

# RECYCLING PROGRAMS FROM ENGINEERING FOR STUDENTS AND THEIR FAMILIES

**Jairo Alberto Hurtado**

Pontificia Universidad Javeriana, Bogotá, Colombia

**Flor Ángela Bravo**

Universidad Nacional de Colombia Sede de La Paz, Cesar, Colombia

**Gloria Inés Mestre**

Asociación Colombiana de Investigadores en Comunicación (ACICOM), Colombia

## ABSTRACT

In today's world, the need to take care of our environment and reduce our footprint on it is increasingly essential. Although the universities have recycling programs inside the campus, including collection sites, in our country, Colombia, there are no programs from the university aimed at motivating the work of recycling by students and their families inside their homes. To create awareness in each student and involve their family members, the recycling program at home was created, which has academic recognition through additional voluntary evaluations. Our project is based on three types of activities, which are supported by programs by private companies, unfavorably these programs have not been widely disseminated nor are they remembered among people as would be desired. Therefore, many of our students who start the program were unaware of the existence of these programs and the potential for action that they could have in their environment. The three recycling programs are plastic bottles filled with single-use plastic ("botella de amor" = "bottle of love") to create furniture with recycled material for use in schools, plastic caps ("tapitas para sanar" = "caps to heal") for a foundation that makes treatment of children with cancer, and recycling of used cooking oil ("manos verdes" = "green hands") for the manufacture of soaps and candles. This document shows the process of conception, creation, and implementation of the campaign, the results obtained both from the students and within the families, together with the satisfaction, involvement, and participation of the students. Also, the project promotes the development of communication skills for engineers.

## KEYWORDS

Recycling, Sustainability, Engaging students, Engineering education, Communication skills, CDIO Standards: 7, 11. CDIO Optional Standard 1 (V 3.0)

## INTRODUCTION

Toward the end of January, the sea was growing harsh, it was beginning to dump its heavy garbage on the town, and a few weeks later everything was contaminated with its unbearable mood. From that time on the world wasn't worth living in, at least until

the following December, so no one stayed awake after eight o'clock. (García Márquez, 1999, p. 226)

Sometimes life consists of diving into the waters of reality; sometimes it consists of immersing yourself in something like a chapter of a magical realist or science fiction story. At the beginning of *The Sea of Lost Time* story, Gabriel García Márquez brings us closer to the paradoxes of development and the dreams of humanity. As in the story of the Nobel Prize in Literature, contemporary reality is debated and presents questionable aspects. Entering the 21st century, many corners of the planetary geography continue to suffer the irruptions of the modernizing project. Capurganá, a tourist center on the Pacific Ocean in Colombia, is part of the Darién region, an area of global importance for the conservation of biodiversity. Migrating birds and other animals found in this corridor a crucial point in their journeys through Latin American territory. It is also part of the world's migrant route. However, the maritime and jungle landscape of Capurganá is drowning in 200 tons of garbage (Osorio, 2022; *El Tiempo*, 2022). Despite the seriousness of the previous news, the fact did not transcend the world news agenda. However, Colombia is the country with the greatest biological wealth per square kilometer: 14% of the planet's biodiversity. But its biodiversity and titles are in danger: the first place globally for the number of species of birds and orchids; the second in plants, amphibians, butterflies, and freshwater fish; third place in palms and reptiles; and the fourth in mammals. According to the Humboldt Institute (2021), the serious deterioration of biodiversity is putting life in the country at risk.

The United Nations (UN) leads several initiatives related to the preservation of the environment and other issues related to sustainable development in the world. Due to the growth of the world population, it is expected that by 2050 global solid waste ("trash") is expected to increase from 2.01 billion tons to 3.40 billion tons per year. According to UNESCO (2021) "if we continue to live the way we do now, the equivalent of almost three planets would be needed to provide the natural resources" (p.3). As for plastic waste, if consumption patterns and waste management practices do not begin to change, it is estimated that by 2050 there would be 12,000 million tons of plastic waste in landfills and in the environment. With this scenario, the Ministry of Environment and Sustainable Development of Colombia (2022) projects that the rate of recycling and use of solid waste by 2022 will increase to 14.22%.

In the joint work on environmental issues and the formulation of proposals that involve the perspective of sustainable development, sustainability, environmental education, among others, various actors of society are participating (United Nations, 2021). Institutions related to university education for example: UNESCO 2021, Futures of Education initiative, and the CDIO initiative are leading projects to integrate these issues into university education processes (Wedel et al, 2019; Cheah et al, 2012; Cheah, 2014; Malmqvist et al, 2020a; Malmqvist et al, 2020b). Finally, a study (Rosén, A, et al, 2019) showed that "enhanced integration of sustainable development will contribute to improving the relevance and future compliance of engineering educations and could also contribute to students' and teachers' motivation" (p. 74).

## **ENGINEERING EDUCATION FOR LOCAL AND GLOBAL CHANGES**

Pope Francis (2015) in the Encyclical Letter *Laudato Si* said:

The urgent challenge to protect our common home includes a concern to bring the whole human family together to seek a sustainable and integral development, for we

know that things can change. Humanity still has the ability to work together in building our common home (p. 12).

In affinity with this call from Pope Francis, the Pontificia Universidad Javeriana in Bogotá, Colombia, leads a waste reduction and recycling management program that aspires to have positive effects on the academic, professional, and personal lives of the people involved. This program, aimed initially at students of the basic cycle of the Electronic Engineering career, has the purpose of encouraging care for the environment based on the following general objectives:

First, strengthen local and global cooperation to form "citizens of the world", as proposed by Martha C. Nussbaum in tune with education:

We live in a world in which people face one another across gulfs of geography, language, and nationality. More than at any time in the past, we all depend on people we have never seen, and they depend on us. Nor do any of us stand outside this global interdependency. The global economy has tied all of us to distant lives. Our simplest decisions as consumers affect the living standard of people in distant nations who are involved in the production of products we use. Our daily lives put pressure on the global environment. Education, then, should equip us all to function effectively in such discussions, seeing ourselves as "citizens of the world" (Nussbaum, 2012, pp. 79-80).

Second, to contribute to awareness based on the recognition of our "Earth-Home" and teach the "Earth identity". The concepts "Earth-Home" and "Earth identity" come from the *Seven complex lessons in education for future* (Morin, 1999); UNESCO recognizes the validity and necessity of this knowledge in the 21st century for education throughout life:

*Development conceived exclusively as techno-economic progress, including durable development, is in the long term unsustainable. We need a more rich and complex notion of development which is not only material but also intellectual, emotional, moral.... The education of the future should teach an ethics of planetary understanding [author's emphasis] (UNESCO, 2021, pp. 34, 39).*

The above approach is valid by virtue of the environmental situation in the world, but also given the seriousness of the problem in the Colombian context, since in Colombia 12 million tons of garbage are produced per year, of which it is recycled on average 17%.

The Pontificia Universidad Javeriana created its ecological and environmental policy in 2015 and participates in the *UI Green Metric World University Ranking*, an initiative of Universitas Indonesia (UI Green Metric, 2022). Although the incorporation of the ecological and environmental dimension has its origins in the seventies, the programs designed in the training courses with a perspective of a holistic approach to the issues of environment and sustainable development are contributing to training students who can act as agents exchange.

The project, which combines the conceptual perspective and real problems such as those indicated, was also implemented considering the principles of CDIO, as described below. Keeping in mind the greater purpose (to encourage care for the environment), activities were designed to point in this direction with the conviction that engineering learning and teaching well admit a holistic and transdisciplinary vision. In this direction, Jamison from Aalborg University proposed the term *hybrid learning* for engineering education that includes aspects considered for this project:

In the transformative learning experience, grand challenges such as sustainability are not fixed; they are continuously constructed and reconstructed, and the students are to be prepared not only to enter but also to set the scene for the change of discourses, institutions, and practices (Jamison, 2014, p. 268).

It has been mentioned that the knowledge coming from relevant experiences of CDIO in other universities was searched, mainly, regarding sustainability or sustainable development: Cheah (2014) describes a model curriculum for Education for Sustainable Development (ESD). Binder et al (2017) show a possible implementation of Sustainability aspects in Mining Engineering education. Finally, Uruburu et al, (2018) expose results and reflections on teaching-learning methodology to incorporate sustainability aspects in engineering projects.

In another sense, the actions of the CDIO network were consulted in the review and update of the Standards and Syllabus about sustainable development, competencies for sustainability, and CDIO optional standards 3.0.

## PROGRAM AND EXPERIENCE

The need to include an agenda on environmental issues in the syllabus of the subjects of the first two years has been identified. Thus, students were proposed to carry out an optional activity on the declared purpose of caring for the common home. This activity could integrate both the students and their family nucleus and/or the people with whom they shared a home. The optional activity sought to confront the habits and practices of consumption and recycling of students and their families to motivate thinking that would allow them to understand their relationships with the environment in a more sustainable, responsible, cooperative, and ethical way.

The participation of students and their families in the programs of non-profit organizations that were selected for this project because they deal with waste management and recycling. Generating other types of interactions from their actions to solve community problems.

As additional motivation, students are offered the opportunity to earn an additional quiz score of 5.0 (highest possible score) for participating in each of the following three recycling programs.

- Program of Bottles of love ("*Botellas de amor*", in Spanish) transforms plastic waste through the action of filling plastic bottles with all kinds of flexible plastic packaging (Botellas de Amor, 2019). They would seem small or insignificant actions, but with this material (Recycled Plastic Lumber), they are building homes and furniture to improve the lives of vulnerable communities (Teleantioquia, 2017). The limitation is that it only works in six sites in the country.
- Program of Caps to heal ("*Tapitas para sanar*", in Spanish) promotes the recycling of plastic bottle caps (Sanar, 2022). Collection points have been increasing in places such as shopping centers, educational institutions, and companies. The strategy for 2022 is to promote the acquisition of mini collectors that are more functional for small spaces. In addition, they facilitate a better work of communication, promotion, and environmental education. The resources of this program are aimed at supporting children and adolescents with cancer.
- Program of Green Hands ("*manos verdes*", in Spanish) was born in 2016, from the idea of a citizen who decided to contribute to the environment by recycling used cooking oil

and converting it into biofuel (Manos Verdes, 2022; Team Foods, 2020). The strategy began in the main restaurants, hotels, and supermarkets in the country. The growth in 76 municipalities in the territory is complemented by the strategy of reaching homes. Collection devices are being installed in residential complexes (Marce, 2020).

When engineering students were exposed to the existence of these organizations and their programs, they noticed a lack of knowledge or low recollection of their purposes. In this sense, it is that fields such as Communication for social change and Education for Sustainable Development (ESD) are included in the matrix of these projects to base the achievement of the objectives, at a personal and collective level.

In the formulation of this project, two aspects mentioned by Grosseck et al (2019, p. 2), about the Education for Sustainable Development (practice of teaching for sustainability) were considered. First, “can be seen as a holistic approach, involving the integration of major sustainable development issues into all teaching and learning strategies”. Second, “is a means of promoting key competencies for sustainability, such as critical thinking, systematic thinking, self-awareness, problem-solving, etc.”.

Within the learning outcomes of the course, there is no explicit mention of anything related to caring for the environment. However, the fact that they are not explicit does not mean that they should not be mentioned or considered. It should be clarified that although these environmental care activities have an academic recognition in the quizzes mark, it is more symbolic than practical, since 12 tests are usually carried out per semester and the average mark is higher than 4.0, for what the additional marks in 5.0 do not produce a significant change in this final mark (less than 0.02/5.00). What it does do is initially motivate students to start at least one program and, although there is no significant variation in the grade, they continue to do so in the following classes in which the same activity is offered.

From the first class, they are informed about this optional activity, and they are given the delivery dates. They must send a photo with the empty bottles before the sixth week of class, and they must send another photo with the progress of their work (it is not necessary that this 100% fills the bottle) before week 14. Having a bottle or more filled with single-use plastic or cooking oil, it only gives you a single additional quiz mark at 5.0. Figure 1 shows some of the submitted photos of the “bottle of love”. Initially, the photo was only of the bottles, but to make the activity more personalized, they should appear in the photo with the bottles.



Figure 1. Students showing their "bottles of love".

In Colombia, each person consumes more than 24 kg of plastic per person per year and only 56% of it is single-use, that is, straws, cutlery, plates, containers, and bags. (Semana, 2022)

Figure 2 shows some of the submitted photos of the “green hands” bottle.

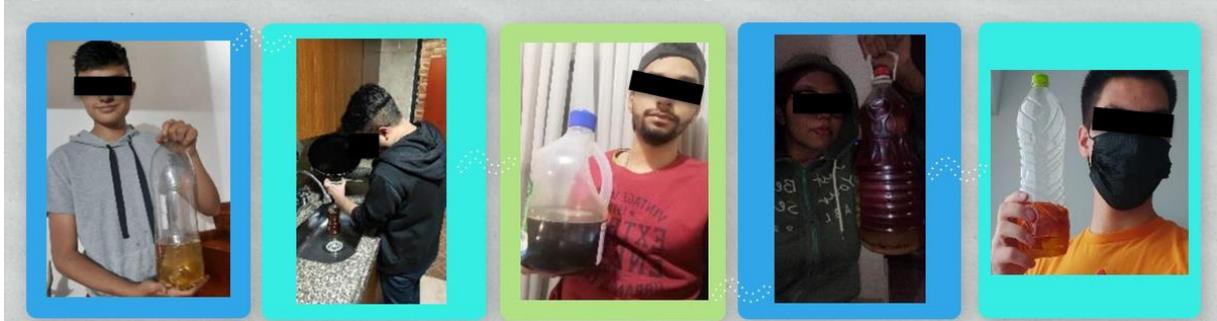


Figure 2. Students showing their bottles of oil, “Green Hands”.

It is estimated that just 1 liter of oil can contaminate 1 million liters of water (Oil Care, 2015).

Figure 3 shows some of the submitted photos of the “caps to heal”.



Figure 3. Students showing their “Caps to Heal”.

Plastic bottles and plastic caps can be deposited at different collection points throughout the city. On the campus of the university, there are these collection points, shown in Figure 4.



Figure 4. Collection point at the University campus.

The bottles with oil must be taken to a supermarket chain, which has a branch two blocks from the university campus. It should be clarified that there is no type of payment or economic compensation for the delivery of the bottles or caps.

The program began before the COVID-19 pandemic, in face-to-face classes, and continued during the time of the pandemic, in which it had a greater effect.

## **SURVEY AND RESULTS**

A survey was carried out among the students who have taken the course in order to find out their perception of the proposed recycling activities. This survey was answered by 33 students, of which 18 were men and 15 women, the age of the participants is from 17 to 22 years. 88% of the students stated that they participated in the recycling activities. The students who did not participate stated that it was due to a lack of time or because they did not generate enough plastic at home to carry out the activity.

Students were asked what their motivation was for participating in this activity. The main motivations for participating in the program were to collaborate with the care of the environment and to obtain an additional mark in quizzes, with 72% of the students choosing these options. Carrying out a different activity was chosen by 69% and 66% of the students did it to feel good about themselves and 28% indicated that it was to learn something new.

It is curious that although the effect on the note is very small, it was one of the main motivations to participate in the program. This may be due to students trying to take every opportunity to improve their grades.

Regarding the importance that they give to their contribution to the solution of environmental problems in their environment, 78% that it is very important or important, while 38% indicate that it is moderately important.

Students were also asked how important they consider sustainable development to be in engineering. 79% state that it is very important and 21% that it is important. Regarding the relevance of including optional activities related to the reduction of solid waste and recycling in Electronic Engineering subjects, the survey shows that 96% of those surveyed agree to include these activities.

The survey also asked about the recycling programs that they were aware of before starting the course. The "Bottles of Love" program was known by 44% of those surveyed, 36% were aware of the "Cap to Heal" program and only 12% were aware of the Manos Verdes program (oil recycling). Finally, 8% of the students stated that they did not know any of the programs.

An interesting result of the survey is related to the degree of influence you have caused in the family and/or in the people with whom the students live in their participation in these waste reduction and recycling programs. The results show that 62% of the students have a very high or high influence, a much higher percentage than their prior knowledge of recycling programs. While 28% indicate that it had a medium influence. 10% say they had little or no influence. Additionally, 83% of the students indicate that after finishing the course the importance they give to environmental issues increased.

Another question that was asked to the students was about what aspects related to the recycling activities were interesting for them when studying the subjects. Some students indicated that what was most interesting was that these activities involved several members of their families. For example, one student said: *"It was interesting to get my whole family to help me in this activity and to make a change in four families regarding recycling"*

Other students expressed the continuity of these learning activities after finishing the subject. For example, a student said: *"It was interesting to see that from then on, we continued recycling even though the subject had already finished, it was interesting to fill the bottles because we did it as a family"*

The students also highlighted the importance of giving plastic a second use, being aware of the amount of plastic they generate and the importance of recycling and environmental care. For example, a student stated that *"the process of transforming plastics into furniture for the home was interesting. The amount of waste that I produce per day that can be recycled."*

Finally, some students proposed some actions to strengthen the training of engineers in environmental issues. Here are some of the ideas proposed by the students:

- Conducting talks with people who work in these recycling programs
- Development of more awareness activities about caring for the environment and the importance of recycling.
- Development of engineering projects focused on sustainability, recycling, and awareness.
- Reducing the delivery of class work using sheets of paper.
- Development of citizen competencies that promote good habits towards the environment.

## **CONCLUSIONS AND FUTURE WORK**

The crisis produced by the COVID-19 pandemic forced the educational system to assume the virtual space, which could provide a favorable aspect that requires further study, to the extent that it confronted students with the world of the personal, but also with local and global changes, the need for solutions and the importance of global citizenship. As the economist Mariana Mazzucato (2021, p. 8) states, "the COVID-19 crisis has revealed the fragility of capitalism".

Due to the findings of the results and the feedback from the students, it is necessary to explore other links of knowledge and practices from Education for Sustainable Development and the Communication for social change. The project also favored the practices of interpersonal and communication skills.

The intention of the program to raise awareness about caring for our planet through individual actions and to influence our families and friends through these actions (standard 7, 11) was fulfilled, so much so that in some houses the spaces and number of garbage containers were reorganized. In addition, their interest and commitment to environmental protection increased (Optional Standard 1 V 3.0).

As future work, we want to extend this experience to other degrees and carry out more awareness activities, such as informative talks on small individual and collective actions that help reduce the impact on our environment.

## FINANCIAL SUPPORT ACKNOWLEDGEMENTS

The author(s) received no financial support for this work.

## REFERENCES

- Binder, A., Clausen, E. & Hutwalker, A. (2017). Integrating sustainability aspects in mining engineering education. *Proceedings of the 13th International CDIO Conference* (pp. 548-558). Calgary, Canada.
- Botella de Amor Fundación (2019, March 31). Botellas de Amor Fundación. [Video]. YouTube. <https://youtu.be/1RqrVzu9rUE>
- Botella de Amor Fundación (2019, September 10). Presentación Botella de amor [Video]. YouTube. <https://youtu.be/vW6Ghbi0ffl>
- CDIO (2022). *CDIO Optional Standards 3.0*. <http://www.cdio.org/content/cdio-optional-standards-30>
- Cheah, S. M., Yang, K., & Sale, D. (2012). Pedagogical approach to integrate sustainable development into engineering curriculum. *Proceedings of the 8th International CDIO Conference*. <http://cdio.org/knowledge-library/documents/pedagogical-approach-integrate-sustainable-development-engineering-curri>
- Cheah, S. M. (2014). CDIO as curriculum model for education for sustainable development. *Proceedings of the 10th International CDIO Conference* (pp. 1-13). Barcelona, Spain.
- El Tiempo (2022, January 14). El problema de basuras en los municipios apartados, pequeños y turísticos. Retrieved January 14, 2022 from <https://www.eltiempo.com/vida/medio-ambiente/el-problema-de-basuras-en-los-municipios-apartados-pequenos-y-turisticos-644775>
- Francis, Pope. (2015). *Encyclical Letter Laudato Si', on care for our common home*. <https://www.laudatosi.va/es/enciclica.html>
- Fundación Sanar (2022). Tapas para sanar. <https://www.tapasparasamar.com/>
- García, G. (1999). *Collected stories*. (G. Rabassa and J. S., Bernstein, Trans.). Harper Perennial Modern Classics. (Original work published 1992)
- Instituto Humboldt. (2021). Grave deterioro de la biodiversidad nacional pone en riesgo la vida en Colombia. <http://www.humboldt.org.co/es/boletines-y-comunicados/item/1658-grave-deterioro-de-la-biodiversidad-nacional-pone-en-riesgo-la-vida-en-colombia>
- Jamison, A, Kolmos, A, & Holgaard, J. E. (2014). Hybrid Learning: an integrative approach to engineering education. *Journal of Engineering Education* 103(2), 253-273. <https://doi.org/10.1002/jee.20041>
- Manos verdes (2022). Quiénes somos. <https://manosverdes.co/quienes-somos/>
- Malmqvist, J., Edström, K., & Rosén A. (2020a). CDIO Standards 3.0 - Updates to the Core CDIO Standards. *Proceedings of the 16th International CDIO Conference* (pp. 60-76). Turku, Finland.
- Malmqvist, J, Edström, K, Rosén, A., Hugo, R, & Campbell, D. (2020b). Optional CDIO Standards: Sustainable Development, Simulation-Based Mathematics, Engineering Entrepreneurship, Internationalisation & Mobility. *Proceedings of the 16th International CDIO Conference* (pp. 48-58).
- Marce La Recicladora (2020, January). *¿Qué es una botella de amor? ¿Para qué sirve?* [Video]. YouTube. <https://youtu.be/yEmDBq9-e2k>
- Mazzucato, Mariana. (2021). *Mission Economy: A Moonshot Guide of Changing Capitalism*. Harper Business.
- Ministerio de Ambiente y Desarrollo Sostenible. (2022, January 7). *En 2050 habría en el mundo unos 2.000 millones de toneladas de basura* [Press]. <https://www.minambiente.gov.co/sala-de-prensa>
- Morin, Edgar. (1999). *Seven complex lessons in education for the future*. UNESCO. Retrieved January 14, 2022 from <https://unesdoc.unesco.org/ark:/48223/pf0000117740>
- Nussbaum, Martha C. 2012. *Not for profit. Why democracy needs the humanities*. Princeton Press.
- Oil care (2022). Impact of oil spills. Retrieved January 14, 2022 from <http://oilcare.org.uk/what-we-do/impacts-of-oil/#:~:text=Just%201%20litre%20of%20oil,that%20live%20in%20the%20water>
- Proceedings of the 18th International CDIO Conference, hosted by Reykjavik University, Reykjavik Iceland, June 13-15, 2022.*

- Osorio, D. (2022, January 12). *Capurganá, el paraíso turístico que se ahoga en basura*. El Colombiano. <https://www.elcolombiano.com/colombia/capurgana-choco-en-crisis-de-basura-por-migracion-y-turismo-HG16329284>
- Rosén, A., Edström, K., Grøm, A., Gumaelius, L., Munkebo Hussmann, P., Högfeldt, A. K., & Fruergaard Astrup, T. (2019). Mapping the CDIO Syllabus to the UNESCO. Key Competencies for Sustainability. Proceedings of the 15th International CDIO Conference. (pp. 67-84). Denmark.
- Sanar. (2022). *Tapas para Sanar*. Retrieved March 22, 2022 from <https://sanarcancer.org/>
- Semana (2020, March 1). El 78% de los hogares colombianos no recicla. Retrieved January 14, 2022 from <https://www.semana.com/medio-ambiente/articulo/el-78-de-los-hogares-colombianos-no-recicla/44231/>
- Team Foods (2020, May 12). Tu también puedes ser parte de este movimiento. [Video]. YouTube. <https://youtu.be/cIMBkGeaFD4>
- Teleantioquia Noticias (2017, April). Llena una botella de amor. [Video]. YouTube. [https://youtu.be/YP9hO8\\_LoKU](https://youtu.be/YP9hO8_LoKU)
- UI Green Metric. University of Indonesia (2022). UI Green Metric World University Rankings. Retrieved January 10, 2022 from <https://greenmetric.ui.ac.id/>
- UNESCO. (2021). Trash Hack Action Learning for Sustainable Development. A Teacher's Guide. Retrieved January 14, 2022 from <https://unesdoc.unesco.org/ark:/48223/pf0000375408>
- Uruburu, A., Moreno-Romero, A., Carrasco-Gallego, R., Borge, R., Lumbreras, J., & Miñano, R. (2018). Integrating sustainability in academic CDIO subjects: a review after three years of experience. *Proceedings of the 14th International CDIO Conference*. (pp. 238-249). Kanazawa, Japan.
- Wedel, M., Malmqvist, J., Arehag, M., & Svanström, M. (2008). Implementing engineering education for environmental sustainability into CDIO programs. *Proceeding of the 4th International CDIO Conference*. Belgium, Hogeschool Gent.

## BIOGRAPHICAL INFORMATION

**Jairo Alberto Hurtado** PhD is an associate professor at Pontificia Universidad Javeriana, Bogota, Colombia, at Electronics Department. He was Chair of Electronics Engineering Program and he has been working on different projects to improve learning process of his students.

**Flor Ángela Bravo** PhD is an assistant professor at Universidad Nacional Sede de La Paz, Cesar, Colombia. Her current research focuses on Robotics, Human-Robot Interaction, STEAM education, and Educational Robotics.

**Gloria Inés Mestre López** is Specialist on Economic Journalism. Professor at Universidad EAFIT, Knowledge of Life Program, Colombia. Member of the Governing Board of the Colombian Association of Researchers on Communication, ACICOM.

### **Corresponding author**

Assoc. Prof. Jairo A. Hurtado  
Electronics Department  
Pontificia Universidad Javeriana  
Calle 40 No. 5-50. Ed. José Gabriel  
Maldonado S.J.  
Bogotá, Colombia  
[jhurtado@javeriana.edu.co](mailto:jhurtado@javeriana.edu.co)  
(57-1) 3208320 Ext 5327



This work is licensed under a [Creative Commons Attribution-NonCommercial-NoDerivs 4.0 International License](https://creativecommons.org/licenses/by-nc-nd/4.0/).