Learning Interactions: Robotics Supporting the Classroom

Giovana Barros, Beatriz Motta, Vitor Teixeira, Alexandre Gravatá, Sérgio Silva Júnior(✉), Leandro de Sá, Marília Amaral, and Leonelo Almeida

Federal University of Technology, Curitiba, Paraná, Brazil
{giovanabarros,beatrizmotta,vittei.2000,alexandregravata, sergiojunior.2018,leandrosa}@alunos.utfpr.edu.br, {mariliaa, leoneloalmeida}@utfpr.edu.br

Abstract. Programming teaching can improve children's skills in logical-mathematical concepts. This learning process can benefit from the use of artifacts that value principles of Human-Computer Interaction and the area of early childhood education. From the Interaction Design, Visibility, Constraints, Consistency and Affordance principles were addressed together with the design principles adapted for children's technology, such as Literacy, Feedback and Guidance, Mental Development, Imagination, Motor Skills, Tangibility, Motivation and Engagement, Social Interaction and Collaboration, to plan an artifact designed to assist the introduction to learning programming logic for children. The artifact is also based on concepts related to ludic activities and imagination in education. Given this context, this paper intends to present a ludic artifact, the *Roboquedo*, to support this teaching of programming aimed at children. The development stages of *Roboquedo* are presented, based on the Interaction Design process and the characteristics of the artifact, combined with the Interaction Design area, introductory teaching of programming and ludic education.

Keywords: Interaction design · Education · Children · Robotics

1 Introduction

Logical mathematical reasoning and introductory programming teaching can be interesting resources to be inserted in early childhood education. Nevertheless, this preliminary education for children and young people points to possible improvements in the development of mathematical logic [1, 4, 10] and even social and emotional aspects [9], especially when principles of Human-Computer Interaction (HCI) are added to the elements of early childhood education. However, it is not trivial to start this type of teaching, and one of the possible approaches involves practical and ludic aspects, which provide collaboration and autonomy to students.

According to Leite [5] "It is through the act of playing that transition paths to higher levels of mental development are opened, allowing the child to restructure, and re-elaborate their way of understanding, thinking, feeling and interacting with reality".

C. Stephanidis et al. (Eds.): HCII 2021, CCIS 1421, pp. 3–10, 2021.
https://doi.org/10.1007/978-3-030-78645-8_1

Henceforth, this article presents the development of a ludic artifact which follows the principles of Interaction Design, to support the introductory teaching of programming for children, the *Roboquedo* (in Portuguese, "*Robô + Brinquedo*", combination of the words Robot and Toy), developed by PET - CoCE[1].

The *Roboquedo* has as differentials, in face of the existing options, the low financial cost, the use of free technologies and the possibility of using it in a collaborative way. This toy has the following elements: a turtle-shaped robot, a physical map to suggest robot activities, and two forms of directional control of the robot, one tangible (acrylic table with arrows to indicate directions to the robot), and one through a mobile device (with a software to indicate directions to the robot), which will be detailed in Sect. 4 of this article.

This article is divided into five sections. Section 2 presents the theoretical foundation, Sect. 3 presents the research steps, while in Sect. 4 we present the *Roboquedo* artifact and its elements, followed by Sect. 5 with the final considerations and next steps of the research, which is in progress.

2 Theoretical Foundation

Vigotski [9] establishes that the toy appears as an activity when children develop necessities that are not possible to be realized immediately. Necessity, for the author, is defined as "everything that is a reason for action". It would be in the toy, therefore, that children find the possibility to satisfy these necessities. At this stage, imagination is a new psychological process, since younger children are restricted to the impositions of the environment [8]. It can be said that the imagination, for children, would be the toy without action [9]. Thus, Vigotski [9] differentiates the act of playing from other activities as being the imagination in action since the toy does not derive only from any unrealizable desire formed in children. The toy makes it possible to create a zone of proximal development, that is, the transition from one development stage to another, by providing support for the separation between meaning and object, when it is used as a toy and by imposing rules with the imagination making the children submit to them as the purpose of play [9].

To think ludic artifacts with the aim of introducing programming teaching (sequence of commands, input, processing and output) [1], in addition to considering the characteristics of ludic education it is important to understand how children interact with these artifacts. In this regard, the concepts of Interaction Design [6], covered in HCI, offer principles, methods, theories and approaches for the development of aspects related to children's interactions with *Roboquedo*. Regarding the principles, the classics can be listed: Affordance, Feedback, Visibility and Consistency [6]. Besides these, Chiasson and Gutwin [3] suggest the addition and adaptation of some principles, considering the context of children's use, based on three categories of child development, namely: cognitive development, physical development and social and emotional development.

[1] A PET group (Tutorial Education Program) is formed by university students under the tutelage of a member of the faculty, with the objective of providing actions for students to carry out activities that fall within the pillars of research, extension and teaching, aiming at a differentiated formation of its members.

In the first category, the presence of four principles is pointed out: Literacy, Feedback and Guidance, Mental Development and Imagination. In the second category, two principles: Motor Skills and Tangibility. The third has three principles: Motivation and Engagement, Social Interaction and Collaboration. For the development of *Roboquedo*, all the principles of Preece, Rogers and Sharp [6] and Chiasson and Gutwin [5] were followed.

3 Research Steps

The steps for the development of this artifact followed the steps stipulated in the Interaction Design process by Preece [6]: a) Identify needs and establish requirements; b) Develop alternative designs; c) Build interactive versions; d) Evaluate designs.

At first, as already explained in Sect. 1 of this article, the research context was established, and with this definition, the requirements for *Roboquedo* were listed, among them:

1. Data entry must be done through a tangible medium and a digital device;
2. The turtle robot must obey the commands given in the input and data medium;
3. The turtle robot must follow the direction (right – left) indicated by the user;
4. The turtle robot must walk for 5 s with each move request;
5. The displacement time of the turtle robot must be possible to change;
6. The turtle robot should work via Bluetooth;
7. The map must contain a route with beginning, proposed activities and end.

Thus, with the set of requirements, alternative *Roboquedo* designs were built, as shown in Fig. 1.

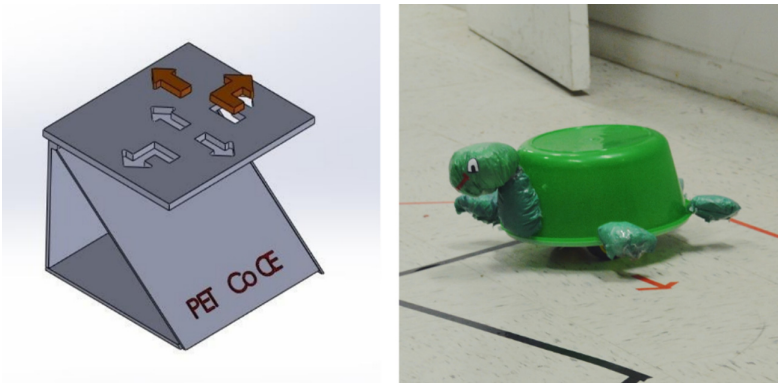

Fig. 1. Alternative designs for the table and the robot.

In the third step of the Interaction Design process, interactive versions were built, both tangible and digital, as presented in detail in Sect. 4 of this article. The fourth step "Evaluate Design" involved an assessment of the artifact, carried out by the team itself,

regarding compliance, safety and resistance. This evaluation followed the NBR NM 300-1, which has existed since 2004 in Brazil [2]. In this evaluation it was understood that the *Roboquedo* meets the following topics: does not have sharp edges, has non-toxic paint and responded smoothly to the drop and throw test.

Since the beginning of the project, four versions of *Roboquedo* have been created and since improved, following the principles of Interaction Design [3, 6] and the characteristics of low cost, usability and compliance with safety standards [2]. It is worth noting that *Roboquedo* was presented at public events for children, teachers and family members, as a demonstration, but they have not yet been held based on interaction with the intended audience. This step will be carried out in the future and will have all the necessary care.

4 The Roboquedo

As already mentioned, *Roboquedo* was developed with the intention of inserting logical reasoning and the introduction of programming teaching in early childhood education in a practical and ludic way [1, 9]. It consists of the following elements: a turtle-shaped robot, a physical map for suggesting robot activities, and two forms of directional control of the robot, one tangible (acrylic table with arrows to indicate directions to the robot), and one through a mobile device (software to indicate directions to the robot).

The ludic objective of the artifact is to make the turtle robot scroll through the map either through the tangible interface or through the mobile device. To start the activity, the turtle robot must be positioned at the beginning of the map; the child, or the group of children, (via the mobile device or the table) indicates the sequence of directions that he wants the artifact to make on the map. Then, the robot moves to a certain "stage" of the map, which has a written action to be performed by the children. The dynamics are repeated until the robot covers the entire path. This activity promotes the exploration of concepts such as: commands, data input, processing and laterality, and in addition, collaboration/cooperation concepts can be worked on.

The next subsections present the details of each element of *Roboquedo.*

4.1 Turtle Robot

The turtle-shaped robot consists of an Arduino board, two motors, a controller board for the motors and a Bluetooth module, in addition to three wheels and an internal acrylic structure to receive the components.

Through the Bluetooth module, the Arduino receives commands: go forward, backward, turn left or turn right, from the table (tangible interface) or from the mobile device, and start the motors by means of the controller board according to the command. In each command the motors move for a predefined time for each action. With each command, the *Roboquedo* moves for 5 s, however, such speed conditions can be regulated according to the target audience.

These technical characteristics support the Consistency principle [6], through the movements performed from the commands requested on the input devices. The turtle shape of the carcass, made on a 3D printer, has its design inspired by a platform game

known to children, as can be seen in Fig. 2. As its appearance is reminiscent of a toy, the robot stimulates the presence of the Imagination principle [3, 9]. It is also possible to emphasize the presence of Tangibility [3] since there is also physical interaction of children with the robot.

Fig. 2. The turtle robot.

4.2 Map

The map on which the actions of the turtle robot are developed is a square physical "mat" with 2.5 m on its side, positioned on the floor for the robot to follow the indicated path through the control interfaces (table and application). Figure 3 shows the design of this map/carpet (a) and the carpet in use (b).

Fig. 3. Carpet-shaped map for developing the actions of the turtle robot.

It is possible to observe that the map presents "stages" and that in each one it is proposed, in simple language and presentation, according to the principle of Literacy

[4], an action to be performed by the children. Among them we have list animal names, dance, make the turtle spin and position the turtle in the lake. When going through all the stages (there are 12 in total) the turtle must reach the final stage, which is the arrival at its home.

The map clearly shows the beginning and end of the game, as well as what is the path to be taken from one point to another, taking into account the principle of Consistency and Visibility [6]. The actions taken by the children in each stage are related, in a ludic way, to the shape of the robot's turtle, according to the Imagination principle [3, 9]. In the controls, in each stage, there is the stimulus for physical movements performed only by the children (dancing) or performed by the children using the robot (placing the robot on the lake, on the map) thus promoting the principles of Tangibility and Motivation and Engagement [3]. Tangible interactions encourage Collaboration [3] and, as a result, stimulate children's communication "increasing the degree to which children have to externalize their thoughts, increasing their awareness of the experience" [7], also encouraging the principle of Social Interaction [3]. The turtle performs on the map the requested action on the data input device, presenting the principle of Feedback and Guidance [3, 6].

4.3 Mobile Device Interface

One of the forms of directional control of the robot is an application for mobile device. This application is based on the use of Bluetooth technology through an Arduino board. The interface of the mobile device consists of buttons in the shape of arrows. Each arrow or button pressed will indicate the direction the robot should take on the map/mat. Figure 4 shows the interface of the mobile device with this arrow control.

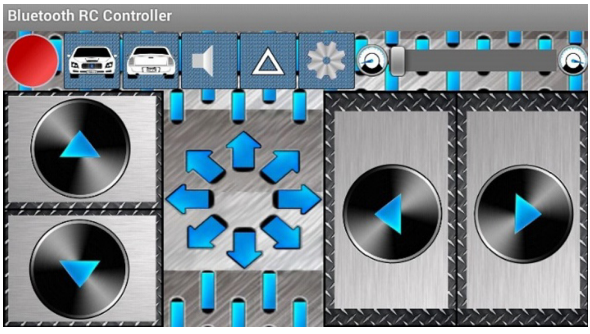

Fig. 4. Application interface for turtle robot control.

The interface presents the Affordance principle [6] through the application of the directional arrow metaphor, which indicate the position of the robot on the map. The robot performs the action defined by the selected arrow immediately, considering the principles of Feedback and Guidance [3, 6]. These technical characteristics support the actions of the robot, promoting the principles of Literacy and Mental Development [3], that is, a visual interface, without predominance of texts and with metaphors (drawing

the arrows representing its actions) to aid the robot's navigation on the map. In this way it is possible to combine such interactions with the preliminary concepts of teaching programming (command, command sequence, processing, data entry and exit) and rules in ludic education [9].

4.4 Tangible Interface

The table is made of acrylic with rounded corners (Fig. 5), respecting safety standards [2]. The transparent material was chosen on purpose to awaken in children an interest in the functioning of the internal components of the device.

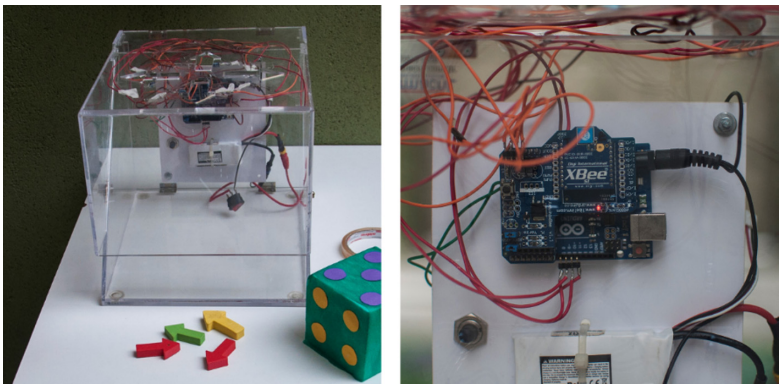

Fig. 5. Table interface for the turtle robot control.

The table meets the principles of Tangibility, Literacy and Mental Development [3], offering children physical interaction with the arrows referring to the directions chosen during the route on the map. The acrylic structure provides as inputs only the fittings in the shape of the arrows, in compliance with the principles of Motor Skills [3], Constraints and Visibility [6]. As in the map, the tangible interface promotes Collaboration [3, 7]. The arrow shape of the data input refers to the shape of plug-in toys, demonstrating the Imagination principle [3, 9].

5 Final Considerations and Next Steps

Robotics in education provides new experiences, perspectives, and a rich environment for individual and collective learning in the classroom [1]. When considering the introduction of programming concepts during early childhood education, it is essential to use principles of Interaction Design, combined with ludic education, to stimulate the interest of this audience [1].

When considering tangible, imaginable and interactive aspects [10], *Roboquedo* can be considered an option to address initial programming concepts such as commands, data entry, data processing and output, for an early childhood introduction to programming. Concepts present in Interaction Design [3, 6] are relevant allies to the area of

education, since the principles cover aspects for observation and improvement of the learning process with the aid of the artifact.

The *Roboquedo* is still under development, and one of the next steps to be followed is to analyze the current artifact and raise improvements and ideas for features, which can be added to *Roboquedo* to provide new forms of interaction. The team is already considering some ideas that consist of modifications both in hardware and software, such as the addition of a gyroscope and a spin counter in the engine to refine the robot's position on the map. Furthermore, the addition of speech recognition as a new command method is also being studied.

We expect as future actions, in the post-COVID19 pandemic period, to have interactions with children, family members and teachers. For this, the project will be submitted to a research ethics committee. In addition, we expect to make the entire contents of the *Roboquedo* project freely and openly available in a web repository, so that it is accessible to others who want to reuse this project. Another future objective is to carry out studies on accessibility and ergonomics of the artifact.

Acknowledgements. To Tutorial Education Program – Connections of Knowledge – Ministry of Education (MEC), Secretariat of Higher Education (SESu) and Secretariat of Continuing Education, Literacy and Diversity (SECAD).

References

1. Amaral, M.A., Sdroievski, N.M., de Oliveira, L.C., Castelini, P.: Sobre experiências, críticas e potenciais: computação física educacional e altas habilidades. In: Barbosa, R., Blikstein, P. (eds.) Robótica educacional: experiências inovadoras na educação brasileira, pp. 251–275. Penso, Porto Alegre (2020)
2. Associação Brasileira de Normas Técnicas. NBR NM 300-1: Segurança de Brinquedos (2004)
3. Chiasson, S., Gutwin, C.: Design principles for children's technology. Technical report HCI-TR-05-02, Saskatchewan Computer Science Department (2005)
4. Kazakoff, E.R., Sullivan, A., Bers, M.U.: The effect of a classroom-based intensive robotics and programming workshop on sequencing ability in early childhood. Early Childhood Educ. J. **41**(4), 245–255 (2013)
5. Leite, E.C.R., Ruiz, J.B., Ruiz, A.M.C., Aguiar, T.F.: O brinquedo na educação infantil: contribuições de Piaget, Vigotsky e Vallon. Akrópolis **13**(1), 13–21 (2005)
6. Preece, J., Rogers, Y., Sharp, H.: Interaction Design: Beyond Human-Computer Interaction. Wiley, Indianapolis (2011)
7. Price, S., Rogers, Y., Scaife, M., Stanton, D., Neale, H.: Using 'tangibles' to promote novel forms of playful learning. Interact. Comput. **15**(2), 169–185 (2003)
8. Rego, T.C.: Vygotsky: uma perspectiva histórico-cultural da educação, 25nd edn. Vozes, Petrópolis (2020)
9. Vigotski, L.S.: A formação social da mente, 7nd edn. Martins Fontes, São Paulo (2007)
10. Wang, D., Zhang, C., Wang, H.: T-Maze: a tangible programming tool for children. In: Proceedings of the 10th International Conference on Interaction Design and Children (IDC 2011), pp. 127–135. ACM, New York (2011)