

# Sustainable Development: Contributions to the Engineer Education

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## I. INTRODUCTION

The growing demand for economic growth and the resulting degradation of the environmental systems have been triggering the necessity of the implementation of new processes and technologies that include integrated concepts of efficiency in the use of natural resources and in the reduction of discharges of polluting materials on the environment. It advocates the concept of sustainable development, that is, one that “fulfills the current needs without compromising the future generations’ ability to fulfill their own needs” [1]. Usually, this concept is wrongly linked to the natural resources’ limited character (e. g.: water, air, and soil). We must clarify that the sustainable development rules must favor life quality improvement for the society and environmental quality maintenance for the natural ecosystems, without unlink them from the necessary economic growth.

Regarding it, sustainability considers that deteriorated environments do not contribute to the maintenance of the people’s social, environmental, and economic welfare and that every planning must be focused on medium and long term alternatives, alongside political actions [2]. Correspondingly, the actions of different professionals, especially from the Engineering sector, presents a high potential to contribute with new processes, products, and technologies that respect the environment and human quality of life. However, recent works have been showing a lack of knowledge regarding sustainability in Engineering courses [3], [4], [5], which in long term, result in difficulty to meet new sustainable development, environmental protection, and social needs [6].

Currently, it is fundamental that, in engineering course curricula, the sustainable subject is approached in greater depth by the professors and that they might be aware of how

important is to teach this subject in the classroom, since it is lightly explored in the academic field [7].

Reference [8] consider that the purpose of teaching sustainability and social responsibility in engineering courses is to promote the welfare of the different publics affected by the Engineer’s actions. Also, they have registered that the offer of disciplines linked to the subject contributed to increase the number of final graduation projects whose themes revolve on sustainability; to increase the number of students of other courses, besides engineering, that are searching for the subject; and to incite the interest for post-graduation courses with this theme [8].

With that in mind, this paper’s purpose is to investigate the level of knowledge and interest of engineering students in topics related with Sustainable Development, encouraging discussions about the knowledge blanks of these future professionals, establishing possible measures to complement engineering course curricula, increasing the future engineers’ awareness so they might include sustainable aspects on their projects

## II. WORKSHOP

To evaluate the knowledge of engineering students on Sustainable Development and discuss this subject, a Workshop was organized during the XV Week of Research and Extension of the Federal University of Santa Catarina, Joinville, Brazil, in October 20, 2016. Therefore, before starting the workshop, the participants answered a quiz, developed by Azapagic *et al.* [3], whose purpose was to analyze the initial knowledge level of everyone involved. Such quiz included a list of subjects linked to sustainability and four answer options based on the level of knowledge on each topic: I do not know anything about it, I have heard about it but I cannot explain it, I have some knowledge about it, and I know a lot about it. This quiz is very wide, contemplates aspects regarding different engineering subjects and may as well be applied to other institutions and courses.

Then the workshop was divided into two main activities. First, the subject was contextualized through an oral presentation. There was an explanation of the origin and definition of the Sustainable Development concept, the meaning and importance of the environmental quality maintenance for our society and for productive activities, and the concepts of ethics on the profession. The purpose of this

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TABLE 2. Quiz made at the end of the workshop to evaluate the students' knowledge gain after the activities were done.(Cont.)

<p><b>3.</b> The current economic scenery's changes and demands result in more and more competitive markets, which represents real challenges for private organizations. Perform productive activities, in this context, is not a simple task. Incorporating the socio-environmental responsibility becomes a requirement to licentiate potentially polluting activities and companies must adapt themselves to such demands. Regarding this subject, check the alternative(s) that represent(s) the socio-environmental aspects that must be incorporated by the companies.</p> <p>a) Productive activities must be performed taking the individual's welfare into account, trying to satisfy the persons that are responsible for the continuity of the companies and for generating jobs</p> <p>b) A decision that may damage human health and the environment may be justified in some cases due to the necessity of maintaining companies that generate several jobs</p> <p>c) The corporative world is permeated by individual interest conflicts. Therefore, ethics contribute to regulate these relations, establishing limits and parameters to be followed</p> <p>d) Keep a dialog with communities that are directly or indirectly affected by productive activities contributes with actions that respect the collective needs, contributing to ensure jobs and income, respecting everyone's space</p>
<p><b>4.</b> Nowadays, productive activities must consider the "sustainability" component during their operations. Large entrepreneurship activities, like those that include roadway, railway, waterway, and pipeline constructions, already have to deal with some environmental restrictions before their design to ensure environmental preservation and biodiversity maintenance. Regarding this subject, check the alternative(s) that represent(s) justifications for these environmental restrictions:</p> <p>a) The activities must comply with environmental regulations to ensure the environmental preservation of environmental systems.</p> <p>b) Water quality maintenance is fundamental to ensure the continuity of productive processes that demand water that is not contaminated with corrosive or abrasive substances, since the presence thereof is harmful to the productive process.</p> <p>c) Complying with environmental regulations means delaying the implementation of new activities that might contribute with the income generation and economic development of a specific region.</p>

The data registered in the quizzes, initial and final, were organized in the *Excel* software. Charts were generated with the response proportion of each subject and interpreted to identify the level of understanding of the subjects linked to sustainable development and the results of the workshop's holding.

### III. RESULTS AND DISCUSSION

The workshop had a total of nine participants, including seven males and two females. Among these, there were students of Aerospace Engineering, Infrastructure Engineering, Railway and Subway Engineering, Naval Engineering, and Interdisciplinary Bachelor's Degree in Mobility, attending from the first to the fourth year of education. Two other professionals, graduated in Civil Engineering and Architecture and Urbanism, were present. This was a pilot study to validate the quizzes, both from Azapagic *et al.* [3] and that created by the authors for improvement in future applications.

The first stage of the research consisted in evaluating the knowledge on environmental problems (Fig. 1). The students showed greater knowledge on the following subjects: deforesting, depletion of natural resource, ozone reduction,

global warming, biodiversity and water pollution. This means that they understand what generate these negative impacts and recognize their effective occurrence on the planet. This result may be linked to the great advertising of said subjects, which are frequently studied since the early school education years; and also on social media, which more and more talk about the environmental problems that affect our society.

On the other hand, the subjects of which the students presented a lower knowledge level, that is, which they have never heard of, were: photochemical smog, salinity, desertification, and solid waste (Fig. 1). All of these subjects are highly relevant for our productive activities and our society's quality of life. Desertification, salinization, and solid waste are linked to changes on the use of the soil, which may hinder several activities and cause diseases and environmental degradation, while the photochemical smog drastically changes the quality of the air that we breathe, causing health problems [9], [10], [11].

The students' unfamiliarity with these subjects reveals an important blank that must be filled in terms of awareness and also of proposal of sustainable technological alternatives.

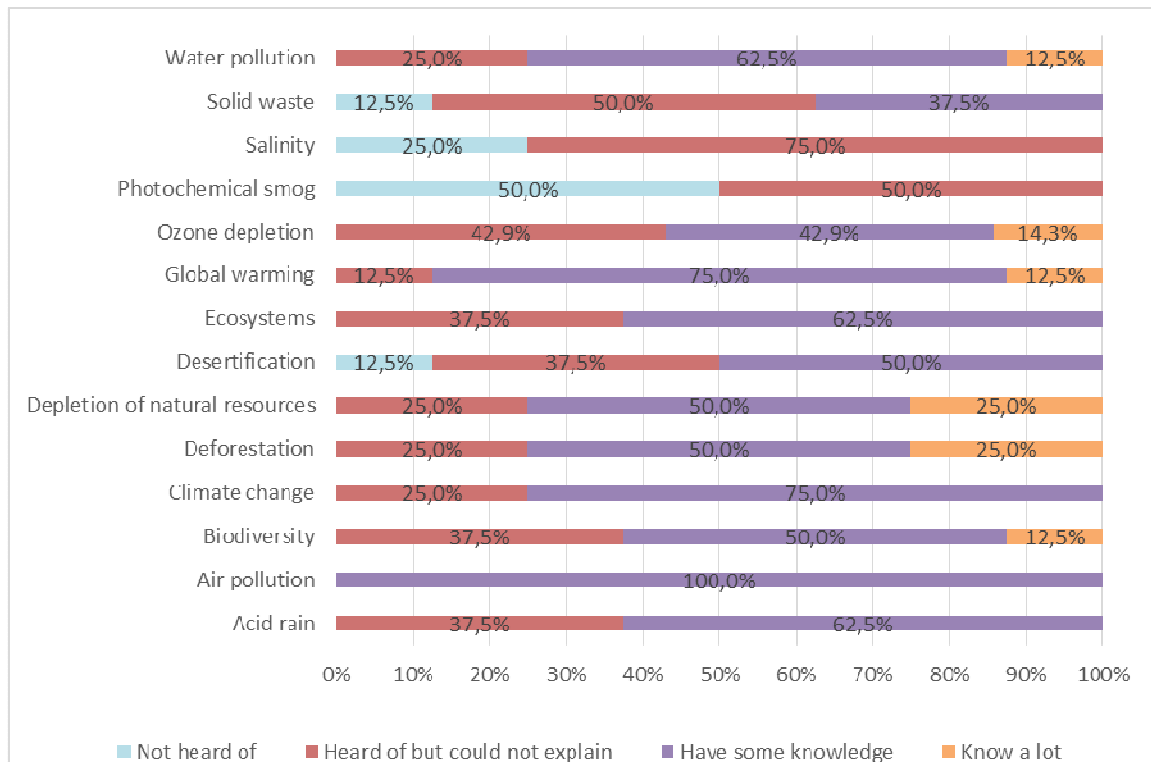


Figure 1 - Environmental Issues

Regarding legislation, politics and environmental rules, we noticed that most students are unfamiliar or have little knowledge about the subject (Fig. 2). The subjects in which the students showed greater knowledge— the Kyoto Protocol, and the Rio Declaration - are the ones that are more mentioned in media broadcasts, which facilitate the first contact with the subject and the possibility of individual deepening. It should be mentioned that more than 60% of the students heard about but cannot explain Regulation ISO 14001 (Fig. 2). This regulation provides directives to implement Environmental Management Systems on companies, currently in growing expansion and of extreme relevance for the performance of future professionals, which points to another important blank that must be filled during the educational curriculum.

Considering that engineers are responsible for creating new technologies and adapting processes and products, their knowledge on tools, technologies, and environmental

approaches was analyzed (Fig. 3). In this topic, the students showed a better knowledge level and, although basic, most of them heard about subjects like clean technologies, clean-up technologies waste minimization and design for the environment. Such subjects attract more attention of future professionals because they are inherently linked to their performance.

Therefore, we should contextualize these subjects' implementation in the students' scientific and professional performance, encouraging their deepening and the direct application of such concepts or objectives in the proposal of new alternatives during education. It should be mentioned that new trains of thought and approaches have been advocating that instead of making efforts to deal with the waste that we produce, we should focus on planning industrial processes that do not produce waste [12].

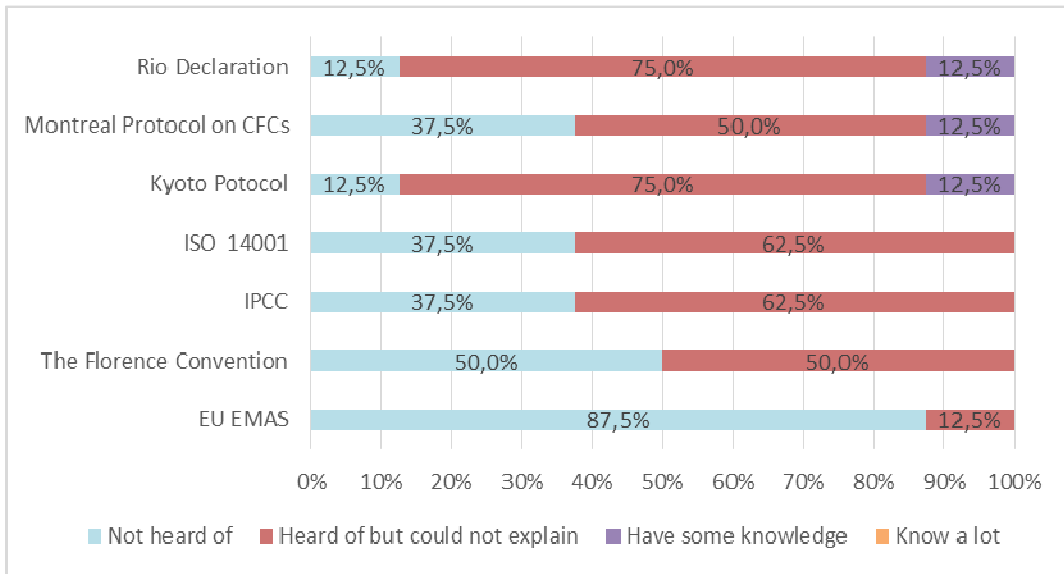


Figure 2 - Environmental Legislation, Policy and Standards

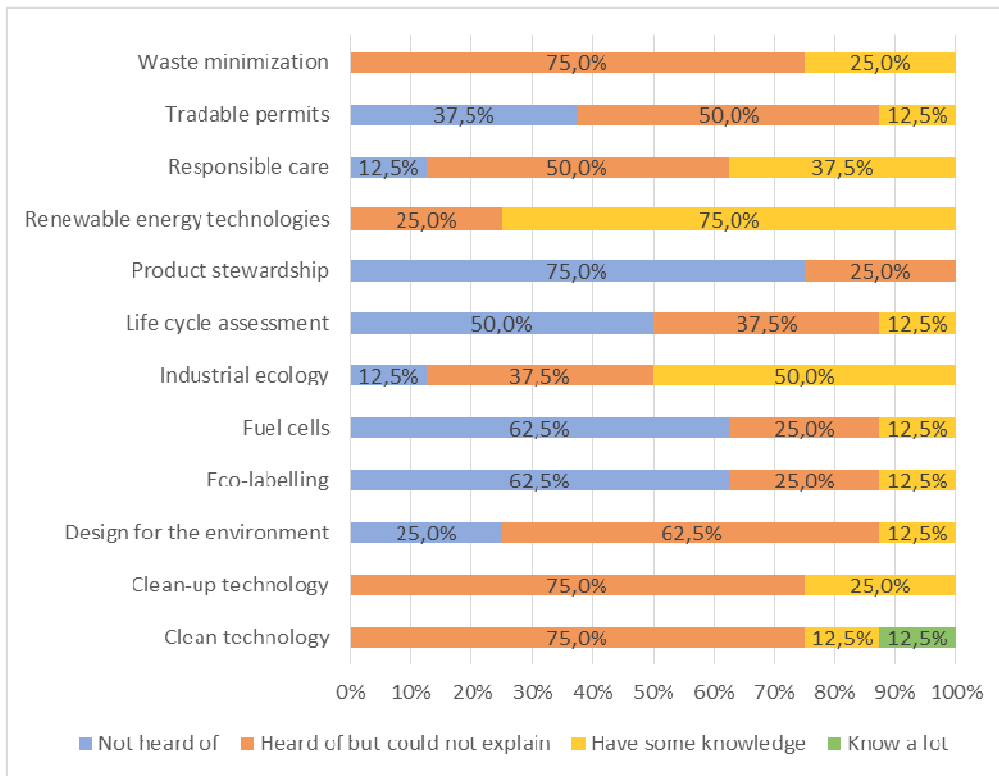


Figure 3 - Environmental Tools, Technologies and Approaches

The knowledge analysis on sustainable development revealed that over half of the students never heard about stakeholder participation, gender equity, and precautionary principle (Fig. 4). We must underscore here the unawareness of the human being’s importance and the social aspect as a fundamental component for the real promotion of sustainable development.

Sustainability is usually linked more conspicuously only to nature. However, keeping a balanced and healthy environment affects the persons’ (stakeholders) quality of life and the development of productive activities directly. Also, pollution treating processes are encouraged, although the most coherent and efficient thing to do would be preventing waste production, according to the precautionary principle.

It is important to underscore that the students presented some knowledge on the concept and components of sustainable development—social, environmental, and economic—, on population growth, and the supporting abilities of the planet, besides actions that can be taken by companies and engineers to promote sustainable development (Fig. 4). Considering that one of the major aggravating factors for the levels of environmental degradation that we witness today is human population growth, which consumes much more resources than the planet can replenish, it is fundamental that the future engineering professionals think on this problem and work to minimize its negative effects [13].

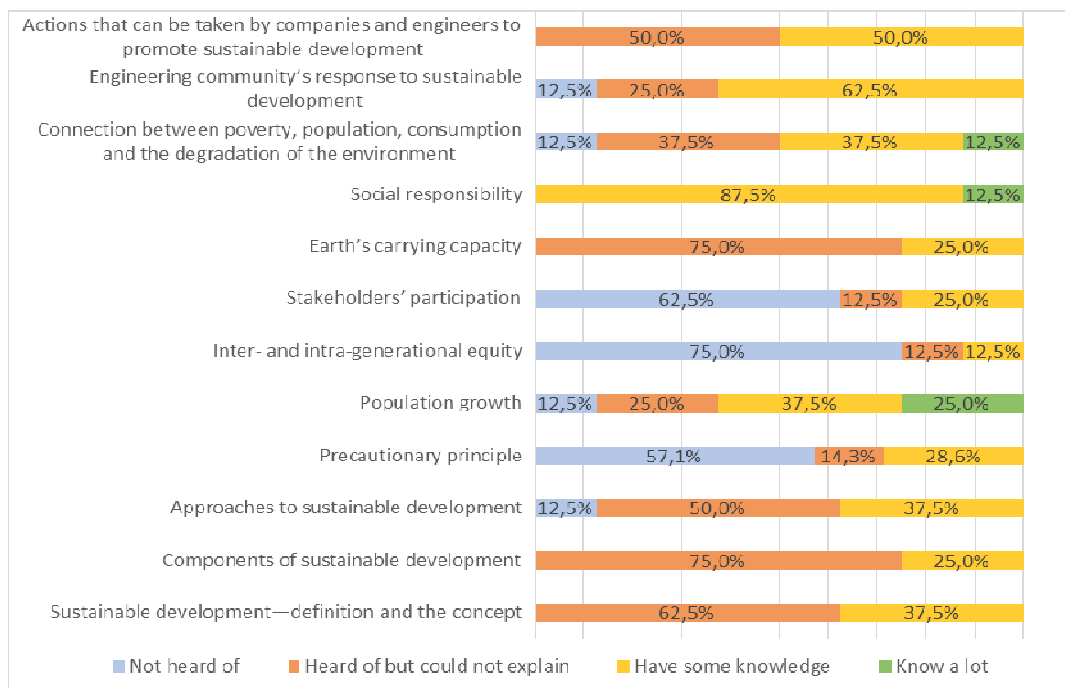


Figure 4 - Sustainable Development

Most students considered Sustainable Development very important for the future generations, society, Country, for themselves as engineers and as individuals (Fig. 5). These responses reflect the idea that every person may cooperate to

improve everyone’s quality of life, and that our society must implement sustainability in their everyday life to remain economically, socially, and environmentally productive.

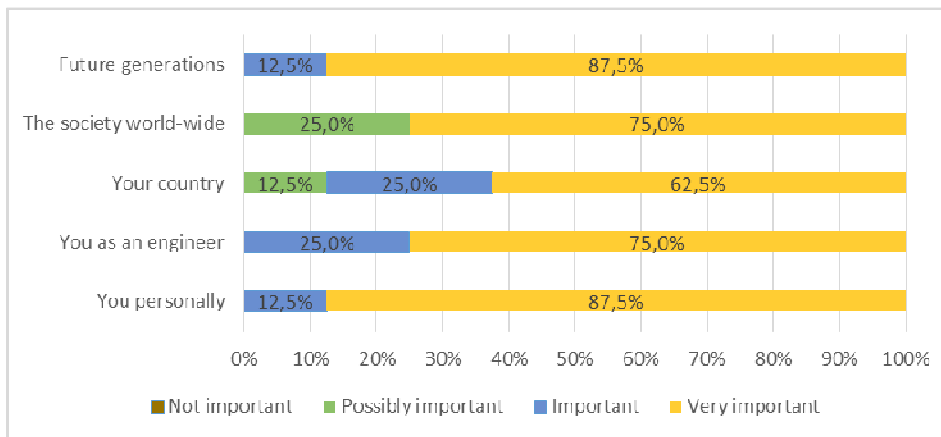


Figure 5 - How would you rate the importance of sustainable development

The last question revolved on the level of environment education in formal education. A student said that he never had environmental education classes in school, while half of the participants, students that are attending engineering classes for 1 or 2 years, said that they still have not attended a class on the subject in the university. Such results also reflect deficiencies on the courses curricula, not only due to the lack of specific disciplines, but also due to the inefficiency in approaching the subject in correlated disciplines. For example, Fisher and McAdams [5] tried to establish the levels of divergence in the understanding of sustainability based on the classes taken by engineering students.

The kind and not the number of classes taken by the students reflected on how the concept of sustainability was conceived. Students that took the Natural Sciences course, for example, had a better understanding of the environmental aspects, while those who took Business, Economics, and Politics had a better understanding of eco-efficiency concepts. Therefore, different sustainability aspects, when dealt by different disciplines, result in different and complementary understandings by each individual.

During the exercise involving hypothetical situations, 80% of the students said that they were inclined to not making their choices and conducting their activities based on illegality, immorality, and against sustainability precepts, justifying their answers based on professional ethics. On the other hand, the remaining 20% said that they could choose some less-sustainable alternatives if the economic benefit was justifiable.

It is important to notice that ethical choices related to reporting superiors and relatives due to non-sustainable actions could have been taken during the activity, which does not mean that it will be done in real situations. The benefit of the dialog during this stage of the workshop was that it alerted the future professionals about some situations which they might face, and think about choices based on ethics and sustainability when facing ethical and sustainable conflicting situations.

A final quiz was applied after the discussion stage to evaluate the acquired knowledge and enable a comparison of the initial and final knowledge after the execution of the activities. As for the main purpose of Sustainable Development, every participant said that it would be: "To propose a compromise between development and environment, encouraging socioeconomic progress through a rational and efficient use of environmental resources." As for the importance of sustainable actions applied to engineering (Fig. 6), most students considered forest conservation and water quality preservation as very important for sustainable development. It was also highlighted the unanimous response of the use of renewable energies as very important for the engineering sector (Fig. 6).

Such result is an evidence of the understanding gain on sustainability's purpose, especially in the professional field. That is evidence that they are aware of the seriousness of these subjects and that they consider them relevant to their learning in higher education.



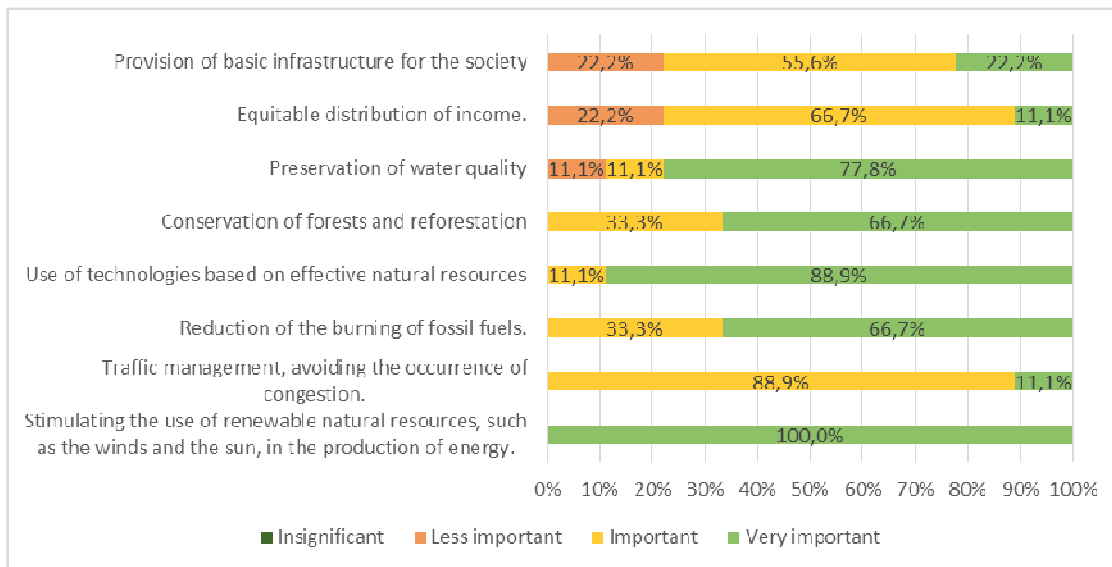


Figure 6 - The promotion of sustainable development

On the other hand, some students considered the provision of an infrastructure to the society and an equitable income distribution as “less important” for sustainable development in their professional careers. This result is very similar to the first quiz’s result, which is evidence that these subjects are not fully understood, and that it is a point that should be improved in teaching and awareness activities. This result is somewhat worrying, since these items are equally relevant to the others regarding sustainable development teaching.

As for the socio-environmental responsibility of the companies, 50% of the students think that keeping a dialog with communities that are directly or indirectly affected by productive activities contributes with actions that respect the collective needs, contributing to ensure jobs and income, respecting everyone’s space. Forty-four percent of them believe that the corporative world is permeated by individual interest conflicts. Therefore, ethics contribute to regulate these relations, establishing limits and parameters to be followed. And the remaining 6% believe that productive activities must be performed taking the individual’s welfare into account, trying to satisfy the persons that are responsible for the continuity of the companies and for generating jobs.

Finally, regarding environmental restrictions, 64% of the participants registered that the activities must comply with environmental regulations to ensure the environmental preservation of environmental systems. Likewise, 36% registered that water quality maintenance is fundamental to ensure the continuity of productive processes that demand water that is not contaminated with corrosive or abrasive substances, since the presence thereof is harmful to the productive process.

### III. CONCLUSION

The workshop proved to be a useful and dynamic activity. Even though the number of participants was small, the first attempt of discussing such a matter among engineering students proved to be beneficial to sustainability comprehension and connection to real world situations with which the students shall face in their profession. It enabled a data survey of overall knowledge of sustainability and the confirmation of new workshops to be applied during future events.

This kind of approach is beneficial to fill the gap highlighted in the literature review, which shows that the sustainable development concepts are low in engineering students, both in Brazil and in other countries. This first attempt of discussing ethics and sustainability with engineering students allowed us to identify knowledge gaps, hear the student’s critics about the integration of such matters into engineering curriculum, while drafting actions such as integrating different teachers into discussing the subjects in their classes, bringing specialists to lecture about the application of sustainability into real case industries scenarios and raising awareness about the importance of the subjects.

With that being said, this first attempt to discuss ethics and sustainability in engineering can contribute to preparedness of the future professionals in cases where they shall need to take ethical decisions, along with the stimulus of creative thinking during technology/alternative creation.

#### ACKNOWLEDGMENT

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