Robotics tips and tricks for inclusion and integration of students

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***Abstract*— Robotics and computational thinking are valuable tools for developing science, technology, engineering and mathematics (STEM) pedagogy, and to promote inclusion and integration of students. We currently have a multitude of robotic education tools at our disposal. These tools arise with the aim of promoting innovation and student motivation during the learning process. Robots are becoming more and more common in our society today. Therefore, it is important to integrate robots into all levels of our everyday life. This work is focused on presenting Raspberry Pi as enhancer of educational robotics. The first step is presenting robotics as a tool for promoting the inclusion and integration of students. For this work a background and overview is also provided. The third part proposed different setups to prepare a Raspberry Pi for remote activities and robotics using Arduino as hardware interface. The last but not the least is an open discussion with the aim of exchanging impressions and getting feedback from the attendees.**

Keywords— education, programming, robotics, STEM;

I. INTRODUCTION

The question of Diversity and Inclusion emerges around the word with many different looks, but the first thing to consider is that they should work together. We should attract to science, technology, engineering and mathematics (STEM) in general, and engineering in particular, all students that shows interest for the field, no matter the gender, ethnicity or if they have special needs, but as shows in the work [1] the Diversity should work with the Inclusion to maintain these students and professionals in the field.

There are many opportunities to improve and empower STEM education. Yet today, students pursue expertise in STEM fields. But we still have an inadequate pipeline of teachers skilled in those subjects. Nevertheless, robotics appears to be a promising educational tool. Today, it is possible to engage students with innovative and motivating options during the learning process using educational robotics tools. The modernization and improvement of most processes is being developed through the use of robots. This is because robotic applications are easily integrated into industrial processes [2].

Robotics kits facilitate the connection between STEM disciplines [3]. In addition, it is possible to involve students in learning computer fundamentals through a combination of simple materials and games. The article [4] describes a set of learning activities that were found suitable for non-formal learning environments. Additionally, some educational robotic workshop such as [5] are being carried out to include the educational layer into the platform development.

This work is related to the workshop "Inclusion and Integration of Students with Robotics" presented in IEEE EDUCON 2018, which eases the learning process into the robotics. The chosen tools to accomplish this are Scratch Crumble and Arduino. The importance of integrating robots into all levels of our society lies in the fact that the help of robotic applications facilitates the tasks we perform in our daily lives. This paper is divided in 4 sections. Section II summarizes workshop structure. This Section includes a short description of the used tools and resources needed. Section III indicates the pre-knowledge required for the workshop attendees. The last section indicates the presenters' institution and position.

II. WORKSHOP STRUCTURE

This workshop is intended to be deployed for 90 minutes. The agenda is divided in four main blocks. The first block is intended to robotics is presented as a tool to promote the inclusion and integration of students. The second part introduces STEM pedagogy and robotics education as the underlying background of this workshop. Furthermore, an overview of the workshop is provided too. In a third step, the Raspberry Pi and Arduino tools are presented, and the content is deployed based on both tools. Furthermore, Finally, some time is reserved to discuss about the content and the experiences.

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A. Tools to inclusion and integration of students

There are many interesting tools to support students during their school years. In academy, some students belong to underrepresented groups, the most obvious underrepresented group is women. They are about 50% of the population in any country, but their presence in Engineering is not even close to half of the students or professionals. There are many different aspects about women in Engineering, the work [6] study the small number of female professionals in Engineering in Japan, and the work [7] study the perception of women and underrepresented groups due to race and ethnicity.

Thinking in diversity, other groups are underrepresented, as racial or ethnics groups. Some groups are part of the society, as the African American in USA that are described in [8], and without inclusion initiatives, even the well successful professionals or students can be in a position that they are not executing all their full abilities. Other groups are new to a specific country or region and they should be integrated to the society and university, as described in [9], where Mixed Reality is used to integrate foreign students.

One challenging question for inclusion are the students with special needs. The work [10] deals with the accessibility for blind students in MOOCS (Massive Open Online Courses), while the work [11] deals with the experience of students that are at same time in two groups, underrepresented race/ethnical groups and students with physical disabilities. The question of inclusion goes also for students with intellectual disabilities. The work [12] deals with students with intellectual disabilities, preparing them, with a post-secondary course, to work with 3D printing in a technical field, while the work [13] deals with a neurodiversity team of students where some of them are neurotypical and/or have autism.

The traditional education was a student sit on chair watching the teacher presentation and latter, alone with a book doing the tasks that the teacher proposes. When new technologies arise as an educational tool, the first use was a self-study, or out of class study, where the student is alone again.

Now, kids born with technology, things that previous generations had to read the manual and study to make work, are a natural part of the life of current generation.

Educational process is also evolving, and integrate students with different backgrounds is an important question for many schools and universities. Technology can be used to integrate these students, with work groups where the students are encouraged to work in a group where the different abilities of each student are valued to solve a problem for the entire group. Robotics can be one of the tools used to integrate these students.

Robotics can be easily driven in the field of STEM relying the fun and the scientific method as an enhancer of motivation of students outside and inside the classroom. Furthermore, it integrates activities which improves competencies such as teamwork, problem solving, resilience and communication. These activities help instructors and faculty who can integrate them as part of the school curricula.

During the first 20 minutes of the workshop, robotics as a key factor for STEM education is described.

B. Workshop background and overview

Robotic education is becoming very popular these days. Simple robots are being used within STEM education as a powerful tool which eases the way to teach STEM knowledge. Additionally, when you want to transform concepts that are perceived by the students as non-attractive into attractive activities within the framework of a learning process, robots are a very effective solution. This is because it is now very easy to integrate robots into virtually any type of process. The use of robots as educational tools also encourages students to become involved in STEM. Despite this, the process of introducing robotics is not an easy task. First, robotics is the combination of four complex and distinct areas of knowledge: mechanics, electricity, electronics and computing. These areas of knowledge are combined with the aim of designing and building applications capable of interacting with the environment and making decisions. A robot can be defined as an electromechanical machine consisting of sensors and actuators. The former to acquire information about the environment, and the latter to be able to act on the environment. Therefore, a first step in the introduction to robotics should be oriented towards the acquisition of programming knowledge and basic knowledge of mechatronics.

Next 20 minutes of the workshop are used to show robotics as a key factor for STEM education is described.

C. Raspberry Pi for educational robotics

The Pi Raspberry Foundation developed a single-board computer (SBC) with the aim of promoting the teaching of basic computer science in schools and developing countries. This SBC is called Pi Raspberry and has been developed in the UK. The original model became much more popular than expected, so at first it was quite difficult to get it. In addition to the use for which it was designed, people purchased Raspberry Pi for home use and even for robotics related uses [14].

The Raspberry Pi has now evolved to version 3. In addition, there is a model called Raspberry Pi Zero with an even more compact size.

Although it is not expressly stated whether it is free hardware or with trademark rights, the official website explains that they have distribution and sales contracts with two companies, but at the same time anyone can become a reseller or distributor of Raspberry Pi cards, so it means that it is a product with registered property, maintaining control of the platform, but allowing its free use both at an educational and private level.

However, the software is open source, and its official operating system is an adapted version of Debian, called Raspbian, although it allows other operating systems, including a version of Windows 10. All versions include a Broadcom processor, RAM memory, GPU, USB ports, HDMI, Ethernet (the first model did not have it), 40 GPIO pins and a camera connector. None of its editions include memory, being this in its first version an SD card and in later editions a MicroSD card.

Fig. 1 shows a Raspberry Pi 3 board. This SBC board includes: a 1.2GHz 64-bit quad-core ARMv8 CPU, 802.11n Wireless LAN, Bluetooth 4.1, Bluetooth Low Energy (BLE), 4 USB ports, 40 GPIO (General Purpose Input Output) pins, full HDMI port, Ethernet port, combined 3.5mm audio jack and

composite video, camera interface (CSI), display interface (DSI), micro SD card slot and VideoCore IV 3D graphics core.

Fig 1. Raspberry Pi 3.

This block is intended to cover the following activities:

- Setup a Raspberry Pi: Pixel OS.
- Setup the LAMP (Linux, Apache, MySQL and PHP) server.
- Setup WordPress.
- Drive Arduino through the web.

LAMP is the acronym of Linux, Apache, MySQL and PHP. The first step is to install a full Raspbian with the PIXEL desktop.

PIXEL (Pi Improved Xwindows Environment, Lightweight). Figure 2 shows a screenshot of the PIXEL desktop.

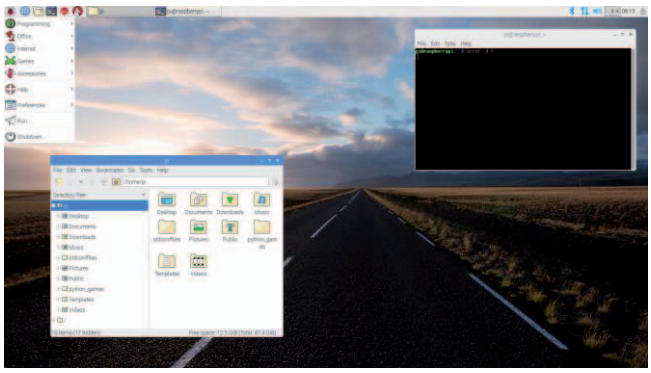

Fig 2. PIXEL desktop.

After that, Apache server, MySQL database and PHP are installed. The last step is to install WordPress. WordPress allow easily the following:

- Adding pages and posts to the website.
- Installing different themes from the Appearance menu.
- Customizing the theme, or creating one new.
- Using the web server to display useful information to people on the network.

Once the Raspberry is ready as web server, the next step is to deal with Arduino. Arduino was released by Massimo Banzi in 2005 as a modest tool for Banzi's students at the Interaction Design Institute Ivrea (IDII). Arduino is an open-source electronics platform based on easy-to-use hardware and software. It is a platform that incorporates a simple microcontroller and an interface development environment to create the applications to be downloaded into the board. The use of Arduino projects includes a wide range of applications from robotics to automatic control irrigation systems [15].

The website provides different ways of using Arduino:

- Arduino Web Editor [16].
- Arduino IDE for different operating systems (Windows, Debian / Ubuntu and Mac OS X).

The programming interface is a text programming software based on C language. For Arduino programs there are two main parts. At the top of the program, the setup zone can be seen. At the bottom of the program, the main loop for code is located. The main loop is used to hold the commands for the programs. Fig. 3 shows a snapshot of Arduino IDE. A simple program is included too.

Fig 3. Arduino IDE.

Fig. depicts a simple robotic platform based on Arduino. Tis robot is composed by 4 motors, a chassis and an Arduino controller.

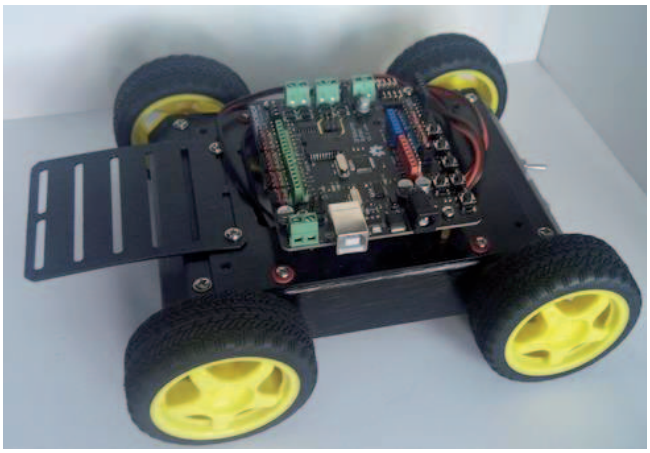

Fig 4. Arduino robot platform.

[17] describes cost-effective solutions to promote STEM using Single Board Computers (SBCs) such as the Raspberry Pi, and Microcontrollers such as Arduino. Authors in [18] a range of prototyping boards such as Arduino, Raspberry Pi, and BeagleBone Black, and how these devices can be used in curriculum in a range of courses for projects. The use of Arduino projects includes a wide range of applications from robotics to automatic control irrigation systems [19]. Arduino is widely used in education, e-Textiles Integrate the Arts and STEM in computing education using Arduino as processor [20].

At this time, the LAMP server running WordPress into the Raspberry Pi 3 is used to connect the web with an Arduino robot kit. Along 30 minutes this it is used to deploy the same multiplatform educational content, now using a simple hardware platform with an easy-to-use block programming IDE (Integrated Development Environment) interface.

The objectives of this part are the following:

- Know Raspberry Pi with LAMP.
- Know Arduino.
- Know Arduino based robot kit.
- Interfacing the robot via network connection.

D. Discussion

At this point, a discussion is opened with the aim of exchanging impressions and getting feedback from the attendees. For this purpose, a total of 25 minutes from the workshop are reserved. The discussion is focused on how educational robotics can be good to motivate young students to basics disciplines, as mathematics and physics. The students think that these are too complicated and abstract disciplines, but with the applications in robotics, students can see how useful these disciplines can be.

III. PRE-KNOWLEDGE OF THE ATTENDEES

Previous experience in programming or robotics is not needed due to the nature of the used tools and the content. From the programming side, WordPress graphical interface eases the programming tasks. On the other hand, Arduino text programming interface is used with simple modifications from examples provided by the Arduino IDE. From the hardware side, Raspberry Pi and Arduino are used with basic electronic elements and connections. Therefore, a deep knowledge about electronic is not required.

IV. PRESENTERS INSTITUTION AND POSITION

Aruquia Peixoto is with CEFET/RJ (Centro Federal de Educação Tecnológica Celso Suckow da Fonseca) as Assistant Professor. Pedro Plaza is with Plaza Robotica as Educational Content Designer.

Dr. Aruquia Peixoto is an Assistant Professor at CEFET/RJ in Rio de Janeiro, Brazil. She has a B.S. in Mathematics from UFRJ (Federal University of Rio de Janeiro), a M.S. in Engineering of Computing and Systems from COPPE/UFRJ and a PhD in Mechanical Engineering from PUC/RJ, all these institutions are in Rio de Janeiro, Brazil, and are some of the best universities in Brazil. She worked in the implementation of the State University of Roraima in the extreme north of Brazil, in 2006. She advised undergraduate students in scientific projects in UERJ (State University of Rio de Janeiro), where she win four prizes, co-advising the students with Paulo Rogerio Sabini, two prizes in UERJ, one as best work of Mathematics and the other as one of three best works in the technological field, and she have two national honorable mentions in student projects presentations in the Jornadas de Inicação Científica organized by IMPA (National Institute of Pure and Applied Mathematics). She is member of the ACM SIGGRAPH International Resources Committee since 2013, member of the SIGGRAPH Asia Symposium on Education Committee since 2016 and 2017, and co-organized the meetings Women in CG during the SIGGRAPH and SIGGRAPH Asia Conferences, organized the meeting Girls in STEM in SIGGRAPH Asia 2016, and a round table Women in Engineering: Issues and Perspectives at the IEEE EDUCON 2017. During the year 2016 to 2017 she was visiting faculty at University of Kansas. Since 2017 she has been a member of the council ACM-W (ACM Council for Women), as SIG Liaison. For IEEE EDUCON 2018 she is Chair of the Special Session IDEE (Inclusion and Diversity in Education Engineering), and Chair of the Publication, Web and eMedia Committee.

Pedro Plaza is currently pursuing the Ph.D. degree in Industrial Engineering at the ETSII (Industrial Engineering School) of the Spanish University for Distance Education (UNED). He received the M.Sc. degree from the ETSII (Industrial Engineering School) of the Spanish University for Distance Education (UNED), Madrid, Spain, in 2013. Also, he has an Industrial Engineering degree of the Carlos III University of Madrid (UC3M), in 2010. He is currently R&D Project Engineer at Siemens Rail Automation. Pedro Plaza is Editorial Board Member in International Journal of Automation and Robotic Technology in Inderscience. He is the author of several publications in prestigious conferences. Pedro Plaza has collaborated on several research projects. He is a member of the

IEEE, the IEEE Robotics and Automation Society, the IEEE Education Society the IEEE Young Professionals and IEEE Women in Engineering. Also, he is robotics co-coordinator in the IEEE student branch of UNED.

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REFERENCES

[1] C. Puritty, L. R. Strickland, E. Alia, B. Blonder, E. Klein, M. T. Kohl, E. McGee, M. Quintana, R. E. Ridley, B. Tellman, and L. R. Gerber, (2017). Without inclusion, diversity initiatives may not be enough. Science, 357(6356), pp.1101-1102.

[2] G. Carro, S. Martin, E. Sancristobal, F. Mur and M. Castro (2012) Robotics, the New Industrial Revolution. IEEE Technology and Society Magazine, vol. 31, no. 2, pp. 51-58. DOI: 10.1109/MTS.2012.2196595

[3] G. Carro, R. Carrasco, P. Plaza, M. A. Cañas, E. Sancristobal, M. Castro and F. Mur. (2015) Mechatronics and robotics as motivational tools in remote laboratories. IEEE Global Engineering Education Conference (EDUCON), Tallinn, pp. 118-123. DOI: 10.1109/EDUCON.2015.7095960

[4] M. Cápay (2015) Engaging games with the computer science underlying concepts. International Conference on Interactive Collaborative Learning (ICL), Florence, pp. 975-979. DOI: 10.1109/ICL.2015.7318160

[5] P. Plaza, E. Sancristobal, G. Carro and M. Castro (2017) Home-made robotic education, a new way to explore, 2017 IEEE Global Engineering Education Conference (EDUCON), Athens, pp. 132-136 DOI: 10.1109/EDUCON.2017.7942837

[6] B. Balakrishnan and F. S. Low (2016) Learning Experience and Socio-Cultural Influences on Female Engineering Students' Perspectives on Engineering Courses and Careers. Minerva, 54(2), pp.219-239.

[7] W. C. Lee, H. M. Matusovich and P. R. Brown (2014) Measuring underrepresented student perceptions of inclusion within engineering departments and universities. *International Journal of Engineering Education*, *30*(1), pp.150-165.

[8] E. O. McGee and L. Bentley (2017) The Troubled Success of Black Women in STEM. Cognition and Instruction, 35(4), pp.265

[9] J. Mateu, M. J. Lasala and X. Alamán (2014) VirtualTouch: a tool for developing mixed reality educational applications and an example of use for inclusive education. *International Journal of Human-Computer Interaction*, *30*(10), pp.815-828.

[10] A. Królak, W. Chen, N. C. Sanderson and S. Kessel (2017) The Accessibility of MOOCs for Blind Learners. In *Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility* (pp. 401-402). ACM.

[11] C. E. Hawley, E. Cardoso and B. T. McMahon (2013) Adolescence to adulthood in STEM education and career development: The experience of students at the intersection of underrepresented minority status and disability. Journal of Vocational Rehabilitation, 39(3), pp.193-204.

[12] E. Buehler, W. Easley, S. McDonald, N. Comrie and A. Hurst (2015) Inclusion and education: 3D printing for integrated classrooms. In Proceedings of the 17th International ACM SIGACCESS Conference on Computers & Accessibility (pp. 281-290). ACM.

[13] A. Zolyomi, A. S. Ross, A Bhattacharya, L. Milne and S. Munson (2017) Value Sensitive Design for Neurodiverse Teams in Higher Education. In Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility (pp. 353-354). ACM.

[14] Raspberry Pi website. [Online]. Available on: https://www.raspberrypi.org/, visited on 1 January 2018.

[15] Arduino website. [Online]. Available on: http://www.arduino.cc, visited on 1 January 2018.

[16] Arduino web editor website. [Online]. Available on: https://create.arduino.cc/editor, visited on 1 January 2018.

[17] N. S. Yamanoor and S. Yamanoor, "High quality, low cost education with the Raspberry Pi," 2017 IEEE Global Humanitarian Technology Conference (GHTC), San Jose, CA, USA, 2017, pp. 1-5. DOI: 10.1109/GHTC.2017.8239274

[18] P. Jamieson and J. Herdtner, "More missing the Boat — Arduino, Raspberry Pi, and small prototyping boards and engineering education needs them," 2015 IEEE Frontiers in Education Conference (FIE), El Paso, TX, 2015, pp. 1-6. DOI: 10.1109/FIE.2015.7344259

[19] P. P. Merino, E. S. Ruiz, G. C. Fernandez and M. C. Gil, "A Wireless robotic educational platform approach," 2016 13th International Conference on Remote Engineering and Virtual Instrumentation (REV), Madrid, 2016, pp. 145-152. DOI: 10.1109/REV.2016.7444455

[20] K. Peppler, "STEAM-Powered Computing Education: Using E-Textiles to Integrate the Arts and STEM," in Computer, vol. 46, no. 9, pp. 38-43, September 2013. DOI: 10.1109/MC.2013.257