IOSR Journal of Research & Method in Education (IOSR-JRME)
e-ISSN: 2320–1959.p- ISSN: 2320–1940 Volume 9, Issue 5 Ser. II. (Sep. - Oct .2019), PP 70-83
www.iosrjournals.org

Integrator Project: a conception of knowledge integration in a Production Engineering Undergraduate Course

Tamires Fernanda Barbosa Nunes[1], Stela Xavier Terra[2], Larissa Medianeira Bolzan[3], Rafael da Costa Carrir[4], Alejandro Martins Rodriguez[5]

[1]*(Postgraduate Program in Production Engineering, Federal University of Santa Maria, Brazil)*
[2]*(Center for Engineering, Federal University of Pelotas, Brazil)*
[3]*(Center for Engineering, Federal University of Pelotas, Brazil)*
[4]*(Center for Engineering, Federal University of Pelotas, Brazil)*
[5]*(Center for Engineering, Federal University of Pelotas, Brazil)*

Abstract: *The Integrator Project discipline aims to givestudentspractical situations in whichtheyneed to solve real problems. The problems are supported by the interdisciplinarity of a project in order to integrate the knowledge and the experienceslived by undergraduatestudents. Considering the importance of the Integrator Project discipline, thispaperaims to analyze the degree of its importance to the learning and training of future engineers in the Production Engineering course. A questionnaire wasapplied to the undergraduate and graduateswhostudiedthis discipline. As a result, itwasverifiedthatthroughthis discipline the studentsdevelopskills like communication, teamwork, leadership, as well as developingtechnical reports, in whichresearchproblemswereidentified and solutions wereproposed and evenvalidated in some cases. Therefore, the Integrator Project is a proponenttoolthatadds value to the community and, at the same time, allowsstudents to design projectsthatintegratetheories, methods, and techniques. The discipline alsohelpsconsolidate the knowledgeacquiredfromvarious disciplines during the period of graduation.*

Keywords:*Industrial Engineering, Integrator Project, Skills, Professional Development.*

Date of Submission: 09-09-2019 Date of Acceptance: 25-09-2019

I. Introduction

Aspiring production engineers must develop the capacity to identify structure and solve problems. The professional objective of Production Engineering is to transform the gathered information, ordered and properly worked, into results. This happens through the practice that directs the effort expended by the professional in useful solutions for the organizations and, consequently, for the society.

The importance of the critical look at the formation of this professional is remarkable, because it will allow the identification of problems and the creation of solutions to these identified demands. The decisions and performance of professionals in this area have a direct impact on society and the way their demands are managed. Effective training, consequently, gives the professionals the appropriate skills to meet the needs found in a "real" work scenario.

Differently from other engineering degree courses, the production engineer is trained to have a systemic view. Thus, under the aegis of Engineering, she or he seeks ways to solve challenges. Among the methods used in Engineering, there is the simulation, which is lined up by Bazzo &Pereira[1]:

> *How does the Engineer solve your problems? Designing! It is through the project that it applies more significantly its technical and scientific knowledge. In fact, when designing, an Engineer applies more than just formal knowledge specific to his area of expertise. It also uses economic, ethical and social knowledge, as well as experience and common sense. More than that! It gives vent to your creative imagination in the search for something new that can meet the needs of society. Therefore, we can consider that the project is the essence of Engineering.*

If designing is considered the essence of Engineering, it is expected that during the undergraduate course the future production engineers will develop the skills needed to develop problem solving through project design. Therefore, it is of the utmost importance that the discipline of Integrator Project be provided so that students can combine theory and practice during undergraduation.

In the undergraduate course of Production Engineering from a university in the south of Brazil, there is a discipline that meets such need. This is the discipline of Integrator Project. Through the Integrator Project

discipline, the student can identify a real problem, format it and work on finding of a wide range of solutions to this problem, as well as its subsequent validation. The students also prepare a presentation on a technical report related to the project.

The main objective of the Integrator Project discipline is the learning acquired by the student's experience regarding practical ways to solve real-world problems inherent to Engineering. The practice of this discipline within the Engineering courses brings the apprehension of the concept of interdisciplinarity to the educational practice.

Interdisciplinarity does not present a unique meaning, but in all interpretations, it implies an attitude change in the pursuit of knowledge. It refers to all activities experienced in the academic sphere in different approaches, with different points of view, leading to the understanding that a phenomenon needs to be studied, analyzed, through various areas.

Thus, through the integration of the concepts seen in each discipline, interdisciplinarity is built and the didactics of the teaching-learning process are defined.

In short, the interdisciplinarity of a project aids in integrating the knowledge and experiences of students along the course. Based on this premise, it develops skills and competences capable of helping the students become professionals who are able to face the demands of the labor market, as well it inserts practice as a learning element.

Considering the importance of a good course curriculum at the undergraduate level in an engineering course, the main objective of this paper is to quantitatively analyze the degree of importance of the Integrator Project discipline for the learning and training of future engineers in the Production Engineering course at a university in the south of Brazil, through a multiple choice questionnaire applied to the students or undergraduates who attended this course.

II. Integrator Project discipline in Engineering courses

The Integrator Project discipline seeks to problematize themes of fundamental importance in the area of the course. As a way of contextualizing the real work environment, it articulates interdisciplinarity and moves towards transdisciplinarity[2]. In this way, the Integrator Project discipline becomes an alternative whose objective is to meet the need for professional experience of the students, since not all Brazilian students have the opportunity to develop specific skills that they will require in their career, as well as in their curriculum. It is, therefore, essential to develop practical wisdom during the academic training of engineering students.

According to Pozo &Echeverría[3]:

> Orienting the problem-solving curriculum means looking for and planning situations that are open enough to induce students to search and appropriate strategies not only to answer the school questions but also to the everyday reality.

The Integrator Project discipline is becoming a strategic tool of the curricular component, which proposes the learning process based on practical situations. With this, the discipline seeks to promote the professional experience of Engineering students, developing dynamic decision-making skills that only practical experiences can add to professionals.

"Project is an execution plan, it is a plan to achieve goals within budget and time goals; is the set of activities that precedes the execution of a product, system, process or service"[1]. Thus, the practice of designing means establishing a set of procedures that result in an information set, shaping the design process into a methodology applied to problem solving.

According to Bazzo &Pereira[1], the design process can be described in a simplified manner according to the following steps: identification of a need, definition of a problem, information gathering, design, evaluation, solution specification and communication. Through these steps, a problem can be defined. This problem is the object of study, which will be described through the collection of information. Along these lines, the designer has a background of the problem to look for solutions in the first design stage. After that, she or he moves on to the evaluation phase of solutions to see whether it will accept the proposals. Subsequently, the solution, if evaluated positively, will be defined in detail, which must be communicated orally or in written form so that the need defined as a project problem becomes adequately supplied.

It is noteworthy the importance of a discipline capable of integrating the knowledge acquired by the student during her or his undergraduation, both for the student and for society. However, not all Engineering courses list in their curricular structure any type of discipline focusing on an interdisciplinarity project. Most Engineering courses link the experience of integration and practice of the knowledge developed during the undergraduation to them thesis. In these cases, the student does not have the opportunity to experience the practice of facing problems from real demands during her or his academic journey, since the final work may or may not be an applied research.

In this scenario, when there is not any type of Project Integrator discipline, future engineers will go into the job market without this kind of experience during their degree, which may reflect on the profile of these professionals.

Other courses establish in their curricula project disciplines that have specific applications within their area of action, thus allowing the knowledge acquired in the course subjects to be integrated and applied; however, they do not allow the student to choose the problem to be worked on or the area of its engineering course that they wish to deepen their knowledge.

In addition, the Integrator Project discipline is a tool that allows students to identify themselves with their probable areas of work. However, many do not define during their academic formation the practice area they intend to follow. Facing this fact, the referred discipline allows students to better understand and deepen the knowledge acquired in an applied way and go to the job market with a previous field of work, helping in the search for opportunities that fits their professional profile and thus help them become self-realized professionals.

According to Oliveira et al.[4], the development of an integrative project allows students to integrate knowledge and skills acquired during the course, promoting interdisciplinarity, critical thinking and developing communication skills. That is, learning in a practical way makes the process effective.

In keeping with the authors mentioned above, the completion of the Integrator Project stimulates teamwork, learning and, consequently, the evolution of the developed knowledge, outlining the profile of the professional's future, integrating the knowledge and skills acquired by the student, promoting interdisciplinarity, in addition to developing the student's critical thinking and communication skills.

The world scenario is challenging in terms of the labor market, as it is increasingly demanding and seeks, more and more, qualified and competent professionals, capable of solving, creatively and quickly, the demands required by society, besides knowing how to relate in a team and to use communication skills.

This current panorama always demands environmental and technological solutions, mainly ones that preserve life and respect society and the environment. These requirements are based on ethical and social issues in order to promote efficiency through the generation of value.

In line with all the points raised, it is important to highlight the importance of professional development with the capacity to contribute towards a better world, with a better quality of life, a higher quality of education, and to minimize the increasing impacts of consumer demand and social and environmental needs, promoting fast, efficient solutions that aim for an even greater good.

Given the current consumers, who not only search for services or products, but rather they also contemplate the needs of value creation. Organizations are compelled to hire professionals with posture and profile that fit these parameters. This is the scenario that future engineers will face and need to be prepared for. This preparation happens through the practice and development of skill to solve real problems. According to Santos and Barra[2], the discipline of Integrator Project is a tool capable of articulating teaching practice, knowledge, acquired skills, curricular matrix with the reality of the work environment.

As for Scientific Initiation (SI), Da Silva et al.[5] state that it is added to the pillars of continuing education through research, from which emerges the applicability of the knowledge acquired during graduation and is easily visualized. On the other hand, in the absence of integrative disciplines, such as the discipline of Integrator Project, SI assumes the practical and multidisciplinary character from which developed education is effective. According to Da Silva et al.[5], SI drives the development of technological innovations through projects that investigate subjects that cross knowledge frontiers.

Nakao &Felício[6] stated that the development of characteristics such as proactivity is fundamental, since it allows students from engineering schools to participate in the formation process of the society, which they are a part leading or being led. It is worth remembering, according to De Luca et al.[7], that Engineering has a broad and interdisciplinary field of activity in several segments, focusing on problem solving and proposals for solutions involving planning, execution and control. According to the authors, the professional activities inherent to Engineering professionals require skills such as initiative, proactivity, critical sense, teamwork, innovation, among others, focusing on the needs of costume service and the reaching these results.

Katzenbach[8] discusses the overall performance of teams in relation to people acting alone or in organizational groupings, especially when the required performance includes multiple skills, judgment and diverse experiences. Therefore, considering Engineering as a catalyst for performance, it is remarkable that the ability to work as a team is justified by its scientific notoriety.

III. Methodology

In the making of the present paper, the importance of the existence Integrative Project discipline to integrate knowledge, develop skills and deepen learning was emphasized. Based on the search and improvement of knowledge, this paper sought to quantitatively evaluate the importance of the discipline of Integrator Project for Engineering courses.

According to Gil[9] "research can be defined as the formal and systematic process of scientific knowledge development", with the fundamental objective of discovering answers using scientific knowledge.

With the purpose of analyzing the importance of the Integrator Project in the Production Engineering course through scientific research, which was classified according to Table 1: i) Applied referred to its nature; ii) As to the approach, being Quantitative. Information and opinions were translated into numbers for further classification and analysis; iii) in regard to the objectives, as being Descriptive.It aimed to contextualize the importance of the theme through a bibliographical survey and questionnaires addressed to students who have already been approved in the discipline of Integrator Project; iv) Regarding the technical procedures, as Case Study.

This research was done through the elaboration of a questionnaire, with multiple choice questions containing a set of possible answers to assign to each proposed question. The questionnaire was addressed to the students of engineering courses who have completed the discipline of Integrator Project, aiming to analyze the degree of their satisfaction regarding the importance of the discipline of Integrator Project for their professional development.

To determine the size of the sample, a random probabilistic sampling was performed as it is one of the most usual. The defined target population involved students of the undergraduate degree in Production Engineering from a university in the south of Brazil as well as students who have already graduated. Data collection was carried out for 6 weeks from November 6, 2018 until December 18, 2018, by completing the free form provided by a large online services and software company.

Knowing that the exact number of students approved in the discipline by that date was 209 and considering a sampling error of 10% and a 90% confidence margin, the sample size was calculated by equations (1) and (2), according to the methodology proposed by Barbetta[10]:

$$n_0 = \frac{1}{{E_0}^2} \tag{1}$$

$$n = \frac{N.n_0}{N+.n_0} \tag{2}$$

Being: n_0 = first approximation of the sample; N = number of approved students in the discipline; E_0 = sampling error; n = sample size. Following the procedure of the formulas above, a sample of 68 respondents was defined. However, 101 approved students answered the questionnaire.

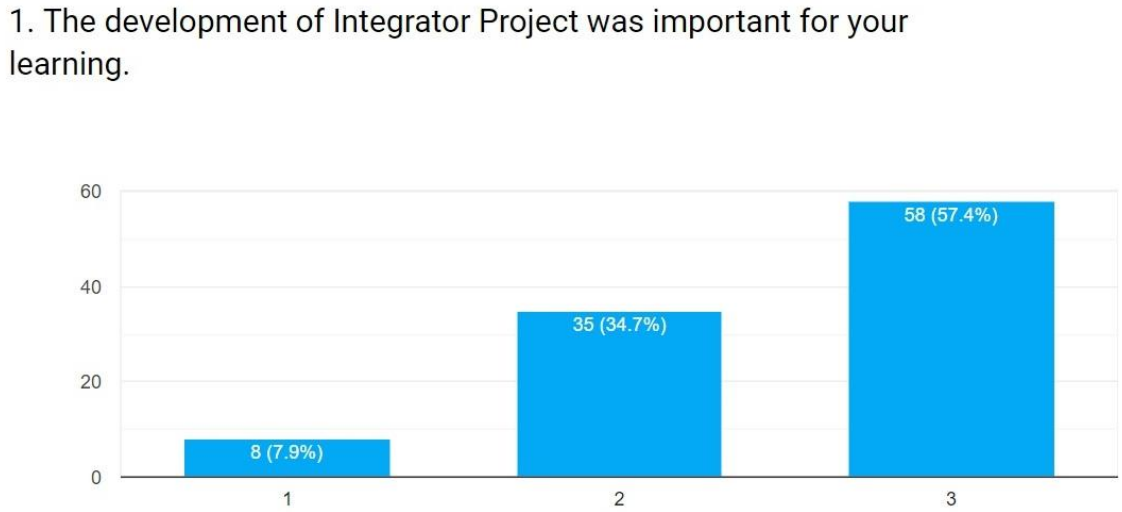
IV. Results of the evaluation of the Integrator Project discipline

The evaluation of the Integrator Project discipline was done by those who had already studied this discipline. It aimed to investigate the assessment about the importance of the discipline for their training and professional development. In the interest of knowing the level of student's satisfaction in relation to the Integrator Project discipline, a questionnaire was elaborated to explore its importance in the curriculum of future Engineers.

The questionnaire proposed consisted of multiple-choice questions. The first eight questions offered three alternatives: I disagree; I partially agree; and I fully agree. Questions 9 and 10 asked for numbers to be assigned to the query: 0-5, 5-7 and 7-10. Questions 11, 12 and 13 had predetermined answers and the last question, 14, was open. The questionnaire is in Appendix A. The survey results are discussed below.

The first question of the questionnaire sought to highlight the general importance of the Integrator Project discipline for the development of the students' learning process. Figure 1 shows the degree of importance attributed by students and graduates to the development of the project. 57.4% of the students and graduates fully agree that the development of the Integrator Project discipline contributed to the consolidation of practical and theoretical learning during graduation.

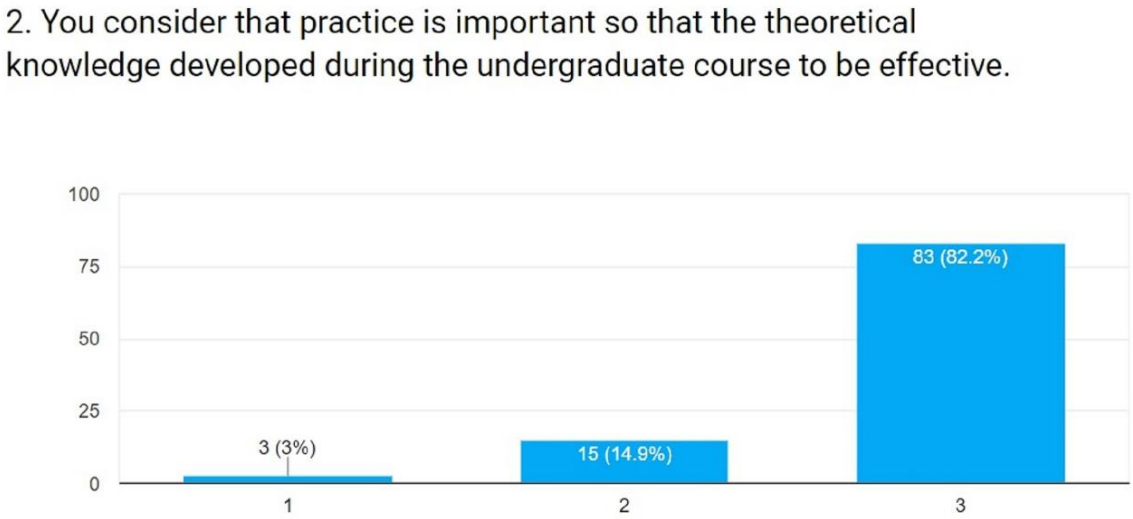
Figure 1: Question 1



Source: Authors (2019)

According to the interviewed students, practical learning is extremely significant for the consolidation of theoretical knowledge acquired during graduation. As Figure 2 demonstrates, 82.2% of the students and undergraduates fully agree with this statement.

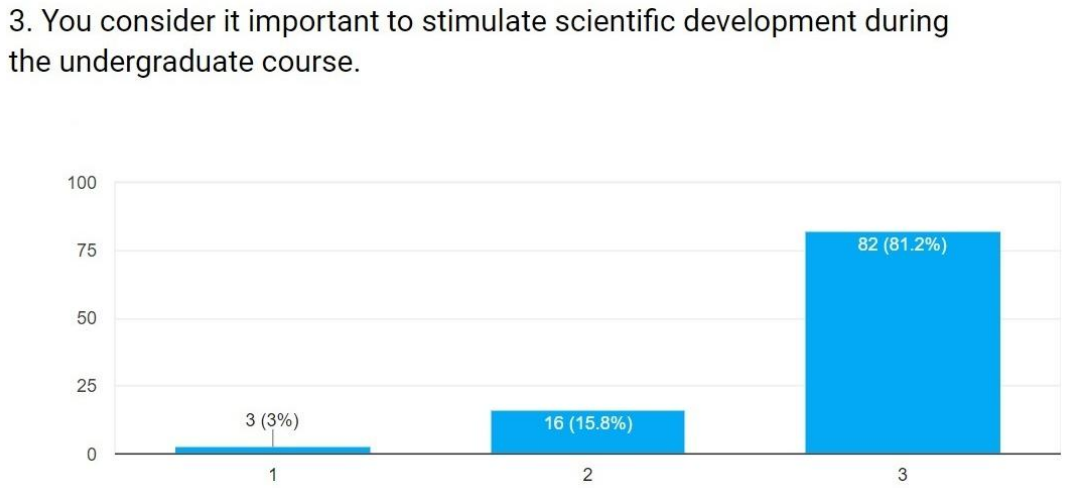
Figure 2: Question 2



Source: Authors (2019)

Considering the relevance of scientific research to the training of Engineering students, the relevance of the scientific development for students, during the graduation period, was analyzed. Figure 3 shows that 81.2% of the students and graduates consider relevant the fomentation of scientific development.

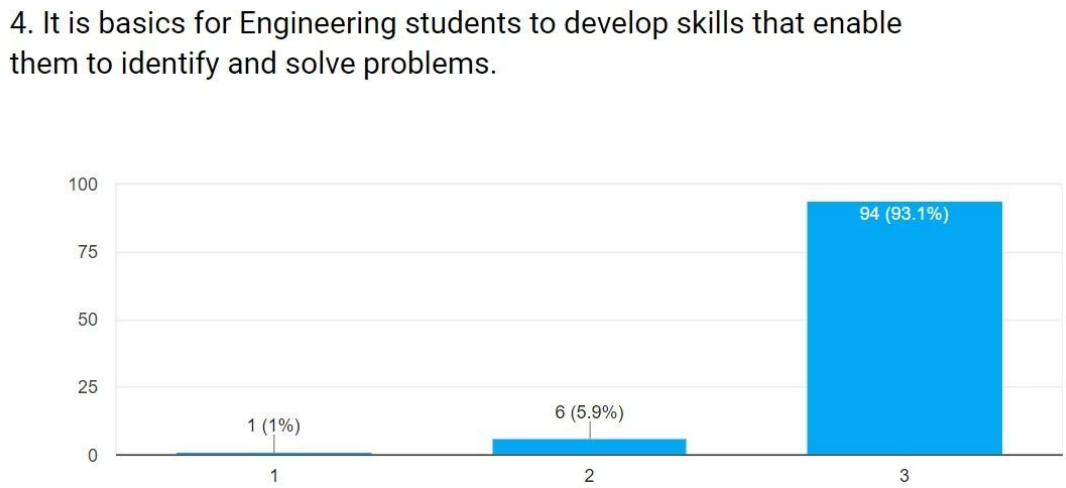
Figure 3: Question 3



Source: Authors (2019)

Among the main characteristics of Engineering professionals is the ability to identify and solve problems. Figure 4 shows that 93.1% of the respondents fully agree that the ability to identify and solve problems is essential to the production engineer's profile for a full professional activity.

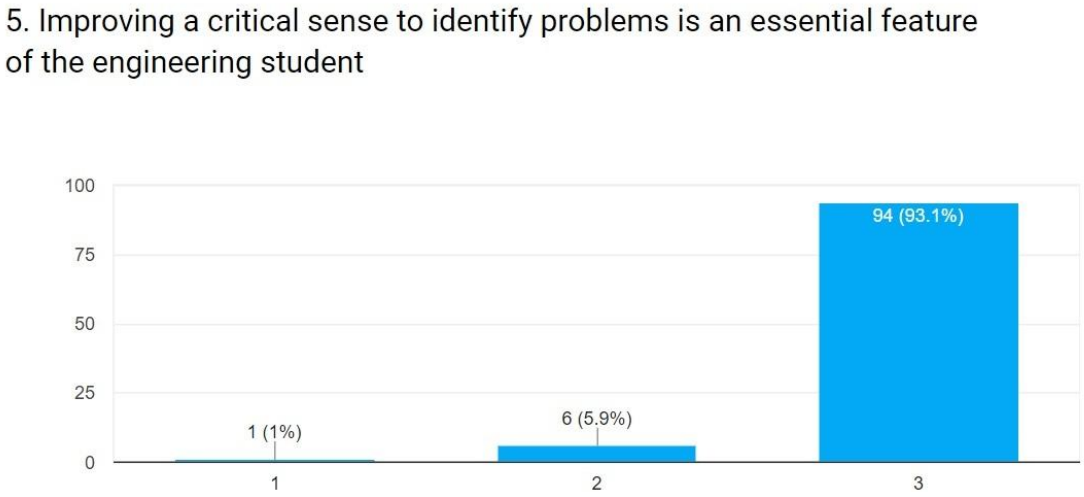
Figure 4: Question 4



Source: Authors (2019)

The ability to develop critical and self-critical awareness allows students and future engineers to constantly assess their professional performance. In addition, these characteristic aggregates significant value to the engineer's profile and her or his professional activities. It contributes to the identification of problems and solutions originated from the demands observed[11]. Figure 5 shows that among the respondents who participated in the survey, 93.1% fully agreed that the development of critical sense is an essential feature of the future professional of Engineering.

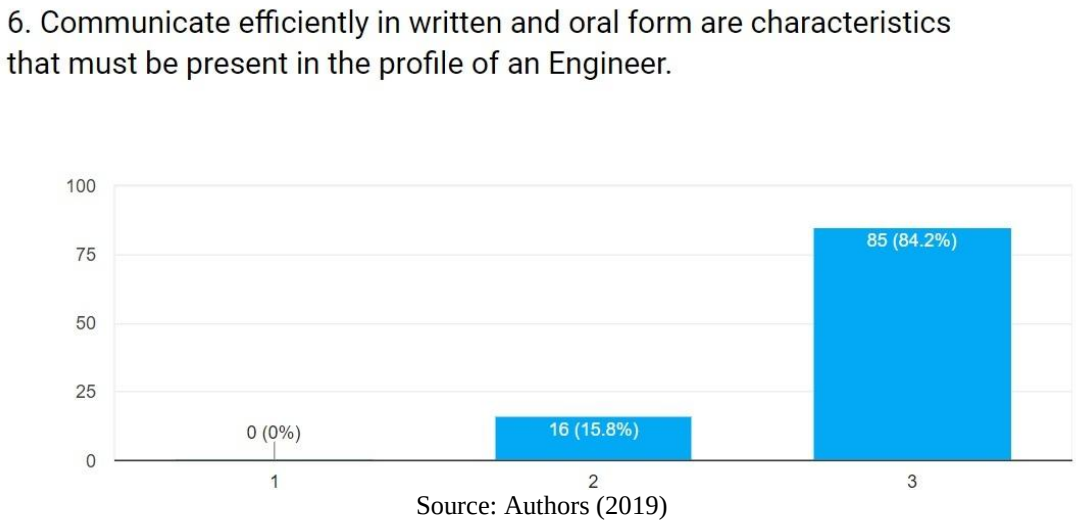
Figure 5: Question 5



Source: Authors (2019)

The pedagogical model for forming new engineers is based on specific knowledge; however, it is known that the labor market demands more and more professionals with skills that go beyond the techniques. Thus, training in a higher education course must provide practical experiences in which students can develop the skills necessary for their career, among them the communicative skills, since effective communication is an essential characteristic for an engineer[12]. Figure 6 shows that the statement about efficient communication, both written and spoken, must be part of the profile of an engineer was agreed in full by 84.2% of the respondents.

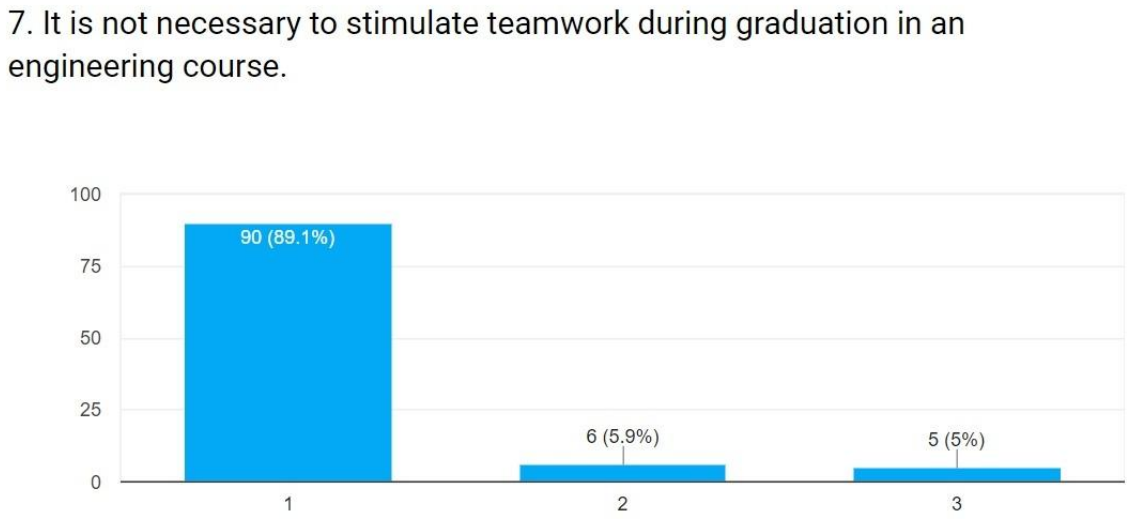
Figure 6: Question 6



Source: Authors (2019)

Regarding the ability to work as a team, this competence is spread as a basic premise in the field of engineering, because engineering deals with process and rarely does a single person have the knowledge or ample experience to fully understand a process. It is noticed that 89.1% of the students and graduates understand that the activities that stimulate the aptitude to work in a team are important for the context of professional qualification.

Figure 7: Question 7



Source: Authors (2019)

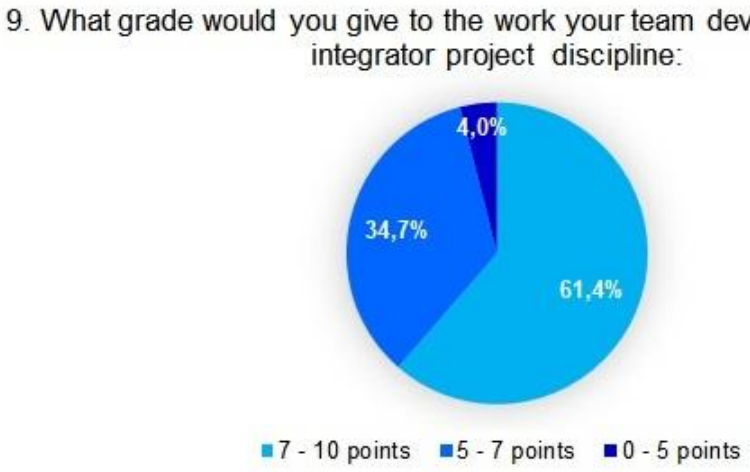
Teamwork, which enhances the performance of the joint objective, is also notorious for the development of an integrative project. For the division of tasks in every type of project, each professional plays a role according to the tasks assigned to her or him. In this research, it is shown in Figure 8 that most of the respondents (47.5%) pointed out that there was no effective participation of all members of their teams over the project development, but 23.8% of the students and alumni stated that they had the experience of effective participation of the members. In addition, another 22.8% answered that they performed the project without staff (individually).

Figure 8: Question 8

Source: Authors (2019)

The judgment about relevance of the integrating project by the team members (see Figure 9) shows that 69.3% of the students and graduates consider that a satisfactory job was done, which was assigned a score of 7 - 10 points, while 26.7% think that the project is worth 5 - 7 points and only 4.0% have arbitrated from zero to 5 points to their respective project integrator.

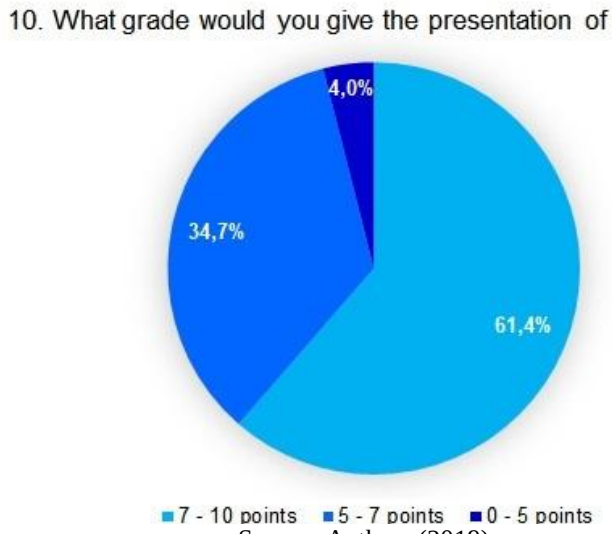
Figure 9: Question 9



Source: Authors (2019)

In the next question verified the opinion about the colleagues' integrator projects. On the graph of Figure 10, 61.4% of the projects presented were assigned scores of 7 to 10 points from the respondents' points of view, with 34.7% of them judging from 5 to 7 points to presentations and only 4.0% were of the opinion that the integrator projects from colleagues were worth 0 to 5 points.

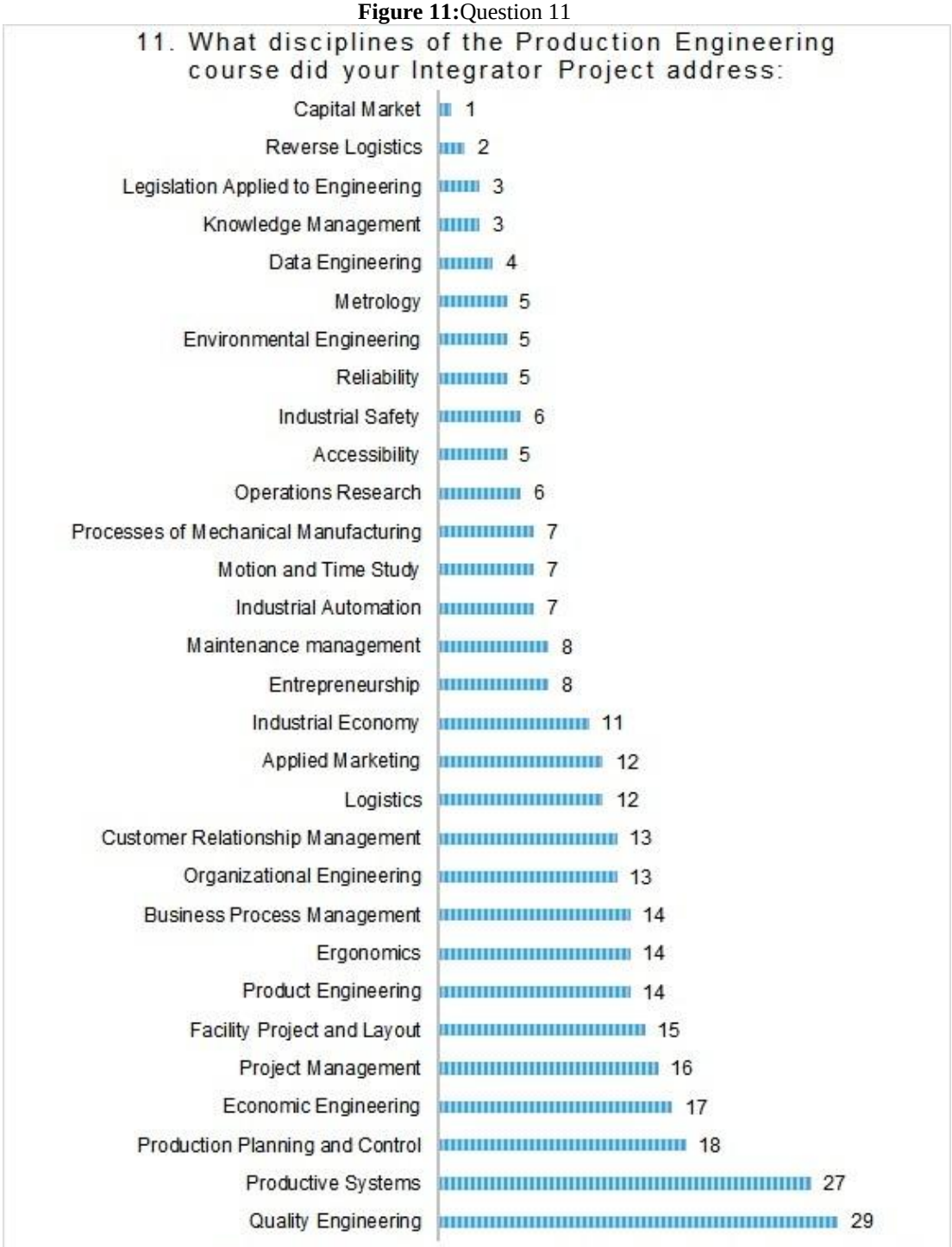
Figure 10: Question 10



Source: Authors (2019)

Question 11 (see Figure 11) scrutinized the production engineering topics addressed by the respondents in their respective integrator projects. The spotlight topics were Project Management (16 mentions), Economic Engineering (17 mentions), Production Planning and Control (18 mentions), Productive Systems (27 mentions) and Quality Engineering (29 mentions).

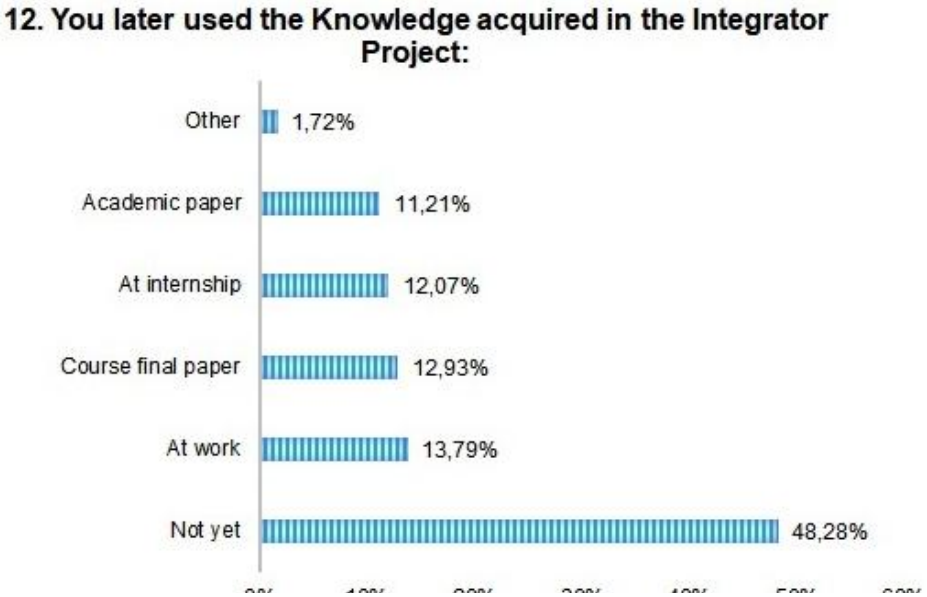
Figure 11: Question 11



Source: Authors (2019)

In relation to what was acquired in terms of knowledge in the course of Integrator Project by students and graduates, 48.3% reported not having applied such knowledge yet. However, the majority (51.7%) claimed to have applied some kind of knowledge: either at work (13.8%), at the undergraduate thesis (12.9%), internship (12.1%), some type of academic publication (11.2%), others (1.7%). Figure 12 shows in a bar graphic this question highlighting the answers about the use of knowledge coming from the Integrator Project.

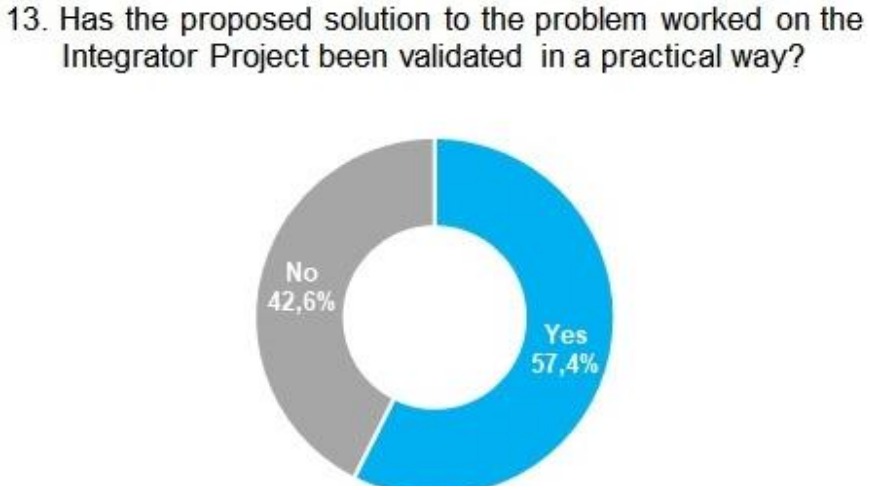
Figure 12: Question 12



Source: Authors (2019)

In question 13, the validation of the solution proposed by students for the problem in the integrator project was verified. According to 57.4% students and graduates, the mentioned solution was validated, while 42.6% stated that it had not been validated. These numbers are shown in Figure 13.

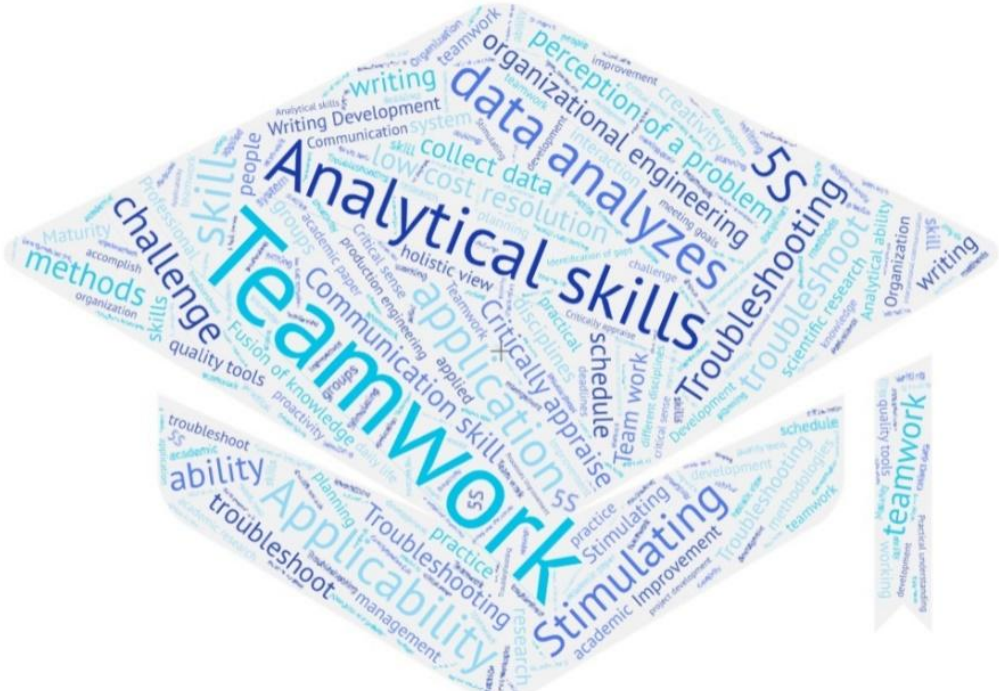
Figure 13: Question 13



Source: Authors (2019)

Finally, question 14 asked what benefit(s) the process of integrator project added to those involved. Among the most mentioned benefits were teamwork, analytical skills and problem-solving experience. Figure 14 illustrates the most explicit words in the respondents' answers in form of a cloud chart.

Figure 14: Question 14



Source: Authors (2019)

V. Conclusion

This paper contributes with unprecedented results, which presented quantitatively the degree of importance of this discipline in the graduation stage, seeing as the object of analysis of the present paper had not yet been analyzed in another situation. As the Integrator Project discipline identified, this discipline formally can be found only in the Production Engineering course of the center for engineering at a federal university in Brazil, which was nationally ranked by World University Rankings 2019-2020 (CWUR)[13] as the thirteenth position of 52 positions in all.

It shows the virtue of teamwork's experience, since a common purpose generates a greater commitment and responsibility. It was reported that the Integrator Project discipline adds to the professional development. According to the respondents from this survey, analytical study and, later, prospection of solutions can stimulate the critical sense when there is a multidisciplinary project that aims to handle a problem. In this discipline, the students had the opportunity to experience the profession; they could develop communication skills, teamwork, leadership, as well as technical reports while identifying problems and designing solutions for them.

The knowledge acquired from different disciplines can be consolidated in the Integrator Project discipline because it allows students to design projects capable of integrating theories, methods and techniques.

In order to deal with the daily situations of their professional activities, future engineers must have developed, during their undergraduation, a set of methods that allow her or him to handle the problems. It follows that undergraduation is configured firstly to develop engineering professionals with the requisite techniques skills for practicing their profession, according to the demands of the labor market; as well as it may potentialize critical sense, creativity and communication, in order to deal with the daily situations of their professional activities.

It should be emphasized that in Engineering, often the most effective "means" to solve a problem is designing. The simulation process requires the use of multiple skills. Why not test it on a subject with this exact target, which, in addition to stimulating multidisciplinarity, can be a source of team experience? Besides, it brings the engineer closer to the local community.

Therefore, the Integrator Project is a capable tool to add value to the community and, at the same time, it benefits the curriculum matrix of undergraduation course. It also fits community reality and even recognizes the demands of the market.

This paper still leaves as suggestions, backed up on notoriety for professional development in the undergraduation process, the syllabus co-creation of the discipline by students and the responsibility of the course to promote improvements. In time, referring to the limitations of this study, it is worth remembering that the answers to the questionnaire were not profound, possibly due to the voluntary nature of the respondents, and also the amount time the respondents could spend on this task.

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Appendix A – Questionnaire Transcription

Questionnaire about the importance of the Integrator Project discipline in an Engineering course

1. The development of Integrator Project was important for your learning.	**1** **2** **3**
2. You consider that practice is important so that the theoretical knowledge developed during the undergraduate course to be effective.	**1** **2** **3**
3. You consider it important to stimulate scientific development during the undergraduate course.	**1** **2** **3**
4. It is basics for Engineering students to develop skills that enable them to identify and solve problems.	**1** **2** **3**
5. Improving a critical sense to identify problems is an essential feature of the engineering student.	**1** **2** **3**
6. Communicate efficiently in written and oral form are characteristics that must be present in the profile of an Engineer.	**1** **2** **3**
7. It is not necessary to stimulate teamwork during undergraduation in an engineering course.	**1** **2** **3**
8. The members of your team participated in an effective way in the development of the integrator project.	**1** **2** **3** I did the project myself
9. What grade would you give to the work your team developed during the integrator project discipline:	**0 – 5** **5 – 7** **7 – 10**
10. What grade would you give the presentation of the works?	**0 – 5** **5 – 7** **7 – 10**
11. What disciplines of the course of Production Engineering did your Integrator Project address:	Question Type; Productive Systems; Industrial Economy; Applied Marketing Quality Engineering; Project Management; Economic Engineering; Metrology; Production Planning and Control; Ergonomics Reliability; Operations Research; Processes of Mechanical Manufacturing; Product Engineering; Motion and Time Study; Logistics; Industrial Automation; Industrial Safety; Environmental Engineering;

	Legislation Applied to Engineering; Maintenance management; Data Engineering; Organizational Engineering; Customer Relationship Management; Entrepreneurship; Accessibility; Business Process Management; Knowledge Management; Reverse Logistics; Capital Market; Facility Project and Layout; Leadership and Team Development
12. You later used the Knowledge acquired in the Integrator Project:	At work; At internship; Academic paper; Course final paper; Not yet; Other
13. Has the proposed solution to the problem worked on the Integrator Project been validated in a practical way?	**Yes** | **No**
14. In your opinion, which professional skills were developed through the Integrator Project discipline in you and in your group?	(text writing)

Source: Authors (2019)

Note: 1 to Disagree; 2 to Partially agree; 3 to Fully agree; In questions 9 and 10 should be assigned grades from 0 - 5, 5 - 7 or 7 - 10 points as answers.

NUNES, T. F. B; TERRA, S. X; BOLZAN, L. M; CARRIR, R. C; RODRIGUEZ, A. M.“Integrator Project: a conception of knowledge integration in a Production Engineering Undergraduate Course."IOSR Journal of Research & Method in Education (IOSR-JRME) , vol. 9, no. 5, 2019, pp. 70-83.