USING ROBOTICS TO GENERATE COLLABORATIVE LEARNING, THROUGH THE CDIO INITIATIVE

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ABSTRACT

Based on the experiences of the robotics group of the Engineering School at the Pontificia Universidad Javeriana, Bogotá, Colombia, the present paper describes how the development of robotics-based projects generates active and collaborative learning that support disciplinary knowledge-building and promote the development of skills. This Student Research Group in Robotics started work in the first half of 2015 with six students and currently has more than 40, from different years (first to fifth) participating actively and with two full-time professors and two partial time professors. From the beginning, it found the potential of developing the projects and the assembly of the robots through the CDIO initiative, implemented at Electronic Engineering Program. Conceive is given by the requirements defined by the challenges request of competition. Design is done by students through teamwork guided by professors. Implement and Operate are carried out exclusively by the students, with the support of the professors. In addition to the promising and continuous good results obtained in national and international competitions in 2015 and 2016, students have appropriated the knowledge; they are responsible for their own learning and are creating permanent strategies to transfer knowledge and experience with the development of communication skills. The commitment of the professors to the group has gone beyond technical support. In addition to strengthening teamwork and values such as ethic, respect, equity, self-confidence and other responsibilities, it has achieved to empower students to assume different roles, typical of group dynamism, which has been highly valued by themselves and their families, who have told us. This paper shows the evolution of the group, which is in an exploratory stage, and a description of main features of this group such as students' roles, workspace, equipment available, and recruitment process. Additionally, we discuss how robot-based activities promote collaborative learning, through the CDIO initiative. Finally, it is detail new perspectives and the learned lessons.

KEYWORDS

Engineering education, CDIO Initiative, educational innovations, collaborative learning, active learning**,** Standards: 7, 8.

INTRODUCTION

Educational robotics is a term commonly used to describe the use of robots as a tool to support both teaching and learning processes (Eguchi, 2013; Keengwe, 2015). The aim of a robot-based activity is to support the knowledge building and foster the acquisition of 21st-century skills such as creativity, problem-solving, critical thinking, and communication, through manipulation and interaction with educational robots (Benitti, 2012).

Robotics-based projects offer students a concrete and tangible way to understand complex and abstract concepts. Additionally, they provide rich active learning contexts that help students make connections among concepts and facilitate the application of this knowledge to real world situations. A special feature of a robot-based activity is that it provides students with instant feedback that helps them aware of mistakes or misconceptions and to reinforce right actions.

During six years, the Electronics Engineering program at the Pontificia Universidad Javeriana program had been involved in a curricular review towards the implementation of the CDIO approach (Gonzalez, et al. 2014). The aim of this curricular review was to improve the program with a comprehensive education that takes into account the local and global context with emphasis on the process of conceiving-designing-implementing- operating products, processes, and systems (Crawley, et al. 2014). Last year, the program started the implementation of this new CDIO curriculum.

A key feature of CDIO programs is integrated learning experiences that lead to the acquisition of disciplinary knowledge and skills (CDIO Standard 7). Another key concept in the CDIO approach is active learning (CDIO Standard 8). This strategy involves students, as active participants, in their own learning process (Gonzalez, et al. 2014). Active learning help students make better connections among concepts and facilitate the application of this knowledge to complex, contextualized, and real problems (Crawley, et al. 2014). Educational robotics is a strategy that facilitates the construction of rich, active learning that support disciplinary knowledge-building and promote the development of skills. From the experiences of robotics group, this article describes how the development of robotics-based projects generates active collaborative learning.

Integral formation is one of the pillars of Ignatian pedagogy (Jesuit Institute, 1993) in the education institutions run by Jesuits, that together with the Institutional Educational Project at Javeriana, promotes research training as part of this comprehensive training.

Vice-rectorate of research promotes the creation of Student Research Group. This learning community constitutes a space research training for undergraduate and graduate students. Professors and students of the University can be part of Student Research Group.

The purpose of the Student Research Group is to support the training of research competencies of undergraduate and graduate students, including the skills of inquiry, observation, recording and comparison, critical and analytical capacity, reinforcement of verbal and written communicative skills and project management, and the learning of the research process developed through the practice itself.

Student Research Group in robotics was born in the first half of 2015, with six students from the Electronic Engineering program who wish to learn more about robotics and put into practice the knowledge acquired in their studies. Nowadays, this group has more than 40 active students, from first year to last year of engineering.

The paper is structured as follows: in the first place, it is presented a brief description of the Student Research Group. Then, it is shown the main operative features of this group such as students' roles, workspace, equipment available, and recruitment process. After that, we discuss how robot-based activities promote collaborative learning through the CDIO initiative. It is also shown the participation in events and the outcomes. In the next section is found the learned lessons. Finally, conclusions and perspectives are presented.

DESCRIPTION AND EVOLUTION OF THE JAVEX GROUP

Robotics group has more than 40 active students, four Engineering professors and a Social Communications and Journalism professor, who helps in the strengthening of communication and diffusion areas. Percentage of women in the group is close to 25%, the same value that in Electronic Engineering Program.

The robotic group started participating in robotics competitions, which allows students to obtain results in a short time and evaluate their evolution. Competition gives the possibility to develop and strengthen some characteristics within the group members, such as cooperative learning, group work, responsibility, respect for the other and resilience. Being in line with the learning outcomes contemplated in the program are an ability to identify, formulate and solve problems engineering, ability to apply knowledge of mathematics, science and engineering, an ability to engage in lifelong learning and ability to communicate effectively.

In order to strengthen some communication skills (oral presentation, communications strategy, written communication and listening and dialog), each semester introduces new students to the robotics group (a presentation made by students group members in an auditorium), mainly first year students, who later will be trained by students of the robotic group in this semester (written and oral communication).

Student Research Group in Robotics has characteristics of learning groups that develop in the context of collaborative learning, active learning, and experiential learning as suggested by the CDIO initiative.

Due to this increase in the number of members and the limited availability of resources, we have begun to work in different areas, such as participation in other types of robotics competitions, robotic training of elementary school children and documentation of processes and results. Figure 1 shows different of these participations of the robotics' group.

Figure 1. Participation fairs and competitions (internal and national championship)

OPERATION OF THE ROBOTICS GROUP

Once good results were achieved in competitions, to robotics group was assigned its own laboratory, in which is the training track, electronic equipment and computers, components, and materials that the students self-manage, for the design and assembly of Robots, as well as for inventory management of parts and spare parts. Additionally, they are responsible for the order and cleaning of the laboratory (available to them 24 hours a day, 7 days a week).

Although professors are responsible for purchasing new equipment or materials, students are the ones who prioritize the needs, based on the available budget.

Likewise, students are in charge of logistics on each trip to competitions (dates of departure and return, hotel, internal transport and transportation of robots).

Students are also responsible for recruiting new members of the group each semester. The new students must learn to program the robot (autonomous learning), then in the company of a group of students (collaborative learning) of the robotics group the aspirants must design a robot clamp, assemble it, put it to work and participate in the internal competition.

Although collaborative learning has been built on cognitive theories and in particular on knowledge in the constructivist approach, finally one must consider how each individual constructs his knowledge and learning. Gross says "the students develop their own learning strategies, point out their goals and goals, and take responsibility for what and how to learn. The role of the teacher is to support the student's decisions" (as cited in Calzadilla, 2002, p. 4)

Any person who performs the complete process of learning the programming language, design, assembly, operation of the robot and participation in the competition (regardless of the position obtained), becomes an active member of the students group of research. Figure 2, shows a picture of the group with new members.

Figure 2. Welcome to new members

METHODOLOGY

Learning through challenges: introducing essential skills to freshman engineering students (Giraldo, Cruz & Hurtado, 2014) describes the foundations and motivations behind the efforts of last years of the Electronic Engineering Program at Pontificia Universidad Javeriana for design a course that engages students through motivating experiences in order to teach them to apply essential skills in a proper engineering context. Essential skills or also today called 21st-century skills as teamwork, written communication, oral communication, decision making, ethics, competitiveness, and cooperation.

Engineering process for the development of each robot is based on CDIO as follows: Conception starts with the requirements given in the challenge to perform. Understanding of it is done individually and later is discussed grouping what is understood to unify criteria and concepts (description of the challenge is a video in English and the students speak Spanish).

In this way, it is possible to obtain a group learning and use of common language, among all the members of the robotics group, where they can openly ask and clarify their concepts. Likewise, an improvement in communication skills in English is achieved.

Then different strategies are presented, architecture of the robot and its functions. Professors are the moderators of this discussion, but students must propose, discuss, argue, and finally make agreements. Figure 3 shows students in different activities on completion field.

Figure 3. Students training and in communication activities

Design phase is done by each subgroup separately (in the conception all contribute and give ideas, but later are divided into working groups, depending on the number of people), where each one will be able to elaborate a robot according to its own design. The design of the robot should include four fundamental parts, the mechanical part, the electrical part, the electronic part and the programming part.

Design is done by the students and it must be presented to the whole group (professors and students) for evaluation and discussion. Questions are asked to the design exhibitors, by the students and teachers, in order to obtain a design that meets the characteristics given in the conception. The idea of collaborative and non-competitive work within the group is maintained.

Implementation part is done completely by the students, who must do from the mechanical assembly of the robot, until the programming of the robot commands. They have a design notebook, so that the progress, modifications, results, and difficulties presented in the process are recorded.

More experienced or advanced students in each area help to younger students or those with less experience, to learn what to do, avoiding relying on only a few people to do so.

Operation of the robots is also performed exclusively by students, some students (drivers) are training to driver the robot properly on the field, they evaluate their operation (battery life, parts replacement, performance on field) to apply improvements.

Thus, development of robotics projects, through cooperation between peers, permanent dialogue, and the possibility of putting ideas into practice, provide a collaborative learning space.

PARTICIPATION IN EVENTS AND OUTCOMES

From the beginning of the group in 2015, in national competitions has obtained a first and second place and twice the "Design Award". It has also been achieved, the classification to three world championships.

In the last World Championships, it has obtained a fourth position and the "Create Award" (“earned by a team whose robot design incorporates a creative engineering solution to the design of challenges of this year”).

Figure 4. World championship and internal tournament

In addition to competitions, students of the robotics group should participate in other activities, including academic events, demonstrations at fairs and school visits.

LEARNED LESSONS

This paper also wants to show that in the learning process of the Student Research Group in Robotics, that given its own nature is a work group, we consider communication in the curriculum from the nature of its structure and then we identify its possibilities as a strategy. This perspective allows the strengthening of the students' skills in written, electronic, graphic and oral communication and multimedia, dialogue, negotiation and conflict resolution processes, and the generation of communication networks.

Particularly, the students of different semesters of the program inscribed in the robotics group during a survey to 20 of its participants stressed as achievements related to this communication skills that they had learned to communicate, listen, talk, respect and accept the point of view of others. Accordingly, 85% of the surveyed considers that their participation in the seedbed has helped them to improve their performance doing teamwork. Concerning the contribution of an effective communication on their performance, 60% of the surveyed said that it helped them completely.

These results can contribute to the permanent development and evaluation process of the program and additionally they can help to identify specific actions to strengthen the teaching and learning strategies related to interpersonal, group work and communication skills. And given the results identified in this group we find necessary to foster their motivation to strengthen these skills in order to resume the work, taking advantage of one of its merits and the inquiries in the field that are also backed by the communicative theory that states that "thinking about communication means thinking about the non-communication" (Wolton, 2009).

Walk through collaborative learning and other educational innovations

Student Research Group in Robotics counts with several features not only in its shape but also on the nature of its work in science and research. First, it meets the functioning requirement of the Students Research Groups endorsed by the university. Given its origin and subsequent development it counts with characteristics, designations and others given by the theory and the learning community, group work or learning group.

Similarly, considering the nature, teaching and learning strategies available in this Student Research Group we find that several concepts appear according to the theoretical perspectives.

However, in this paper we have considered as a core concept the collaborative learning through the definition proposed by Barkley, Cross & Meyer (2014) which we have adopted for the sake of a better learning but not excluding other traits included in other concepts such as "active and experiential learning" or "contextual learning" proposed by the CDIO methodology adopted by the Electronic Engineering Program.

The contact point we want to highlight is that all these concepts, methodologies and strategies are mainly originated on cognitive development, constructivism, and social psychology theories. In this context, we find that some of the characteristics that have been developed in this group share some of the traits stemming from these theoretical perspectives.

In the survey made to 20 students, we found evidence of the way they have undertaken their work and learning process. When we asked them how they evaluate the results related to the experiences of the collaborative learning in their professional careers for being part of the Student Research Group in Robotics, 65% said that it had a high importance and 30% a middle importance.

In collaborative learning, we also consider the degree of commitment, participation, and group work expectations as important issues. Concerning the first item, 50% says that it has meet completely and 45% partially their needs. Regarding expectations, 35% considers them outgrown and 45% as fulfilled.

In the same way, concerning the role of the teacher as a process coach, we asked for the degree of satisfaction with the commitment, management and leadership of the teacher that is accompanying in the group coordination; 85% of the surveyed considered his/her work as very satisfactory. As explain Fiechtner & Davis (as cited in Barkley et al., 2014, p. 24) “the students working in learning groups like the instructor better and perceive the instructor as more supportive and accepting academically and personally”.

Regarding their answers to open questions related to their learning they stressed on the knowledge acquisition, learning to work in teams, new unexplored knowledge possibilities and the possibility to get in touch with people interested in the topic.

CONCLUSIONS AND PERSPECTIVES

The work done in the robotics group has allowed the development and strengthening of abilities and attributes, personal, professional, and interpersonal.

Collective achievements have been more favored than individual successes. This, together with the cooperative work and the very good atmosphere that exists among the members of the group, makes the group to be strengthened permanently.

Due to the size of the group, it has begun the diversification of activities, involving different types of work in robotics and other competitions and thematic, publication of papers in scientific events and more social work, which is related to the creation of open material (Written text or video) for robotics training, robotics workshops for primary school children, and creation of robotics workshops with very low-cost materials.

Robotics group will be open to students from other non-engineering programs, to disseminate knowledge of robotics and to explore the opportunity for multidisciplinary work.

As a conclusion of the benefits of this collaborative learning we can close with this remark from a student: “The Student Research Group in Robotics is not only a mean to develop our capability to work in a team, but it also helps us to acquire knowledge that complements our careers at the same time that we strengthen our values of respect, timeliness and responsibility”.

One aspect that we want to work more in the Student Research Group is the cultural diversity, equal opportunities and gender equity. Barkley et al. (2014) refer that “women, members of underrepresented racial and ethnic groups, adult and reentry students, commuters, and international students have been identified as students for whom peer and group learning seem especially valued and valuable” (p. 27).

Finally, we want to remember that we communicate due to endless reasons, but that mainly our desire drives us to communicate to share, to seduce and to persuade (Wolton, 2009).

REFERENCES

Barkley, E. F., Cross, K. P., & Major, C. H. (2014). *Collaborative Learning Techniques : A Handbook for College Faculty*. San Francisco: Jossey-Bass.

Benitti, F. B. V. (2012). *Exploring the educational potential of robotics in schools: A systematic review. Computers and Education*, 58(3), 978-988. doi:10.1016/j.compedu.2011.10.006

Calzadilla, María Eugenia.(2002). *Aprendizaje colaborativo y tecnologías de la información y la Comunicación,* 1-10. Revista Iberoamericana de Educación-OEI. Recuperado de http://rieoei.org/tec_edu7.htm

González, A., Londoño, J., Fadul, K.,, Bravo, F., & Viveros, F. (June, 2016). *Active Learning in Electronics Engineering at Pontificia Universidad Javeriana*. Proceedings of the 12th International CDIO Conference, Turku University of Applied Sciences, Turku, Finland.

Crawley, E.F., Malmqvist, J., Östlund, S., Brodeur, D.R. & Edström, K. (2014). *Rethinking Engineering Education*. The CDIO Approach. Springer.

Eguchi, A. (2014). *Educational Robotics Theories and Practice: Tips for how to do it Right*. In Robotics: Concepts, Methodologies, Tools, and Applications (pp. 193-223).doi:10.4018/978-1-4666-4607-0.ch011

Giraldo, J., Cruz, J., & Hurtado, J. (June, 2014). *Learning through challenges: introducing soft skills to freshman engineering students*. *Proceedings of the 10th International CDIO Conference.* Universitat Politècnica de Catalunya, Barcelona, España.

Jesuit Institute. (1993). *Ignatian Pedagogy. A Practical Approach*. Recovered from: http://jesuitinstitute.org/Resources/Ignatian%20Pedagogy%20(JI%20Edition%202013).pdf

Keengwe, J. (2015). *Handbook of research on active learning and the flipped classroom model in the digital age IGI Globa*l.

Pontificia Universidad Javeriana. (2016). *Directrices sobre semilleros de investigación (SI) y Jóvenes Investigadores (JI).* Recuperado de *http://www.javeriana.edu.co/investigacion/politicas-y-directrices*

Vásquez, M. (2000). *Historia y comunicación social.* Barcelona: Mondadori.
Wolton, D. (2011). Informar no es comunicar. Contra la ideología tecnológica. Barcelona: Gedisa.

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