ISSN 2447-6102

Article

Developing human values and motivation in engineering students using interdisciplinary approach related to the betterment of the world

Shayani, R.A.[1]*

[1] Department of Electrical Engineering, University of Brasilia, Brazil; shayani@unb.br
* Correspondence: shayani@unb.br

Received: 30/05/2025; Accepted: 03/06/2025; Published: 10/06/2025

Abstract: Engineering courses around the world have a high drop-out rate. When students conclude the physics and calculus subjects, most of them get really demotivated. When they face electric engineering subjects, most of them are more concerned about having the minimum grade to pass than to really understand how this knowledge can make them solve real problems of mankind. They are usually more concerned about understanding how things work than to use engineering knowledge to improve the world. Changes in engineering education must take place, especially considering student motivation. The thesis is that students will learn better if they are motivated to use the knowledge to improve the world. Project Based Learning and flipped classroom are improved educational techniques, but these alone will not be enough if the students are still unmotivated to learn. Engineering student must be empowered to solve big mankind problems, as the most of all motivation. This feeling that the student can make a noble contribution to the society will stimulate them to learn in an active way. Using also active teaching techniques, the classroom will change to a flourishing learning place. The United Nations Sustainable Development Goals are presented to the students as challenges that the knowledge from the class should empower them to couple with. The SDG gives an open-minded interdisciplinary view to engineering student. This educational approach has been carried out on Electrical Engineering classes at University of Brasilia, and more than 98% of the students reported that they developed human values.

Keywords: engineering education; sustainable development goals; education for peace

1. Introduction

Engineering courses around the world have a high dropout rate. When undergraduate students conclude the physics and calculus subjects at the first two years, they get demotivated because they get a lot of theory but lack of practice. When they face engineering subjects, most of them are more concerned about having the minimum grade to pass than to really understand how this knowledge can make them solve real problems of mankind. Besides demotivation, most engineering students think in a very conventional way, with few creativity and innovation. They are usually more concerned about understanding how things work than to use engineering knowledge to the betterment of the world.

Changes in engineering education must take place using interdisciplinary approach related to the betterment of the world in order to develop human values and motivation in engineering students. The objective of this paper is to present the results of an educational approach using Project Based Learning (PBL) with motivational quotes to stimulate the students to use the theoretical knowledge of theoretical technical disciplines to create solutions that promote the betterment of the world. The research question is that students will learn better if they are really motivated to use the knowledge to improve the world. The results are collected by a questionnaire, that was answered in a mandatory way by 100 students that attended the subjects that used this approach.

Engineering education has a binding agreement called “The Washington Accord”, developed initially in 2002 and revised in 2009. The goal of this Accord is to build a knowledge base and attributes on undergraduate engineering students. The knowledge profile of an engineer includes: natural sciences (calculus-based physics), mathematics, engineering fundamentals, specialist knowledge, design, practice and comprehension of the role of engineering in society. The attribute profile of an engineer includes: knowledge, problem analysis, design and development of solutions, investigation, modern tool usage, engineering and society, environment and sustainability, ethics, individual and team work, communication, project management and life-long learning (Alliance, 2014).

In 2002 the Brazilian Ministry of Education released national guidelines for engineering curriculum, that are aligned with Washington Accord. The students should finish the course being generalist, humanist, critic, reflexive, able to develop new technologies, identify and solve, in a creative way, real society problems, considering political, economic, social, environmental and cultural dimensions, with ethics and humanistic vision (CNE/CES, 2002).

In 2019 these guidelines were updated. The Brazilian engineering student should finish the undergraduate course with the following characteristics (CNE/CES, 2019):

- Develop holistic and humanistic vision, be critic, reflexive, creative, cooperative and ethical, with a strong technical knowledge;
- Be able to research, develop, adapt and use new technologies in an innovative and entrepreneur way;
- Be able to identify the needs of the users, formulate, analyze and solve, in a creative way, engineering problems;
- Use multidisciplinary and transdisciplinary perspectives;
- Consider global, political, economical, social, environmental, cultural and safety aspects; and
- Be committed to social responsibility and sustainable development.

These guidelines reinforce the importance of active-learning approach focused on student-learning, instead of lecture-based approach focused on the professor.

Several engineering education international publications emphasizes the importance of student motivation related to real problems solutions. The 2010 UNESCO Engineering Report sheds new light on the need to “transform engineering education, curricula and teaching methods to emphasize relevance and a problem-solving approach to engineering” and “more effectively innovate and apply engineering and technology to global issues and challenges such as poverty reduction, sustainable development and climate change” (UNESCO, 2010).

The 2014 UNESCO Engineering Report register that the important contribution that engineering make to society is not sufficiently emphasized for, or promoted effectively, promoting high failure/dropout rates. The course design should be arranged to be interesting and to enhance motivation as this will be of critical significance in facilitating student development and reducing student failure (Beanland & Hadgraft, 2014).

One example is related to energy and electricity sector, that is fossil-fuel dependent, release a lot of greenhouse gases and is unwilling to use renewable energy sources, despite of climate change. The students learn that the world is fossil-fuel dependent, and are not enough stimulated to find a solution to it. Paris Agreement (United Nations Convention on Climate Change, 2015) highlights the importance of “building capacity” to deal with it. This is a point that must be worked by engineering professors. Climate change is a issue that can be used in classroom as a motivation for the students (Shayani, 2020).

There are already some initiatives to improve the curriculum of electrical power system undergraduate courses, that claim the importance of multidisciplinary subjects (Chicco et al., 2018; Nagamani et al., 2018; Nair et al., 2018; Parvania & Merrill, 2018; Ray et al., 2018; Uzunovic, 2018). But they consider a still narrow view of multidisciplinarity. For example, to work with smart grids, that is very important to increase the share of renewable energy in the energy matrix, the undergraduate student must study power systems, system control and telecommunications. These subjects are still inside electrical engineering field of knowledge, and do not really empower students to deal with climate changes or other social issues.

Sovacool, 2014, presents a different point of view. He detected that energy approach has focus on technologies, but the human being should be the focus. This new approach should be taught at university, in order to really empower engineering students to promote the betterment of the world, not only to supply energy or provide technical solutions (Sovacool, 2014).

2. Materials and Methods

Project Based Learning is an improved educational technique, but this alone will not accomplish if students are still unmotivated to learn. Engineering students must be empowered to solve big mankind problems, as the most of all motivation. This feeling that the student can make a noble contribution to the society will stimulate them to learn in an

active way. Using active teaching techniques, the classroom can change to a flourishing learning place. This can be achieved considering the importance of multidisciplinary subjects, allowing the student to analyze not only the technical aspect of the problem, but the social and environmental aspects too.

This methodology has been tested since 2015. It started with "Electrical Machines" discipline at University of Brasilia, Brazil. In order to motivate the students, the professor asked them to choose an application that uses electrical motor or generator, formulate and solve it. The idea is that the student will be motivated if they choose something that they like to work on it, and the challenge to identify the variables of the problem will develop analyses attributes on them. Instead of receiving a problem from the professor, with all the values on it, the student should seek for the information necessary to model and solve it (Shayani et al., 2018).

The best motivational tool is the United Nations Sustainable Development Goals (UN SDG) (UN, 2017) as society demands that must be solved by electrical machines project. The UN SDG gives an open-minded interdisciplinary view to engineering student. Several students proposed irrigation systems for drought places, residential water reuse system, farm robots, electric trains to transport soy from farms to ports, drones for medicine transportation on flooded areas, autonomous boats for rescue, etc.

In order to show the importance of learning, and that they could change the world if they really want, the professor empower the student with several motivational quotes, retrieved from IEEE website:

- "As engineers, we were going to be in a position to change the world – not just study it." Henry Petroski - Engineer
- "Scientists study the world as it is; engineers create the world that has never been." Theodore von Kármán – Aerospace engineer and Physicist
- "Learn from yesterday, live for today, hope for tomorrow. The important thing is not to stop questioning." Albert Einstein – Physicist and Inventor
- "We are continually faced by great opportunities brilliantly disguised as insoluble problems." Lee Iacocca – Engineer & Automobile Executive
- "The ideal engineer is a composite… He is not a scientist, he is not a mathematician, he is not a sociologist or a writer; but he may use the knowledge and techniques of any or all of these disciplines in solving engineering problems." Nathan W. Dougherty – Civil engineer
- "Engineering is the application of science for human benefit." J. M. Prausnitz – Chemical Engineer
- "I think that´s the single best piece of advice: constantly think about how you could be doing things better and questioning yourself." Elon Musk – Tesla & SpaceX CEO

In addition, motivational quotes about the importance of the use of knowledge to promote the betterment of the world are also presented to the students:

- "Teach them to dedicate their lives to matters of great import, and inspire them to undertake studies that will benefit mankind." 'Abdu'l-Bahá (1844-1921
- "Be anxiosly concerned with the needs of the age ye live in, and centre your deliberations on its exigencies and requirements." Bahá'u'lláh (1817 – 1892)

The assessment of the student academic grown worked ethics skills. If the student does all the exercises, identify a society real problem, propose an engineering solution and present it for their colleagues, using technical information related to the discipline, they succeed and must be approved. The students receive a peer assessment, but a self-assessment is required too. Each student must make a self-assessment of their dedication to the discipline, and write an essay about how the project improved the skills that an engineering must develop.

3. Results

The proposed approach was applied to "Energy planning" (60-hours course) and "Basics of Electricity" (60-hours course) subjects at Department of Electric Engineering, University of Brasilia, Brazil, in 2019 and 2020. 100 undergraduate engineering students from Electrical, Mechanical, Environment, Civil and Chemical Engineering courses attended the classes and answered the self-assessment questionnaire. Each subject was offered twice, using the same educational approach. "Energy planning" had 30 students in each classroom, and "Basics of Electricity" had 20 students in each classroom.

In order to ensure the participation of all students in the analysis of real problems and to be part of the solution, small groups of 2 or 3 students were created. The students were free to join each group, according to theme interest or course background. Some of the projects proposed by the students were: rain water reuse for rural areas; water supply for farms; water supply for public showers to people who live in the street; water supply for firefighting at forest; energy

generation from urban waste; construction waste recycling; sewer treatment; drones to delivery medicines in rural areas; and electric mass transportation.

The questionnaire, named "ethical exam" was composed by an initial instruction and six affirmations, and the student must answer how much they agree with each affirmation. The results are presented in Table 1.

Initial instruction: make a sincere reflection about your dedication to the project and indicate how much you agree with the following affirmations:

Affirmation 1: I seized the opportunity at the maximum level, during the elaboration of the project, to develop holistic and humanistic vision, be critic, reflexive, creative, cooperative and ethical, with a strong technical knowledge.

Affirmation 2: I seized the opportunity at the maximum level, during the elaboration of the project, to be able to research, develop, adapt and use new technologies in an innovative and entrepreneur way.

Affirmation 3: I seized the opportunity at the maximum level, during the elaboration of the project, to be able to identify the needs of the users, formulate, analyze and solve, in a creative way, engineering problems.

Affirmation 4: I seized the opportunity at the maximum level, during the elaboration of the project, to use multidisciplinary and transdisciplinary perspectives.

Affirmation 5: I seized the opportunity at the maximum level, during the elaboration of the project, to consider global, political, economical, social, environmental, cultural and safety aspects

Affirmation 6: I seized the opportunity at the maximum level, during the elaboration of the project, to be committed to social responsibility and sustainable development.

Table 1. Responses for questionnaire (percentual value).

Answers	Affirm. 1	Affirm. 2	Affirm. 3	Affirm. 4	Affirm. 5	Affirm. 6
Strongly agree	62	73	68	67	62	79
Agree	37	25	31	32	35	18
Indifferent	1	2	1	1	2	3
Disagree	0	0	0	0	1	0
Strongly disagree	0	0	0	0	0	0
TOTAL	100	100	100	100	100	100

After these six closed-ended questions, there was also one open-ended question requesting then to do a self-assessment.

4. Discussion

The projects selected by the students demonstrated their concern about environment, economic disparity and poverty. Although they did not have classes about it, the proposed educational approach was effective to stimulate their social and environmental skills, not just technical skills.

About 10 to 15 projects were presented to all students in each classroom. Each group of 2 or 3 students selected their own solution to a real problem, but they also saw the real problem and solution proposed by their peers. This was a valuable moment, specially when groups selected the same problem but presented different solutions, because the experience to see from other point of view is important to develop holistic vision. A peer-assessment was required from the students in a mandatory way, in order to make sure all of them would pay attention to their colleagues' projects.

98% of the students answered "agree" or "strongly agree" to all the affirmations. This suggest that the students liked the approach and, more motivated to study, will get a better retention of the technical subject.

The higher "strongly agree" rate are related to social responsibility and sustainable development. This is an indication that the engineering curriculum has a lack of social classes, but the students like this subject, because this provide the link between theoretical knowledge and real society problems.

5. Conclusions

The proposed educational approach, using Project Based Learning with motivational quotes and considering sustainable development as the main goals of the student projects, was approved by 98% of the undergraduate engineering student that coursed the disciplines that used this approach. In order to deal with environment issues, economic disparity and poverty, the students were stimulated to develop human values, and got motivated to a better retention of the subject because they really understand how it can be used to the betterment of the world.

Based on the results, there is a high possibility that the research question, that students will learn better if they are really motivated to use the knowledge to improve the world, is correct.

As additional research, the projects, that got just theoretical in this phase, should be field implemented, in order to the students get real contact with the community and see how, in fact, they can change the world.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Alliance, I. E.. 25 years Washington Accord 1989-2014 - Celebrating international engineering education standards and recognition. 2014.
2. CNE/CES. Resolução CNE/CES 11, de 11 de março de 2002. Institui Diretrizes Curriculares Nacionais do Curso de Graduação em Engenharia. 2002. http://portal.mec.gov.br/cne/arquivos/pdf/CES112002.pdf
3. CNE/CES. RESOLUÇÃO CNE/CES 2, DE 24 DE ABRIL DE 2019. Institui as Diretrizes Curriculares Nacionais do Curso de Graduação em Engenharia. 2019.
4. UNESCO. Engineering: Issues, Challenges and Opportunities for Development. 2010.
5. Beanland, D., & Hadgraft, R. Engineering Education: Transformation and Innovation. 2014.
6. UNITED NATIONS CONVENTION ON CLIMATE CHANGE. Paris Agreement. In 21st Conference of the Parties. 2015. https://doi.org/FCCC/CP/2015/L.9
7. Shayani, R. A. Professors should motivate students toward noble aims, high resolve, and intense endeavours. International Environment Forum. 2020. https://iefworld.org/newslt133
8. Chicco, G., Crossley, P., & Nucci, C. A.. Electric Power Engineering Education: Cultivating the Talent in the United Kingdom and Italy to Build the Low-Carbon Economy of the Future. 2018. IEEE Power and Energy Magazine, 16(5), 53–63. https://doi.org/10.1109/MPE.2018.2841458
9. Nagamani, C., Venkata Kirthiga, M., & Thomas, M. S. Power Engineering Education: A Description of Current Academic Developments in India. 2018. IEEE Power and Energy Magazine, 16(5), 42–52. https://doi.org/10.1109/MPE.2018.2843899
10. Nair, N., Martin, D., Saha, T., Islam, S., & Watson, N. Electrical Power Engineering Education Down Under: Australia and New Zealand Are Adding Energy to Their University Curricula. 2018. IEEE Power and Energy Magazine, 16(5), 64–73. https://doi.org/10.1109/MPE.2018.2844418
11. Parvania, M., & Merrill, H. M. Toward a 21st Century Power Education: A Bright Future Awaits Students in Utah. 2018. IEEE Power and Energy Magazine, 16(5), 87–95. https://doi.org/10.1109/MPE.2018.2843900
12. Ray, D., Ray Chaudhuri, N., & Brahma, S. Trends in Electric Power Engineering Education: An Analysis of Future Challenges. 2018. IEEE Power and Energy Magazine, 16(5), 32–41. https://doi.org/10.1109/MPE.2018.2833264
13. Uzunovic, E. Education for Engineering: The Changing Future of Power Education [Guest Editorial]. 2018. IEEE Power and Energy Magazine, 16(5), 24–30. https://doi.org/10.1109/MPE.2018.2843898
14. Sovacool, B. K. What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda. 2014. Energy Research and Social Science. https://doi.org/10.1016/j.erss.2014.02.003
15. Shayani, R. A., Viana, D. M., & De Oliveira, M. A. G. (2018). Teaching electric machines using project based learning focusing in solutions to real problems of mankind. International Symposium on Project Approaches in Engineering Education, 8.
16. UN. Sustainable development goals - United Nations. United Nations. 2017. https://doi.org/10.1016/j.eururo.2010.10.002