies, development of relational skills that allow collaborative value-added actions, communication, innovation that meet individual needs, develop skills not thought for this range of mobile professionals.

Higher education institutions will have the responsibility to guarantee opportunities and learning conditions so that students can develop the skills necessary for their professional practice. However, partnerships with the job market are crucial so that these students graduate and feel ready for this new reality. Professors will be responsible for aligning talents, technologies and spaces with the aim of creating both a culture and a teaching and learning environment that attracts *millennials*[1] (generation Y), promote an integrated experience between personal life, study and work. Education will have to undergo mutations to adapt teaching to this new generation, with the student-centered learning process having flexible, informal schedules, several learning spaces and the content organized in small modules.

According to Alarcon *et al.* (2018, p. 3),

> In the 21st century education, the university, according to Boaventura de Souza Santos (2008) will no longer be the monopoly of knowledge, due to market demands and, therefore, will need to undergo significant transformations in its knowledge construction processes, seeking an innovative pedagogical model, through the inter-multidisciplinary curriculum and the transfer of knowledge from universities and research institutions in an integrated and networked way.

[1] Avid, restless young people, skilled in the use of technologies, few experienced, forcing companies to charge educational institutions with differentiated qualifications, in addition to spending millions of dollars in training.

As Professors get acquainted in student-centered methodologies, students will be led to reflect, analyze, solve problems, and seek solutions for case studies. The use of these methodologies presents itself as a potential alternative to resolve the difficulties in relation to the assimilation of content and to integrate competences required by today's society in the training of professionals(Kokotsaki et al., 2016).

Active learning methodologies seek to create learning situations in which students put knowledge into action, think and conceptualize what they do, build knowledge about the content involved in the activities they perform, as well as develop cognitive strategies, critical thinking and reflection on their practices, provide and receive feedback, learn to interact with colleagues and professors, explore attitudes and values, both personal and social (Berbel, 2011; da Silva Pinto et al., 2014; Morán, 2015).

The I4.0 era requires high cognitive skills, which requires transformation in the higher education system. Based on these reflections, this work sought to investigate how students feel prepared for this challenge, and how professors see this academic formation in the face of so many changes.

4. Results and Discussion

This study is based on a qualitative research of an applied nature, in which it was sought to discover what the students and professors think regarding the competencies for this new revolution in the industry. As a data collection instrument, a questionnaire consisting of thirty-five (35) questions was built, divided into three dimensions: intrapersonal (12), interpersonal (9) and didactic (14). These dimensions were based on the necessary soft-skills to be developed, such as communication, attitude, interaction with peers, autonomy, creativity, problem solving and collaborative work.

The research took place in two public, federal institutions in Brazil. One in the city of Salvador Bahia, and the other in Maceió, Alagoas. The target audience were three groups of students. The first consisted of Control and Automation Engineering undergraduate students and the second, graduate (Master and PhD in Mechatronics), both from the Federal University of Bahia (UFBA). The third was composed of students from the Bachelor of Information Systems (SI) course at the Federal Institute of Alagoas (IFAL), totaling 106 people. The profile of the population was traced: regarding gender (14 women and 92 men); as for age (up to 21 years old - 27; between 22 and 30 years old - 53; between 31 and 40 years old - 17; over 40 years old - 9); as to the modality - all in person.

A questionnaire was also applied to the professors of the two public institutions, totaling 28 responses, of which 12 professors from UFBA and 16 from IFAL. Their profile is summarized as follows: regarding gender (6 women and 22 men); as for age (up to 30 years - 1; between 30 and 40 years - 14; between 40 and 50 years - 8; over 50 years - 5; as for training (2 specialists, 12 masters and 14 doctors).

4.1 Data Analysis

In the questionnaire, all questions were of a linear scale[2] (5 - Totally agreed; 4 - Partially agreed; 3 - Relatively; 2 - Partially disagreed and 1 - Totally disagreed). The data analysis was based on the skills

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[2] Created in 1932 by the American psychologist Rensis Likert, the Likert Scale is a psychometric response scale used most often in customer opinion surveys. Being one of the main KPI's (*Key Performance Indicator*) of research in the world, the scale is one of the oldest and most traditional indicators.

needed to this professional from industry 4.0 and whether they are being developed in the context of undergraduate and graduate higher education.

The analysis of the intrapersonal dimension was based on questions that seek to investigate how the skills that are so necessary for this new professional in I4.0 are being developed, which are: communication, autonomy, discipline, creativity, proactivity, problem solving, conflict resolution and analytical resolution. Regarding the communication competence, the question inquired if the subject is easy to communicate. Figure 3 shows the professor and student perspective about this competence:

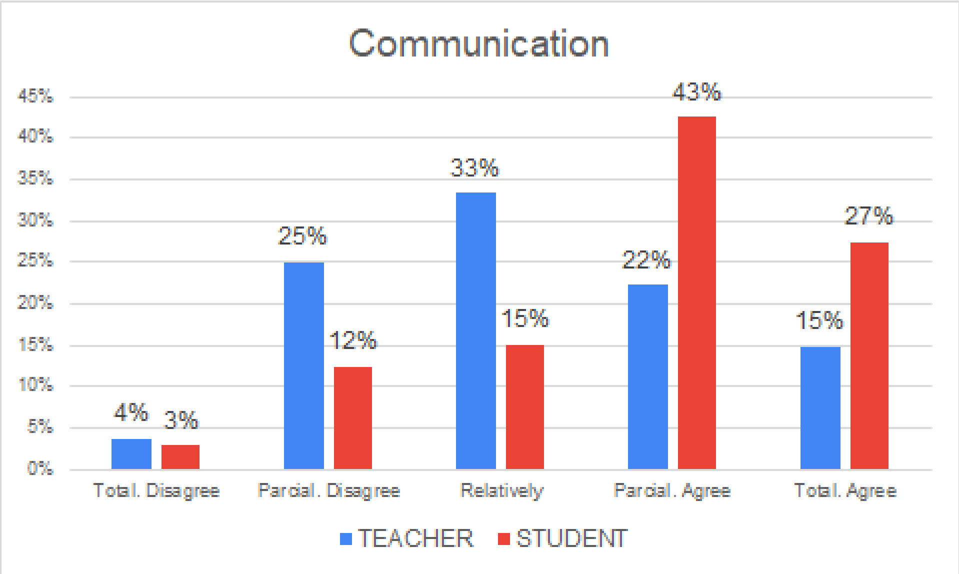

Figure 3 - Communication competence

Source: Authors

A significant difference can be seen in practically all responses from professors and students, the largest of which is 21% in the "partially in agreement". In this new revolution, communication is essential among its professionals, including interpretations from systems and machines. In the industry, instant communication of the various links in the production chain must take place from development to post-sale of the product. When you have good communication in the company, collaborative work is facilitated. For Wilson and Daugherty (2018), engineers will have to form a symbiotic partnership with intelligent machines, requiring some social skills such as emotional intelligence, communication, critical thinking, collaboration, leadership and teamwork.

As for the creativity competence, students and professors responded as shown in Figure 4:

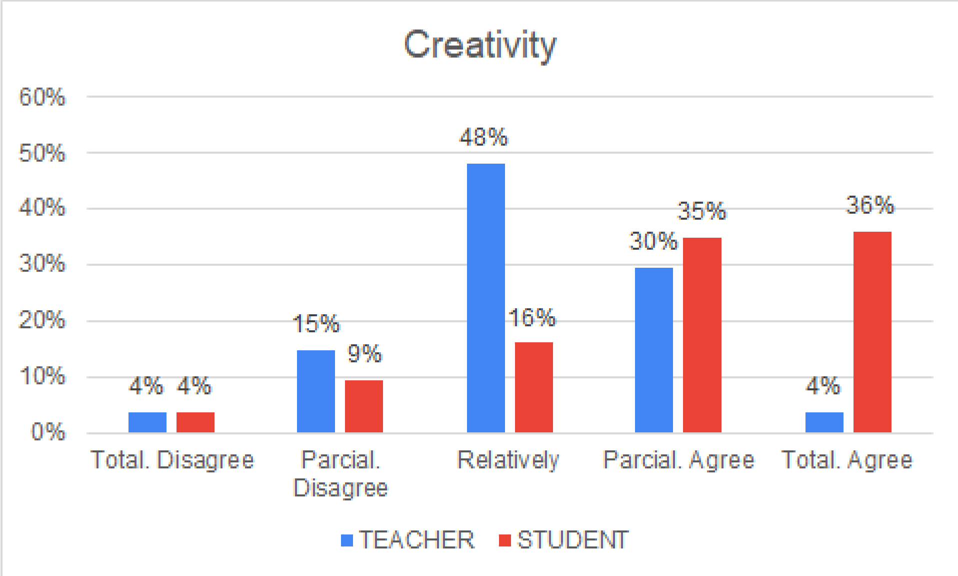

Figure 4 - Creativity Competence

Source: own authors

In the perception of professors, 4% of students are “totally creative”, while 36% students perceive themselves as creative. Once again, there is a difference in perspectives of more than 32%. Considering that traditional methods are based on repetition, there is little room to develop creativity (McCharty & Anderson, 2000). Educational curricula needs to guide learning in order to develop creativity and innovation in the context of I4.0 (Lensing & Friedhoff, 2018).

As for the problem solving competence, the question raised was about the ease of solving problems. Once again, there is a discrepancy between the responses, as shown in Figure 5.

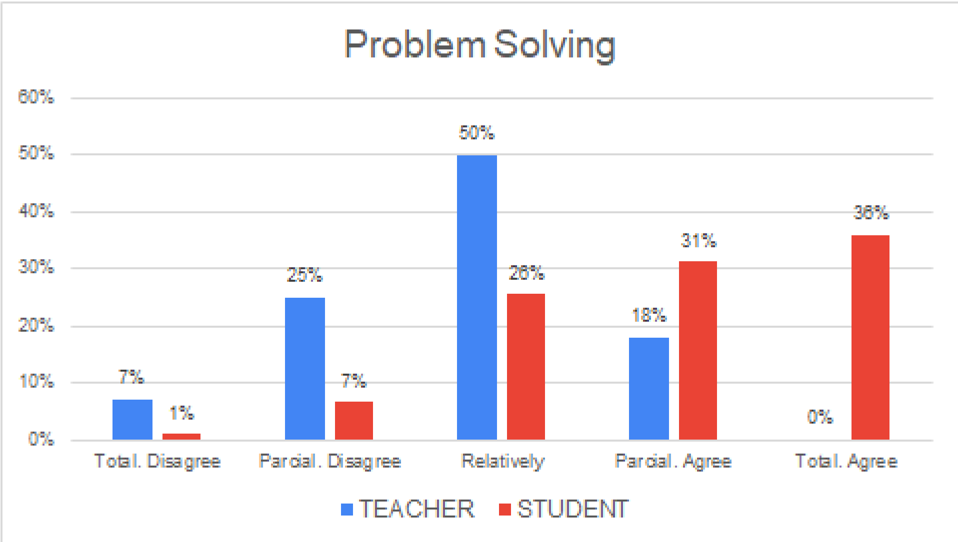

Figure 5 - Problem Solving Competence

Source: authors themselves.

As for this competence, 36% of the students believe they are fully able to solve problems, and 31% partially, however, their professors do not see anyone fully fit, only 18% partially fit and 50% relatively against 26% of the students. This competence is extremely important in this new market context. For Aires (2017, p. 13) :

"In addition to technical knowledge, professionals need to know how to put their knowledge into practice, solving problems with creativity and innovation, generating value for the organization in which they are working, contributing to the construction of the competitive advantage necessary for the organizations of the fourth industrial revolution ".

As for the conflict resolution competency, the differences are even greater between the perspective of professors and students, as shown in Figure 6:

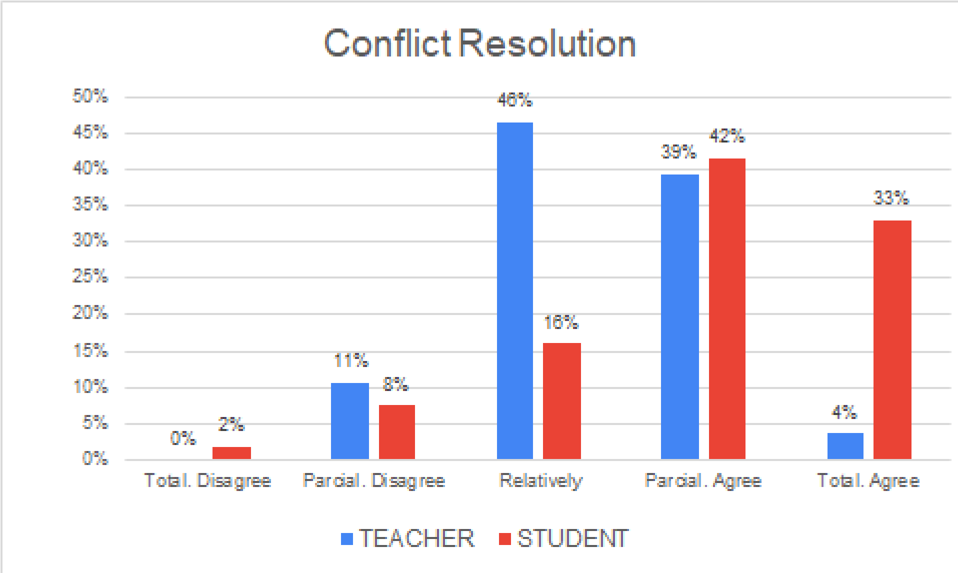

Figure 6 - Conflict Resolution competence.
Source: authors themselves.

According to professors, 46% of students are relatively able to resolve conflicts, 39% partially able and only 4% fully qualified. On the contrary, 33% of students feel totally fit, 42% partially and only 16% relatively. This difference of 30% is quite significant and needs to be investigated further in order to discover if students feel ready for the work environment or have issues within the scope of learning with colleagues.

A very important competence in this new context is the analytical resolution of data, as shown in figure 7:

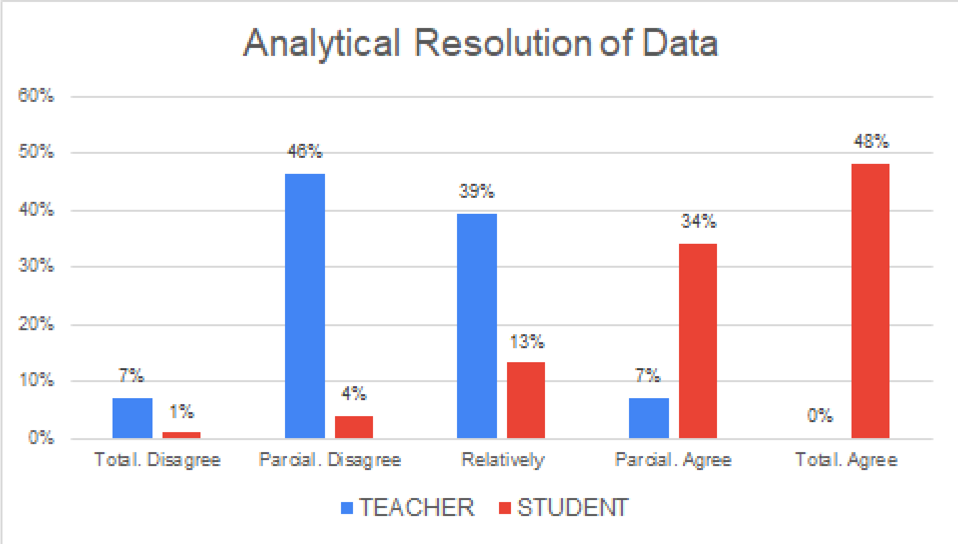

Figure 7 - Analytical Data Resolution competence
Source: authors themselves.

Regarding the analytical resolution of data, there is a huge discrepancy between the perspective of the student and the professor. According to Figure 7, 48% of students claim to be "totally in agreement", 34% "partially" and 13% "relatively", 4% "partially disagree". Their professors, on the other hand, provide discrepant data: 0% "totally agree", 7% "partially", 39% "relatively" and 46% "partially disagreed.

According to Grybowska and Lupicka (2017, p. 3) "analytical skills are the ability to visualize, collect information, articulate, analyze, solve complex problems and make decisions". For engineering and computer science professionals, to which the questionnaire was applied, this is an essential competence to be developed.

As for the interpersonal relationship, we consider the concept defined in the field of sociology that means a relationship between two or more people. It is inserted in several contexts: family, school and work. In this work, we evaluated this concept through observations regarding the competencies of collaboration, leadership and autonomy.

In this context of collaboration, the responses remain divergent between the groups, as shown in Figure 8:

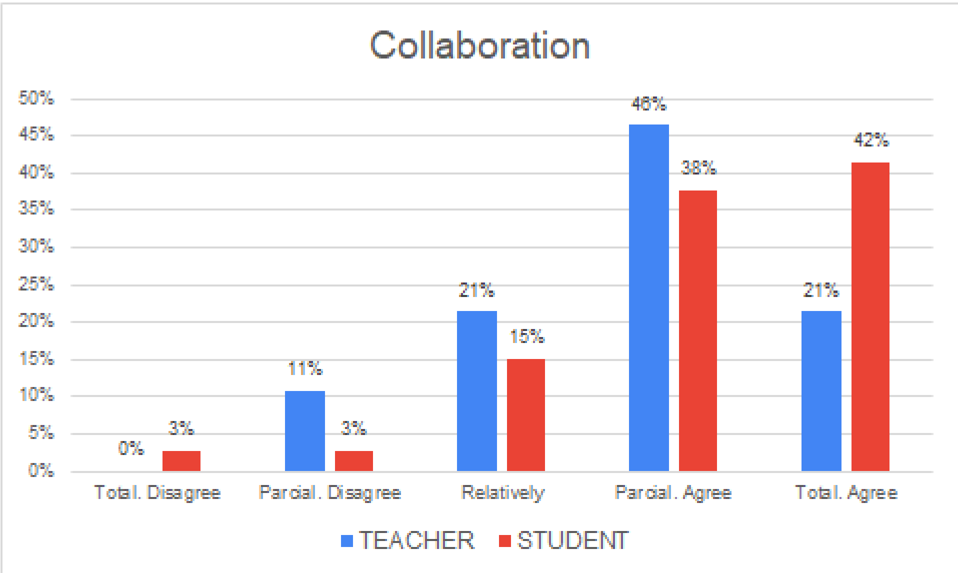

Figure 8 - Collaboration Competence
Source: authors themselves ..

In this competence, there is a significant difference of 21% in the “totally agree” response, contrasting to 7% and 8% compared to other responses. In higher education, it is necessary to encourage collaborative work, as well as the use of tools that help in this process, such as project and activity management in order to foster communication skills between participants.

Thus, it is necessary to build a more flexible educational system, supporting learning for life, seeking to guide the student towards a collective production path, but, at the same time, opening the paths for self-regulated learning. According to the authors (Brockett & Hiemstra, 1991; Candy, 1991; Knowles, 1975), in self-directed learning the learner has a goal to be fulfilled, thus establishing his needs, defining his goals, searching for physical and virtual resources and monitoring his progress. In addition, the interaction among other apprentices and the commitment to the development of individual skills such as: morality, motivation, engagement, proactivity and autonomy. Figure 9 shows the answers related to autonomy skills, referring to the idea of a student guiding his own self-directed learning processes. There was a minor difference in some responses from students and professors. This chart consists of three (3) common questions for students and professors (Q1, Q2 and Q3), totaling 6 answers.

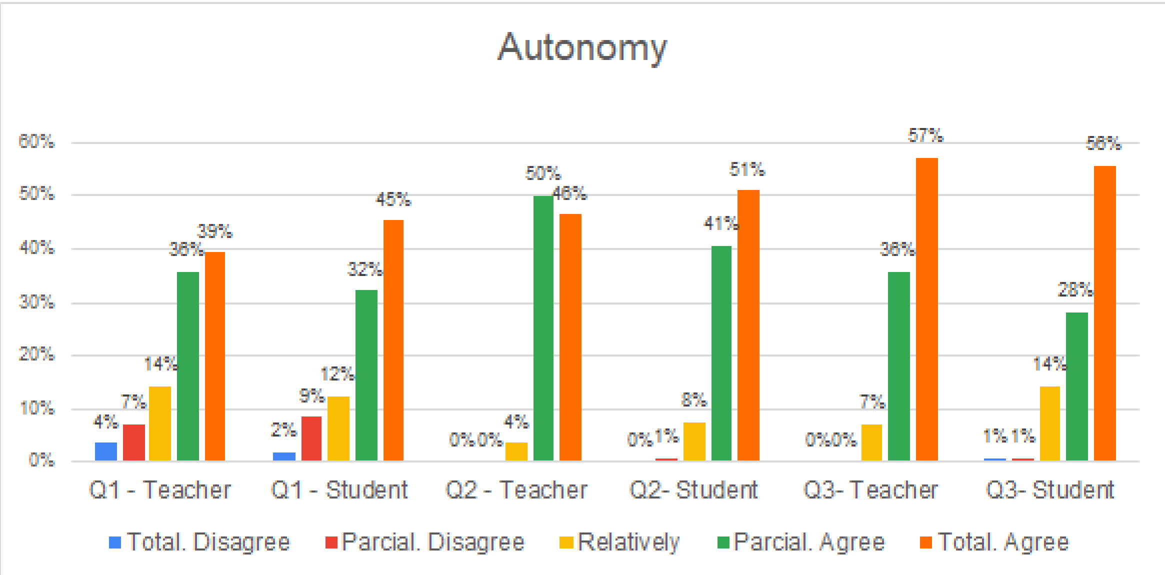

Figure 9 - Autonomy competence.
Source: authors themselves.

The first question (Q1) was whether the subject believes that the interaction with colleagues in the classroom or virtually, positively influences the development of their autonomy. The result was 39% of professors and 45% of students totally in agreement. In the second question (Q2), they were asked whether the use of information and communication technologies (ICT) influences autonomy in the learning process. In this question, the difference was smaller, with 11% in the "partially agreed" and 5% in the "totally agree" response. The third question (Q3) was whether they believe that by participating in extra-class activities, such as research projects, results in greater autonomy in their learning. In the answer “totally in agreement", it was practically the same percentage of professors (57%) against 56% of students. Vygostky (1980) and Piaget (1973) postulated that the individual's learning process occurs through interactions with the world, considering, as a criterion, the individual's age related to the context. These new generations learn through interactions, the collaboration of networks, using technological resources. They want to understand how things happen and not just walk into a room and passively listen to a professor lecturing

Figure 10 provides a summary of the questions (Q1, Q2 and Q3) of professors and students related to proactivity: Q1) In general, you realize that students are interested in knowing what happens in the labor market in order to be able to seek new knowledge? Q2) Do students suggest texts, bibliographies, websites, videos and films that are related to the course subjects for their colleagues? Q3) Do they suggest to the professor other subjects that he would like to learn related to the discipline?

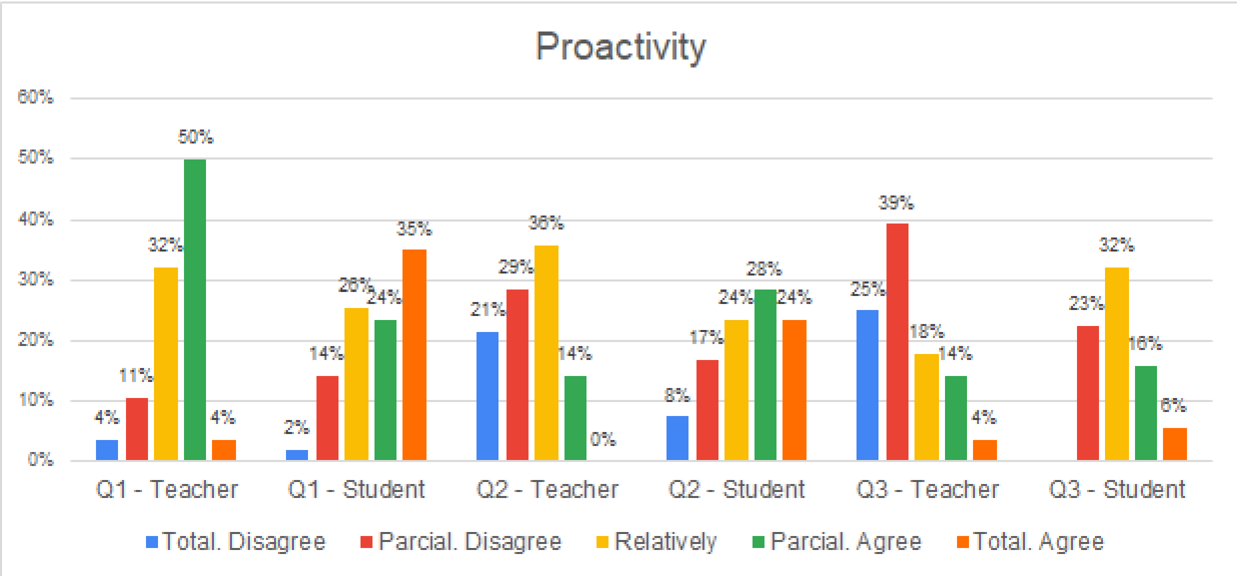

Figure 10 - Proactivity competence

Source: Authors themselves.

Once again the answers are quite divergent. In Q1, only 4% of professors are "totally in agreement", against 35% of students. In Q2, the difference narrowed to 24%, but they are practically opposite in the answer "totally in agreement". 24% of the students claim that they suggest books, websites, videos for their colleagues, whereas for the professors the percentage was zero (0%). In Q3 there is also a difference of 24%, but now the opposite, in the "totally disagree" answer, students 0% against 24% of professors.

For Cotet et al. apud Maisiri et al. (2019, p. 15), "the three main social skills required to an employee in the Industry 4.0 era are: creativity, emotional intelligence and proactive thinking".

Finally, to the technical knowledge competence analysis, a group of 3 questions for both groups were selected: Q1) Is there a balance between theory and practice in your course ?; Q2) Is the course curriculum geared towards the job market ? Q3) In the course, subjects related to industry 4.0 are approached and contextualized, such as: Cloud Computing, Big Data, IoT, Artificial Intelligence ? The answers are shown in Figure 11:

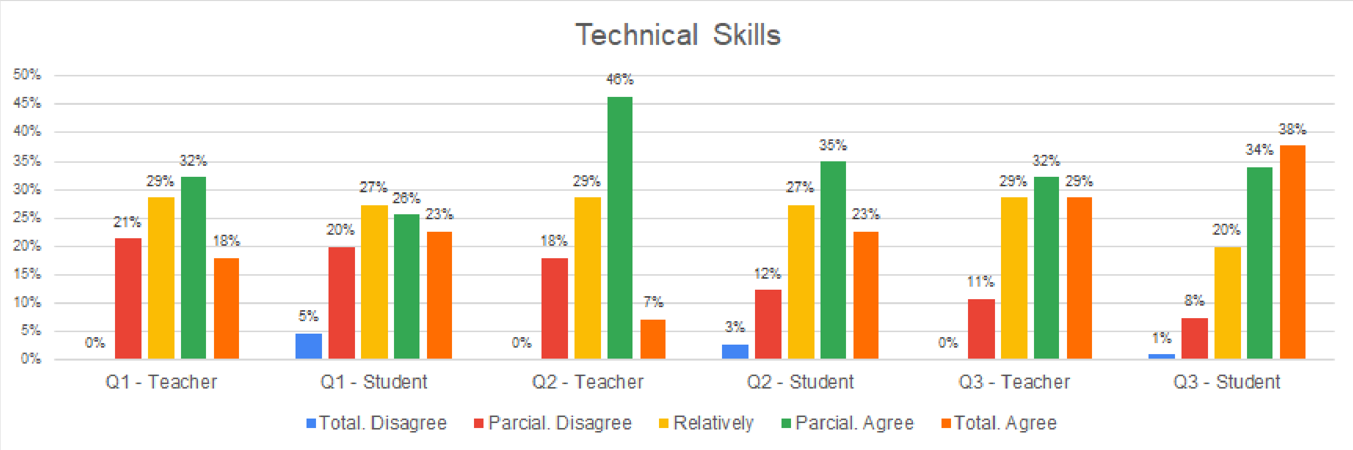

Figure 11 - Technical Skills
Source: authors themselves.

In figure 11, the answers to Q1 differ slightly between them, the biggest difference being 6%. However, in Q2 there were significant differences in the two responses. In the answer “totally in agreement”, the difference was 16% in the responses of the students in relation to the professors, in the “partially in agreement” it was the opposite, 35% of the students believe that the course is geared towards the market, against 46% of the professors . And in Q3, two responses in “totally agree” and “relatively”, the difference was 9%. This analysis raises relevant questions, such as: do students know the real needs of the market? Are the labor market issues discussed in the courses? Are there joint actions between companies and universities? These issues need to be further explored in each educational institution with the reality of each course.

Thus, this section presented the analysis on the point of view of professors and students in relation to the competencies required for I4.0. However, considering several divergences between the answers, we consider the need for another comparative parameter. Section 4.2 contrasts the result collected here with another dataset from a national test applied in Brazil to undergraduate students. The data collected are related to the Control and Automation Engineering (CAE) and Information Systems(IS) courses that are part of our study population.

4.2 Considerations on the Data Analysis

Based on the skills needed by professionals for industry 4.0, the perspective of CAE and IS students is positive. They believe to be prepared for this new market reality. However, there is a disagreement in some responses from students and professors. In order to improve our data analysis, the results of the National Student Performance Exam (ENADE), which is part of SINAES (National Higher Education Assessment System). According to Nascimento et al. (2019) , “ENADE comprises a test with questions that assess general training skills (GTS) and the specific component (SC)”. TS has content related to ethics, citizenship, democracy, environment, sustainability, globalization, multiculturalism, accessibility and social inclusion, encompassing skills such as collaboration, problem solving, autonomy, communication and conflict resolution. The SC, on the other hand, aims to gauge the competences, skills and mastery of knowledge necessary for each profession. In order to obtain this knowledge, didactic issues are involved.

Thus, to better clarify the students' answers, we sought ENADE data from the courses surveyed in the last two years that were evaluated, 2014 and 2017.

In the questionnaire, there were questions that correspond to some general training skills (7 questions) and about specific knowledge of the area (4 questions). Based on the students' and professors' responses, an arithmetic average of the responses "totally in agreement" and "partially in agreement" was created to compare with the results of ENADE in the courses of control engineering and automation (UFBA) and Information Systems (IFAL). Figure 12 shows the averages of the general education of ENADE in the years 2014 and 2017, and figure 13 the average of the responses of students and professors.

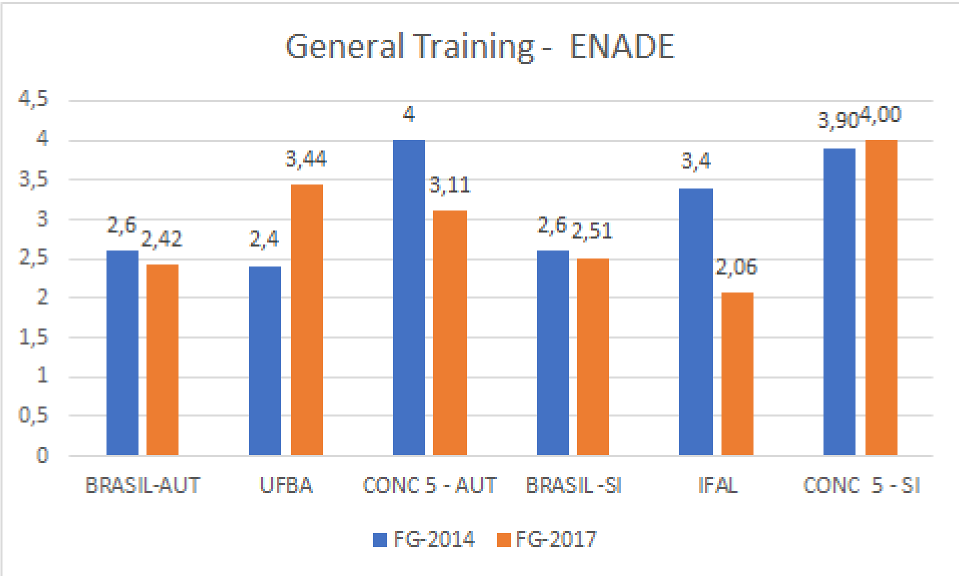

Figure 12 - Average FG ENADE

Source: INEP data elaborated by the authors

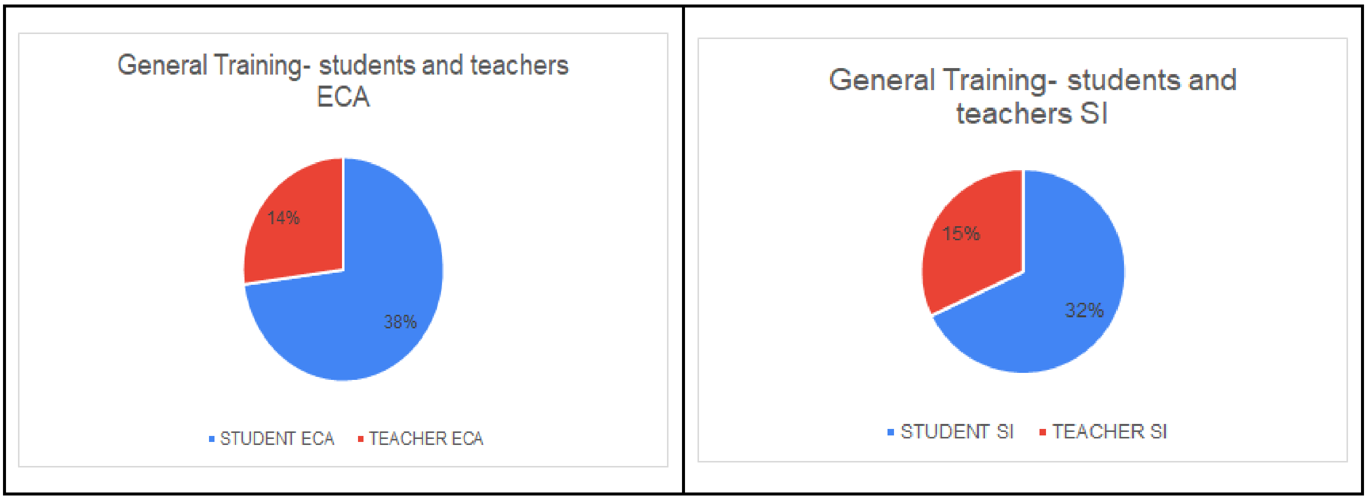

Figure 13 - Average TS students and professors surveyed.

Source: authors themselves

Regarding general education, 38% of CAE students said they were "totally or partially agreed" on issues related to competencies, whereas professors only agree on 14%. Comparing these results with ENADE, in 2014 the CAE course was 7.7% lower than the national average. Thus, in 2017 it had a big increase, getting

42% higher. CAE also had a significant improvement, since in 2014 it was -40%, and in 2017 it was + 10.6%, with an increase of 50.6%. According to Nascimento et al. (2019, p.5), "in this scenario, only UFBA obtained a sharp increase in the GTS grade, suggesting that students had more access to content related to democracy, culture, globalization and the environment, among others addressed in this section of test". Thus, there is a significant increase in the grades of the students' general education, confirming the positive perception of the students surveyed.

In the IS course, the average was 32% of students versus 15% of professors. In the results of ENADE in 2014, the average was 30.7% higher than the national average. Therefore, in 2017 it was down by 18%. In the case of SI, the results contradict the students 'perspective and are in line with the professors'.

Figure 14 shows the average of the specific knowledge of the CAE and SI courses at ENADE in the years 2014 and 2017, and figure 15 and the average of the students and professors surveyed.

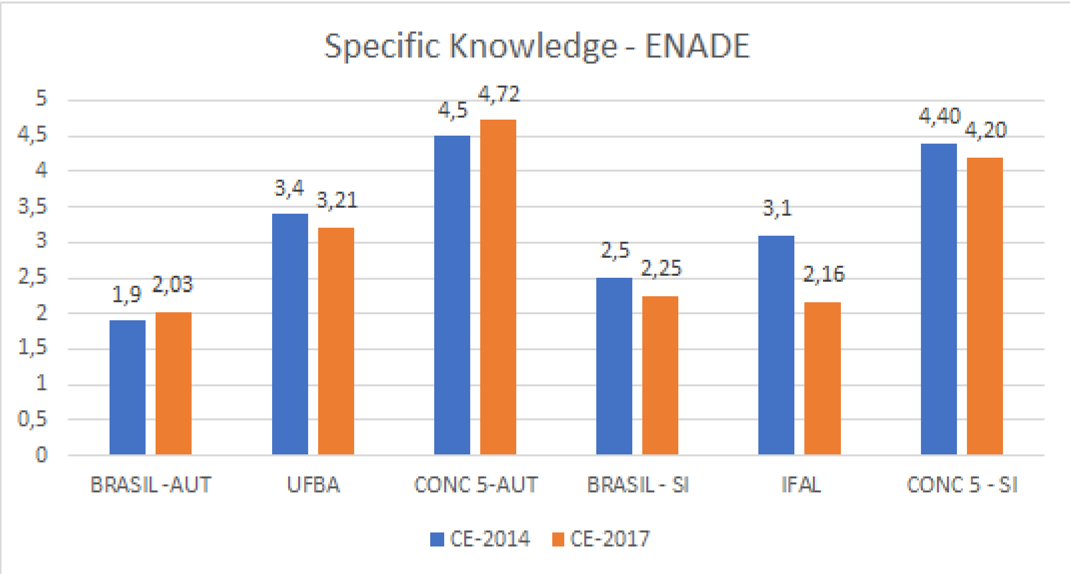

Figure 14 - Average SC of the CAE and SI courses

Source: INEP data elaborated by the authors

Figure 15 - Average SC of the students and professors surveyed.

Source: authors themselves.

In terms of specific knowledge, the responses of those surveyed were similar in both courses, 29% of CAE professors agree that students have “totally or partially” technical skills, this percentage is very close to students 24%. In 2014, CAE (UFBA) compared to the average in Brazil had a score of 78.95% higher (which is an excellent result), and in relation to courses with a grade 5 it was -25%. In 2017, the grade fell compared to 2014, but it was still above the national average by 58.13%. It can be seen, therefore, that despite decreasing 7.5% in relation to 2014, it was above the average of Brazil, with the respondents' responses being consistent with the ENADE results.

In the IS course, professors and students agree when talking about specific knowledge, 30% was the average of the two groups. As for ENADE, in 2014 the average was 24% higher than the national average, so in 2017 there was a significant drop and it was below 4%, a difference of -28% in relation to 2014. In this case of the information systems course, the research results differ significantly from ENADE.

In view of the results discussed, it is considered that higher education institutions and professors need to align themselves with the cognitive and emotional skills that are part of general education. Some actions can be taken, such as: performing a diagnostic evaluation; make use of active methodologies in the learning process; make partnerships with companies so that there is a greater exchange between academia and the productive sector.

Selamat, Taspir, Puteh, and Alias (2017) claim that teaching methods and organizational structures in future higher institutions will change significantly. There will be interdisciplinary training, massive open learning and personalized learning. Technological advancement is happening rapidly; thus, educational institutions must adapt to correspond to innovation cycles.

5. Conclusion

The fourth industrial revolution is here to stay. The purpose of facilitating and expanding the productive processes, making the interaction between men and systems, based on the latest technologies such as cloud computing, robotics, artificial intelligence, *big data*,systems *cyber* physical, among others. The great need for digitization points out that workers in these areas that will be impacted by this revolution will need to develop skills that meet the requirements demanded by the different sectors to keep up with the advances of this new industrial revolution. Therefore, a consultation to courses in the STEM field that are directly related to I-4.0, which will be essential for the preparation of these professionals for this new market.

According to CNI (2016) , there are still many challenges to be overcome, ranging from “investing in equipment that incorporates these technologies, changing the layout, processes and forms of relationship between companies along the production chain, without forgetting the training of employees who have new skills ”. These competencies are linked to the ability to deal with the new technology.

The profile of the contemporary professional requires a person with ethics, who is environmentally conscious, disciplined, willing to do things differently, knows how to lead, solve problems and conflicts, who works collaboratively, adding organizational productivity. Along with the technological innovation that underlies each industrial revolution, a new worker profile is required (Teixeira Filho, 2000), mainly in relation to his knowledge and skills to deal with new technologies. For Maisiri et al. (2019, p. 6), "there must be collaboration between industry and higher education institutions must be fostered to promote real-world problem solving".

The study shows that, in the student's view, they are able to face I4.0, however, this reality contradicts the view of the professors and the results of the ENADE test. It is necessary to work on the development of behavioral and emotional skills in their academic life, as well as making alliances with the industry so that students work closer to their reality.

As a matter of fact, we live in a society with information overload, generating anxiety and distress. There's little space to our inner, emotional life. The intrapersonal dimension looks into how attitudes can be managed and improved, in order to develop them throughout academic life. It was noticed that the biggest divergences happened in the intrapersonal dimension where the communication competence 42.5% of the students "partially agree", different from the 22.2% of the professors. In creativity, the divergence is huge, only 3.7% of professors are "totally in agreement" against 35.8% of students. The differences become more significant in problem solving (PR), conflicts (CR) and analytical data resolution (RAD), where the students' responses in the "totally agree" option are, respectively, 35.8% (PR) , 33% (RC) and 48.1% (RAD) against 0% of professors.

In collaboration, 41.5% believe they are "fully collaborative" against 21.4% of professors. With regard to autonomy, proactivity and technical skills, there was greater agreement in all responses from both groups. Some other variables such as curriculum, infrastructure, methodologies, use of digital information and communication technologies (TDIC) influence this student's training process, therefore, the focus of the study was to know how students feel about this new professional profile for industry 4.0 .

With the effective use of technologies, many physical and mechanical jobs will be replaced by computers. Industry 4.0's advanced technologies and automated systems are increasing the level of complexity of the skills required in the workforce of the future. This interaction requires strong skills, not only from technical specializations, but also from non-technical ones, such as emotional intelligence, critical thinking, creativity, innovative communication, proactivity, collaboration, and teamwork.

After analyzing the data, some actions are suggested to help in the development of this professional profile based on the interpersonal and interpersonal dimensions. With regard to the interpersonal dimension, issues such as collaboration, proactivity and autonomy can be developed together with the didactic dimension in the use of active methodologies. Two questions were related to methodology, the first asked whether the professor's methodology influences his learning process, 67% of the students were "totally in agreement" versus 42% in the professors' opinion, a significant difference of 25%. As for the second question, if the use of active methodologies in the evaluation process contributes to the student's autonomy, 49% of the students are "totally in agreement" versus 42% of the professors. The use of these active methodologies collaborate in the development of intrapersonal and didactic skills such as problem and conflict resolution, collaboration, proactivity and communication. (Baygin et al., 2016).

As future works, a more in-depth study including the employers of I4.0 is crucial. Their view will help define and compare the skills considered in the literature with the real world. In addition, complementing the vision of employers with students and professors can add a more precise understanding of the reasons for so many differences over professional training and a greater interaction between industry and academia to solve real problems.

6. Acknowledgement

The research is financed by the Federal Institute of Alagoas and the Industrial Engineering Program (PEI) of the Federal University of Bahia, in cooperation with the Computing Institute of the Federal University of Alagoas (UFAL).

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