iCERi 2019

12TH INTERNATIONAL CONFERENCE OF EDUCATION, RESEARCH AND INNOVATION

CONFERENCE PROCEEDINGS

SEVILLE (SPAIN)

11-13 NOVEMBER 2019

iCERi 2019

12TH INTERNATIONAL CONFERENCE OF EDUCATION, RESEARCH AND INNOVATION

CONFERENCE PROCEEDINGS

SEVILLE (SPAIN)
11-13 NOVEMBER 2019

Published by
IATED Academy
iated.org

ICERI2019 Proceedings
12th International Conference of Education, Research and Innovation
November 11th-13th, 2019 — Seville, Spain

Edited by
L. Gómez Chova, A. López Martínez, I. Candel Torres
IATED Academy

ISBN: 978-84-09-14755-7
ISSN: 2340-1095
V-2804-2019

Book cover designed by
J.L. Bernat

DEVELOPING AN EXPERIENTIAL LEARNING ACTIVITY TO LEARN ABOUT ROBOTICS

A. Peiro-Signes[1], O. Trull-Domínguez[2], M. V. Segarra-Oña[1], J. Expósito-Puente[2]

[1]Departamento de Organización de Empresas, Universitat Politècnica de València (SPAIN)
[2]IES Gonzalo Anaya (SPAIN)

Abstract

This paper focuses on the results obtained by developing an experiential learning activity (ELA) to transmit the basic concepts of robot programming. ELAs are a powerful tool for developing meaningful learning of several concepts, working with transversal competences and maintaining student interest and motivation on the subject. This paper shows how instructors can develop simple experiences to make a real change in the way they teach in order to adapt to the requirements of today's educational environment. We demonstrate how teachers can use a simple board game to help students test and learn about robot programming concepts, developing motivating sessions which will result in meaningful learning. Through this activity, the foundation is built to acquire basic knowledge related to robot programming and related processes in a structured way. Within this study, we develop the experience and the instructions to guarantee the correct application and effectiveness in the class session. Results on the outcome of the activity are encouraging: students were able to relate aspects covered in subsequent sessions to the situations and knowledge acquired through the activity. Furthermore, students were able to recall the basic principles and concepts experienced during the activity.

Keywords: experiential learning activities, robot programming, transversal competences.

1 INTRODUCTION

Planning new activities in a course requires the consideration of multiple aspects. Beyond the formal aspects related to the activity's fit to the course objectives and contents, we should consider the abilities and skills that students need to work on to acquire key competencies for their future, in addition to infrastructural considerations such as the size of the classroom, its distribution, the number of students, their previous knowledge or the heterogeneity of the students. Evaluating this framework is important to design activities that meet with the course objectives and at the same time encourage student participation and motivation.

Among the different methodologies that educators can choose to achieve course goals, experiential learning activities (ELAs) have proved to be a successful way to deliver concepts, develop competences and maintaining students' engagement during the session.

ELAs are based on experiencing concepts in order to understand them. Students learn about the application and procedures before the concepts, which then allows them to better understand the concepts [1–3]. ELA is a powerful tool to create meaningful learning because, experiences are built on previous knowledge and there is an intense reflective process after the experience [4]. ELAs are normally design for small groups, forcing students to work transversal competences such as teamwork, leadership, communication or critical analysis, and should include a debriefing phase. Additionally, most ELAs are gamified or have some kind of associated simulation, which enhances student motivation toward the session [5]. ELA methodology has been used extensively at different educational levels [6], as well as by companies for various types of employee training.

2 METHODOLOGY

Developing an ELA starts with planning the activity. This phase is necessary to prepare the introduction, the execution and the debriefing phases and is crucial to the success of the activity [7]. In this paper, we describe the development of an experience designed to help students learn some specific concepts related to the basics of robot programming. We used a Connect 4 board game to illustrate students about concepts such as fixed picking point, use of variables, incremental positions, loops and input/output signals, among others.

We developed the activity carefully, considering the concepts to be delivered and the competences that we wanted the students to gain. However, we also have to consider other aspects, such as the available resources and the efficiency or effectiveness of the activity to meet the learning objectives [6]. Thus, from the very beginning, preparing an experiential activity requires alignment of all these aspects to achieve a purpose reflected as learning objectives.

The changes that this methodology represents from the teaching perspective are significant. The educator makes a major effort in the planning phase to reduce their leadership in the learning process, allowing the students to take the lead role in the session. The educator will act as a facilitator of the students' learning process. Thus, in some cases the educators will also need to develop new skills to manage the new situations that will take place during the session.

2.1 Planning

Planning is the initial, and more crucial, phase for ELA success. It is the most complicated part for educators [8]. Starting with the learning objectives, we can outline an activity so that the students can face situations that require analysis, decision-making and reflection. This complete cycle—analysis-decision-reflection—is important to the development of meaningful learning [9–10]. These situations have to be similar to real life but less complex, so that students are able to face the three steps with confidence. Designing the activity then requires setting the objectives, the materials, the instructions and the process to manage both the experience and the debriefing phases.

In this activity, we aimed to build students' basic knowledge and skills related to robot programming and related processes. To encourage participation and motivation, we used a simple board game. The board game helps the educator to explain the objectives, to engage the students and to relate the exercise to industrial processes that require similar repetitive actions. We used a Connect 4 game, which fits our purposes perfectly. This game is easy to understand and allows both simple programming movements and the development of incremental exercises to guide students from simple to more complex programming. Moreover, we can establish some kind of competition at the end for motivational purposes.

We used standard Connect 4 games and 'dobot' robots (see figure 1). We developed a piece on the top to allow the robot to drop off the tokens in the different positions. We also printed templates with the shape of the Connect 4 board base, the pickup positions for the tokens and the robot position. The template assures that robot and environment positioning is good to reach all the necessary points and allows the teacher to control for the positions that the students are using in the program.

Figure 1. Activity resources.

2.2 Introduction of the activity

Introducing the activity in class can be done in many ways. We suggest preparing the area and the resources before the session, setting several Connect 4 games at tables around the classroom. When entering the classroom, the instructor can encourage students to seat in teams around each Connect 4 game. Groups can be made up of two to four students, depending on the size of the class and the availability of the materials, robots and games. Each Connect 4 game is placed in a template which contains the shape of the board and the pickup point for the two types of coloured tokens. The instructor can start by having the students play one round of the game manually, so they can familiarise or refamiliarise themselves with it. Afterward, we recommend asking the students about the process they have just experienced. Tokens were piled in two positions and each group had to take one and drop it in one of the seven possible positions. Discussion can be directed to reveal the type of movements students are making to move the token, the repetitiveness of the task and to reflect on similar industrial processes.

This session is performed after a session where the students have been introduced to using the robot, learning a bit about Cartesian versus joint movements, the 'teach and play back' function and very basic movement and tool actions. Typically, we start programming movements and tool actions, i.e. picking and placing tokens from one position to another. We use Blocky, which is a module based on 'scratch' developed by MIT that is included in the dobot software.

As most robots are machines that are designed to perform repeatable tasks, we introduce the students to the necessity of somehow repeating the task without writing code each time (loops), to repeat part of the task and choose between several options to finish it (variables), to wait or to start the task when someone or something indicates it (input/output), to change some parameters in the task to adapt to the environment (incremental positions), etc.

The activity is designed to be performed in sequential steps, increasing the difficulty in each step. We place the robot in front of the Connect 4 board on the square indicated in the template. The board is composed of a 6 x 7 matrix of possible positions and has a ramp on the top to make the drop off of the tokens easier. Additionally, the template has a pickup position for the tokens of each colour.

2.3 Activity

The first objective is to pick up seven tokens from the pickup position (fixed position and fixed height) and to drop off the tokens in the seven possible positions (different position and fixed height). In this exercise, we introduce the loop and the variable concepts to change the 'y' drop off coordinate, as the 'x' and 'z' coordinates are fixed. A loop is necessary to control for the seven movements and the variable to control for the 'y' position. Initially, the students have to record the 'x', 'y' and 'z' coordinates of the seven possible positions in a template using the teach and playback module, which has been taught in a previous session. Then, they calculate the differences in the 'x', 'y' and 'z' values. The students will realise that there are nearly no differences in the 'x' and 'z' coordinates, because they are fixed, that there are differences in the 'y' coordinates, and that these differences are nearly the same. At this point, the educator introduces the variable concept. 'Y' changes in a constant value for each position. Students can calculate position 5, for example, by adding four times the gap between positions to position 1 and position 7, by adding six times the gap. Therefore, the 'y' coordinate is variable, and it varies depending on the position we are looking for, which will be the variable. Once they have determined all the positions with fixed 'x' and 'z' values and 'y' values separated by a constant gap, the students have to program the pickup and drop off of the seven tokens. When they have finished, the educator points out the large amount of code for an apparently simple exercise. They have introduced the loop concept, the repetition of a similar tasks for a specific number of times. We encourage students to come up with different ways to control a loop, such as, repeat number of times, repeat until, do while or for next loops. Finally, the students repeat the program using a loop to pick up tokens in the pickup position and drop off in the first position seven times. The students can now see how much shorter the code to perform 7 movements is, compared to the previous exercise. Now, introducing the variable in the exercise will allow the students to pick up and drop off in different positions.

Similarly, we built on this exercise using a similar procedure with other exercises to reach our final goal, that is, to play Connect 4 using the robot. The following exercises are designed to work on the objectives of the activity in a structured way. The degree of difficulty increases in each exercise.

- Exercise 2: Tokens are piled in the pickup position (z is variable). The robot has to pick up seven tokens and drop them in the seven possible positions.
- Exercise 3: We introduce a push button. The robot has to pick up a token, go to a fixed position and wait till someone pushes the button (input) to go and drop the token in the corresponding position
- Exercise 4: We introduce election of the position. The robot has to pick up a token, go to the waiting position, there we start a 10 second timeframe (counter). The students have to push the button I times to go to position I, with I being 1 to 7 (counter). If we push more than seven times, the robot will drop off the token in position 7, and if we do not push during the 10 s timeframe, the robot will drop the token in position 1.

- Final exercise: We introduce a second robot to play against another team. As both teams are playing at the same time, we need to connect two signals to communicate with the robots. The input and output signals will indicate to the robots when they can start to play, Then, when the play has finished, the robot has to send (output) a signal to the other robot (input). The input signal will activate the play for the other robot.
- Competition: The groups of students compete against each other using the robot.

Once the robots are programmed in each exercise, some discussion is encouraged to relate the exercise and the game to possible industrial applications or improvements to use it in an industrial application. Discussion allows students to fix the concepts and see the applicability of the knowledge and skills that they are acquiring.

2.4 Debriefing

These exercises are planned to be executed in four or five two-hour class sessions. An important part of the activity is the discussion. We suggest taking 15 to 20 minutes at the end of each session to review the most important aspects of the session and talk about the key concepts, the problems faced, pros and cons of different solutions to the exercise and how we can relate the new knowledge to industrial processes. We also encourage educators to take five minutes at the beginning of the next session to summarise the most important aspects of the previous sessions.

Finally, the students will realise that there is not a single way to solve the exercises, but there are some that are more efficient and less code- and time-consuming. Therefore, for further exercises, they can apply these improvements to streamline the new program.

3 RESULTS

We used a five-point Likert scale questionnaire, where 1 corresponds to ‘totally disagree’ and 5 to ‘totally agree’, to assess the students’ perceptions of the activity. After the final exercise, we surveyed the students about the appropriateness of the activity to learning about robot programming concepts, developing transversal skills related to communication and teamwork and motivating them during the session.

We compiled the average of the questionnaire responses for the first application of the experience on a group of 12 students in a vocational education group of a mechatronics degree (see Table 1).

Table 1. Questionnaire and evaluation results of the activity.

Questions	***Average***
Did the activity help the team to learn how to do basic robot programming?	4.83
Did the activity help the team to learn how to differentiate constant values from variables?	4.92
Did the activity help the team to learn how to transform repetitive activities into loops?	4.92
Did the activity help the team to streamline robot programming?	4.83
Did the activity help the team to understand the impact of robots in industrial tasks?	4.75
To what extent do you think that you could program a robot to perform a new repeatable task similar to the one in the experience?	4.75
To what extent has the experience been preferable and motivating during a master class or regular exercises class?	5.00
Do you think the activity helped the group to act as a team?	4.68
To what extent has communication been important in solving the activity?	4.75
To what extent have you been able to participate and express your opinions in the group discussion and in the general discussion?	4.68
Would you recommend the experience for learning about robot programming?	5.00

Additionally, during the following session we gave the students a similar assignment involving the same concepts, to be completed in two hours in pairs. Five out of six groups completed it successfully.

4 CONCLUSIONS

This paper explains an experiential activity designed to teach basic robot programming. Gamification of the activity helps students to get involve in the activity and understand the objective of the session. The practical application simulates a process that can be easily translated into an industrial environment, helping the students to have a meaningful learning. The activity in small groups encourages teamwork and communication skills which will be of great interest in further job experiences. The results on the outcome of the activity are encouraging; in subsequent sessions, students were able to relate aspects to the situations and knowledge acquired through the activity. Although some adjustments will have to be made through future applications of the experience, overall, we think the activity has been successful in achieving the desired goals.

ACKNOWLEDGEMENTS

This work is part of the study developed by the GAE (Experiential Learning Group) created as an EICE (Innovation and Quality Education Team) at the Universitat Politècnica de València (UPV) and the IES Gonzalo Anaya. The authors would like to thank the UPV for the support through the PIME 2017 “Adaptation and development of experiential learning activities related to the subject context” and the Conselleria de Educación, Investigación, Cultura y Deporte through the project “Adaptación y desarrollo de aprendizajes experienciales al contexto de la formación profesional” (938397).

REFERENCES

[1] A. Peiro-Signes, O. Trull-Dominguez, M. V. Segarra-Ona and B. de-Miguel-Molina, “Using simple experiential learning activities encourage learning of operations management concepts” in Proceedings of EDULEARN17 Conference, 2017, pp. 8712–8718.

[2] A. Peiro-Signes, M. V. Segarra-Ona, O. Trull-Dominguez and M. de-Miguel-Molina, “Bean bags: an experiential learning activity for quality control” in Proceedings of EDULEARN17 Conference, 2017, pp. 8216-8221.

[3] O. Trull-Dominguez, A. Peiro-Signes and M. V. Segarra-Ona, “Learning statistical capacity concept through an experiential learning activity” in Proceedings of EDULEARN17 Conference, 2017, pp. 8797-8801.

[4] D. P. Ausubel, *The acquisition and retention of knowledge: A cognitive view*, vol. 53. 2000.

[5] A. Peiro-Signes and M. V. Segarra-Ona, “Experiential learning as a dynamizer of class activity,” in Proceedings of ICERI 2015 Conference, 2015, pp. 1010–1013.

[6] A. Peiro-Signes, M. L. Alonso-Borso di Carminati and P. Verdejo-Gimeno, “The experiential learning activity: benefits and difficulties in real learning environments.,” in Proceedings of ICERI 2015 Conference, 2015, pp. 1150–1150.

[7] R. Laforge and M. Busing, “The use of industrial software to create experiential learning activities in operations management courses,” Prod. Oper., vol. 7, no. 3, pp. 325–334, 1998.

[8] D. Halpern and M. Hakel, “Applying the science of learning to the university and beyond: Teaching for long-term retention and transfer,” Mag. High. Learn., 2003.

[9] D. Kolb, “Experiential learning: Experience as the source of learning and development,” 2014.

[10] J. Wheeler and P. McLeod, “Expanding our teaching effectiveness: Understanding our responses to ‘in-the-moment’ classroom events,” J. Manag. Educ., 2002.