Educational Game for Laterality Development in Early Childhood and the Importance of Participatory Design

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***Abstract*—The learning process in Early Childhood Education focuses on the development of children and their different forms of expression. Learning can be established by body language, because, by movement, the child establishes symbolic relationships, and constructs his thinking. So, in Early Childhood Education a dialogue with other areas of knowledge is necessary, seeking to provide an immersion in various learning situations. In this context, the present work focuses on analyzing the development of a digital game in Scratch with the participation of students, which reflects paths and levels identified in Physical Education classes, aiming to develop laterality. The research is qualitative and used the scientific procedures of bibliographic research, participant observation, discursive textual analysis, and participatory design for the elaboration of the game. The subjects were children aged between four and six who are in Early Childhood Education. As a result, the digital game really became a strategy to assist in the development of laterality of children, as it enhanced the appropriation of psycho-motor schemes related to spatial and temporal orientation.**

Keywords—Early Childhood Education, Laterality, Educational Game, Participatory Design.

I. INTRODUCTION

When we consider the Early Childhood Education in the Brazilian Common Curricular Base (BNCC) [1] and its defined fields of experience (live situations, experiences, and knowledge of the children), it became evident that the children's knowledge of their own body is highlighted, as it is explored and experienced by movements, playful activities, expressions, and games. This knowledge is acquired through the conscience of the whole body, and the mind - that cannot be separated from the body [2].

According to the National Curriculum Guidelines for Early Childhood Education [3], children's play and activities must be observed, recorded, and evaluated, as it is through play that they are able to express themselves, either through gestures, through the use of their bodies, through communication or feelings. In this sense, the school must provide a welcoming and warming environment so that the child can develop, organize, and plan their play activities. Still according to [4], in today's times, the child's cultural background is important, where the adult plays the role of mediator, and motivates the child to learn and understand the facts while respecting this background.

This work focuses on analyzing the development of laterality of Early Childhood Education students, gathering Physical Education and Informatics, through play and body expression, both developed in playful and challenging activities that combine theory and practice in different spaces, such as the classroom, computer labs, sports courts, and other school spaces. The concept of laterality is very important in this context, because, according to [5], "Laterality [...] represents the integrated and symbolically internalized awareness of both sides of the body, left and right side, which presupposes the notion of the midline of the body.". Body control is important, especially at school, as it is fundamental in the children's learning process, influencing adult life [6, 7, 8].

It worth notice that the students of Early Childhood Education who took part in this research are children who are in the age group of four to six years old. They participated in the planning, organization, data collection, and validation, as well as constant interaction with the researchers involved in the research [9]. For that, methodological procedures related to the age group of the public in question [9] were used, such as drawings, photos, and footage, always respecting the reality and the children's experience. During the research, their behavior was observed when they were in informal conversations with educators and with the other children, with participant observation, and with open interviews.

Through qualitative data analysis, together with the bibliographic research, a game was built, which was analyzed in order to verify whether or not it could contribute to the development of laterality in early childhood students. For the development of the game, the participatory design was used [10, 11]. It should be noted that, this type of experience design can arise due to the needs of students, regardless of the area, thus enriching the development of works and activities and always valuing the interactivity between those involved [12]. In addition, as highlighted in [13], the children's participation in the game design allows for the development of skills linked

to creative and critical thinking, communication, and problem-solving.

According to [14], when using participatory design, certain techniques can be chosen to develop products that provoke positive reactions in users, so that they feel at ease, comfortable, and that they enjoy the experience of using the product.

After some experiments on paper, students developed a digital game and used it in person and online. The game design was defined using different possible courses that represented levels of difficulty, which were established by the students themselves.

This paper presents, in section 2: the theoretical foundation of laterality and its contributions to children's learning. Section 3: describes the methodology used for the development of the research, and section 4: details the results obtained with the students' participation in the game project, addressing their perceptions when using it. Finally, section 5: describes some of the conclusions reached with the development of this work.

II. LATERALITY: REFLEXES IN CHILDREN'S LEARNING

The process of valuing Early Childhood Education is increasingly focusing on understanding the integral development of children and their different forms of expression, which reveal how they understand the reality around them. Having good motor control, they can explore the outside world, carrying out concrete experiments [15]. Thus, it has become a challenge and a necessity for schools, teachers, and the family to reflect on an appropriate and broad dialogue between Early Childhood Education and other areas of knowledge, with immersion in different learning situations [16].

According to Fernández [15], learning occurs through the relation between the organism, the body, intelligence, and the desire of knowledge. This learning involves different factors, whether they are concepts of space-time, postural, and gestural domain. The body becomes explored by discoveries and experiences of itself and with the world; and, therefore, the process is not simple, as it involves psychological, social, and biological factors, causing certain qualitative transformations [6].

Learning also takes place through body language [7], that is, through the body in movement, because in this way the child establishes symbolic relationships, thus building his thinking. Body language is the first to be developed in childhood, as movement is an important act to be performed by the child. "The wealth of possibilities of body language reveals a universe to be experienced, known, enjoyed" [8].

The conscience of their own body structure is the ability of the child and even the adult, under normal conditions, to recognize the existence of himself and his own body and differentiate it in relation to the environment. The body is related to movement, stimulating the knowledge of body parts as a sensory component of the nervous system, responsible for the perception of the occurrence of movement or rest. The development of the body's conscience occurs through stimuli, which can be carried out in a playful way, in the form of games, which play an important role in this process [1, 2].

Various skills, such as balance, notions of space and time, inside and outside, body structure, muscle tone, laterality, among others, are developed by movement, whether through dances, dramatizations, or games [17]. Thus, it is necessary, for its development process, to have a notion of right and left and to know how to situate itself in space and time, to constitute an integral body conscience [18].

Laterality can be related to a compass [19], as it is from there that the child and/or the adult are located in space and time, perceiving the direction in relation to themselves and others. [20] already starts from this same principle, stating that when the individual recognizes and is oriented both on the left and on the right, he/she manages to establish a relationship with the objects that are around him/her.

It is important that the child is stimulated bodily, especially about laterality, as a good acquisition of it enables learning, especially regarding the writing and orientation of letters and numbers (mirroring), enabling good body development. Both parents and the school must provide pleasant environments that encourage movement, so that the child explores the space and develops its potential [5, 21, 22], becoming aware of both sides of the body, both the left and the right.

The following section describes some aspects regarding the methodology used in the research and the construction of the digital game presented.

III. METHODOLOGICAL PROCEDURES

According to [23], this research is established between the Critical and Constructivist-Interpretive paradigms, mainly due to the relationship between researchers and the research context and the search to understand and explain a phenomenon. As already mentioned, the subjects of this research were children; and, therefore, it was necessary to use a methodology appropriate to this age group. Children can plan, organize, and analyze the data together with participating adults [9]. Therefore, the participant research, characterized by the involvement of the individuals participating in the research, was the most appropriate. Fig. 1 illustrates the steps that were part of the development and application/validation process of the proposed game.

For the development of this research, the participation of students was foreseen in the definition and elaboration of a digital game created in the Scratch software [24].

After performing various activities and games, in Physical Education classes, which stimulated laterality, students, through Participatory Design [10, 11, 25], developed a computer game, in which they performed movements with the direction arrows of the keyboard. The game aimed to analyze how students would move from concrete to abstract thinking.

Seeking to align the objectives of the research, the context of Early Childhood Education, and the subjects, we opted for a design approach in the etymological sense [26]: “The verb '*designare*' can be translated as 'determining', but it means more or less: 'to demonstrate'. What is determined is fixed. The design transforms the vague into determined through progressive differentiation. Design (*designatio*) is understood in a general and abstract way. Determination through the presentation. The science of design corresponds to the science of determination.”. In addition, as for the design stages, it is important to understand it beyond an object and its aesthetics [27]. For [27], the state "design of environments and systems" means a human system, the integration between information,

physical artifacts, and interactions in living, working, leisure and learning environments.

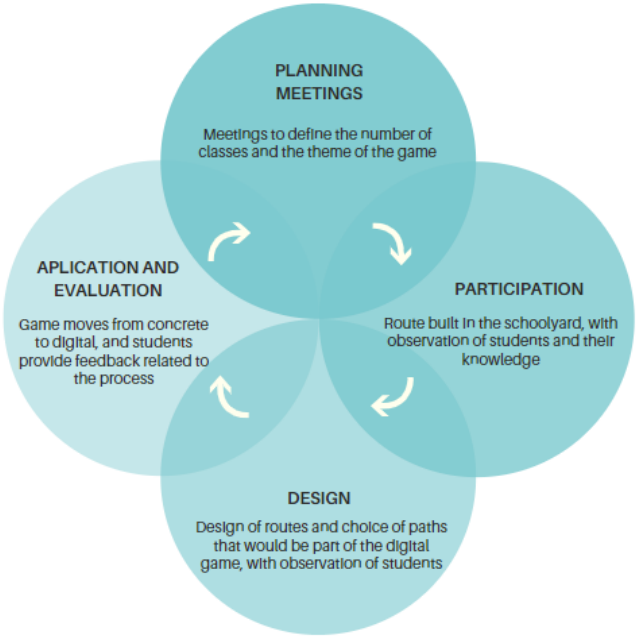

Fig. 1. Game development process

With the intention of involving students in the construction of the game, it was decided to use the participate designing process, which implies the effective participation of students in the whole process. According to [14], the participatory design addresses spontaneity, the discussion of better solutions for the product to be built, and the collaboration between users, always with more effective learning.

To explain the qualitative analysis of the research, open interviews and observations with the children were used, through photos, drawings, and video recording. In the view of [9], “there is a need to cross speech or group dialogues with drawings, with photographs… the recording of their activities can favor the expansion and relativization of our adult point of view”. The systematic, critical, and creative observation of children, of games and interactions, as well as the recording made by children and adults (drawings, photographs, reports) made throughout the process at various times, are indispensable conditions to understand how the child appropriates the ways of acting, feeling and thinking culturally.

Qualitative research of discursive textual analysis "has been shown to be especially useful in studies in which analysis approaches require referrals that are located between solutions proposed by content analysis and discourse analysis" [28]. This analysis can be performed through photos, videos, drawings, among other graphic and visual expressions produced by students. It is observed that it is the researcher who defines which is the best instrument to carry out the analysis.

As previously mentioned, this research is aimed at students of Early Childhood Education aged between four and six years. It was carried out with two classes with approximately 20 students in each one. The definition of the digital game was carried out by the educators and students of these classes, through drawings and discussions [10, 11].

The students participating in the research were observed by the researchers during the Informatics and Physical Education classes. The children demonstrated their knowledge through their verbalizations, actions, and drawings. Observations took place once a week, lasting 50 minutes during ten meetings for each class.

The next section presents the process that was used to build the game and indicates how early childhood students were involved during the process.

IV. Results and Discussions

As previously described, the digital game, developed with Scratch software, focused on analyzing how students would move from concrete to abstract thinking. The game features courses that involve the directions used in Physical Education classes (forward, backward, right, and left).

The students were divided into two spaces. At the first moment of the class, they stayed in the computer lab and received some instructions from the teachers, such as, for example, that the Physical Education and Computer classes would be held together and that they would be called one by one to take a course. The details of the activity were addressed in the space where it took place. Meanwhile, students used iPads and computers to explore games related to the notions of laterality, such as mazes. Secondly, in the chosen space, the teachers prepared a course (a path made with ropes) that they should take in whatever way they thought was best - walking, jumping, or running. It is observed that the route (Fig. 2) has orientations from different directions, such as walking forward, left, and right. The route was traced on the ground, using a rope and objects available at school, and its construction included the participation of children.

Fig. 2. Example of the route in the Physical Education class

The orientation was that they should make the route in the following way: the beginning was identified by the orange object, and the end, by a red object. After the execution, the Physical Education teacher asked them to raise their right hand and then their left hand. The beginning and the end were carried out without any problems since all the students who took the course managed to start in orange and end in red. Regarding the identification of the right hand and the left hand, some raised it correctly, others did not know which hand was the correct one, and one was in doubt. Thus, in subsequent classes, the Physical Education teacher performed activities and games to reinforce the body's spatial notions, such as forward, backward, to the right, to the left, under, over, in and out, with the two participating classes.

It should be noted that the students of Early Childhood Education went through several challenges related to the body

to later use the game. The game definition steps are shown below:

- The students from both classes drew the paths of the digital game; and, subsequently, there was a vote to choose the courses that would be part of the game.
- In addition to the routes, they choose the characters that would be included in the game (a dog and a dog bowl).
- The technology teacher coded the game for students to play it.
- Finally, the students played the digital game and used the same directions already used in physical education classes - forward, backward, to the right and to the left.

To design the game, students were organized into four groups, and it was explained to them that the teacher would create a digital game for them, making it clear that they would also be part of this process. Thus, they began to reflect on which routes would be covered and which character would be used in the game. Then, the students chose a dog as the main character, who should follow the path defined by the game to feed. The choice for this character is due to the fact that the students were reading the book "The Umbrella" (written and illustrated by Dieter Schubert and Ingrid Schubert), whose story has as main focus a dog that finds a red umbrella and is taken on a journey of many adventures and emotions.

After these definitions with the students, the teachers drew an example route (Fig. 3), where they included the chosen character, the feed bowl at the end, and some obstacles in the middle of the route, which should be overcome by the dog.

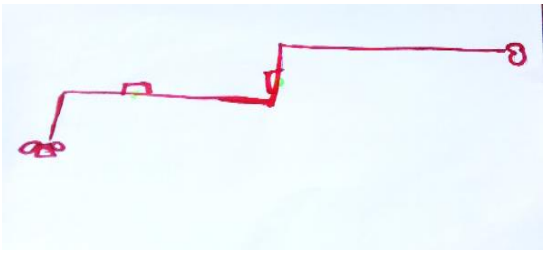

Fig. 3. Example path: created by the teachers

The researchers handed out a sheet and a marker pen to each child, and each drew the route that they found interesting for the dog to follow until it found the food. This activity was based on the theory of [29], aligned with other proposals [10, 11, 25] which affirm that it is important to use prototyping and to design several times what the user wants, either in the programming part or for an object. The same authors argue that techniques such as brainstorming, drawing, and prototyping on paper can be used to design with children [10, 11]. Regardless of how the interactive product looks, it is important to have drafts, prototypes, and models in order to understand the user's desire well, in addition to understanding "why" and "how" the product will be designed [29].

After the design of all the courses, these were shown to the students, who chose the drawings, called Level 1, Level 2, Level 3, Level 4, Level 5, Level 6, and Level 7, as shown in Figures 4 to 10. These levels were part of the game that was created in Scratch, where, at each level, the child moves to the next one, which is more difficult than the previous one, and so on until reaching the last level.

The children chose the path illustrated by Fig. 4 as Level 1 because it presents an easier path to be taken and without major variations in direction. They also claimed that it would take less time to travel.

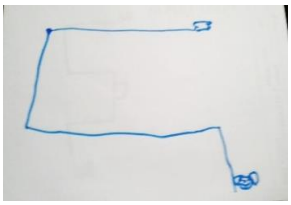

Fig. 4. Level 1

It is noteworthy that the participating children had not yet appropriated the concepts of proportion; so, for them, the time to travel the route was not related to the distance itself, but to the number of times the directions of the path to be traveled by the dog changed.

The path illustrated by Fig. 5 was chosen as Level 2 because it has a vertical path, different from the first and with greater variation of directions, in addition to containing two more stretches than the previous one.

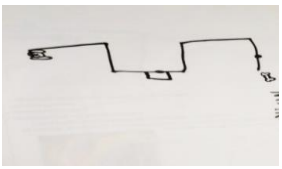

Fig. 5. Level 2

Level 3, as shown in Fig. 6, is much more complex than the previous levels. The children reported that it would be more difficult to walk because it is bigger and has more movements in different directions.

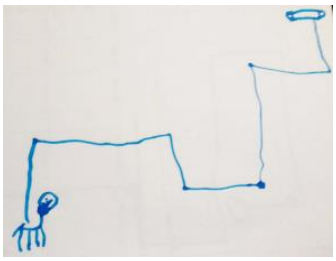

Fig. 6. Level 3

Level 4 (Fig. 7) created a discussion among students, as some thought that it would be the most difficult level, as it presents the great variation in direction and displacement; but, after several conversations, it ended up being the chosen route. The children thought about placing obstacles, represented by points in the drawing, but then they found it better to remove them, as this level of the game already had a long way to go.

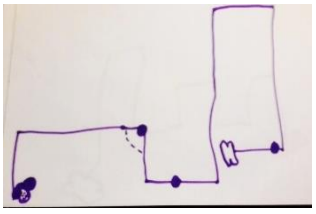

Fig. 7. Level 4

The route illustrated by Fig. 8 was chosen as Level 5, as it presented less difficulty in moving, but more movements in several directions than the other two remaining levels.

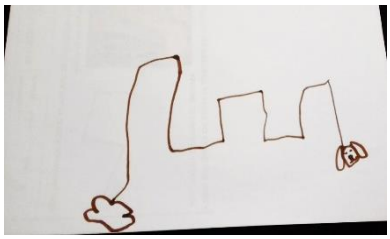

Fig. 8. Level 5

Level 6 (Fig. 9) also has a vertical path, like Level 2. However, it has a wide variety of directions and is an extensive path, as argued by the students participating in the research.

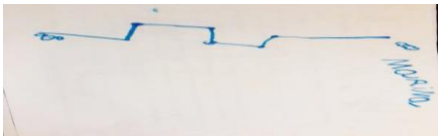

Fig. 9. Level 6

Level 7 (Fig. 10) created controversy together with Level 4, as students considered both difficult. It presents various displacement and with a change of direction along the route.

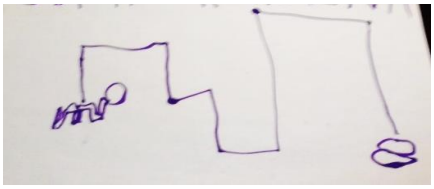

Fig. 10. Level 7

Another aspect that needs to be considered, in relation to the diagrams in Figures 3 to 9, is that: the course, the character (dog), and the bone/feed bowl drawn at the end of the path are all authorial elements of the students.

According to [14], there are three motivations that are necessary for participatory design: the participation of the user in the development of the project; the identification and documentation, at the beginning of the project, of the user experience goals and specific usability; the interaction between the user and the programmer. Thus, the entire process of elaborating the digital game was carried out. The children talked to the educators about their ideas of how the dog's path to the feed bowl should be drawn, as shown by the first motivation of participation design; then, they designed the courses, leaving the game documentation registered, following the second motivation; and, finally, they showed their drawings to the teachers, explaining how it would be the best way to turn them into games, as well as establishing the third motivation of participatory design.

It is important to note that it was essential to follow these motivations for participation design, as this influenced the decisions made in the game design. As stated in [30, 31, 32], it is through play that the child learns and has fun. In the case of this paper, it was decided to present the game levels using the graphic representations produced by the children, and not the digital game screens themselves, as it is believed that the greatest contribution of the work is precisely in the authorship and the demonstrated role by students during the process of creating the digital game.

In the computer lab, the two classes got to know the digital game and played it on computers. The students received the original drawings so that they could compare them with the game; and the children's reaction to seeing what they had planned was of the utmost importance. Several comments were said: “Look! It's my drawing!”, “Teacher, this is very easy”, “We could have made a game more difficult”, “Teacher, even the color of my drawing is the same”. It was noticed, by the students' speech, that they identified with the game and established relationships with what they had previously produced.

Regarding the results related to laterality, it should be noted that, of the 37 participating students, 35 managed to complete all the routes of the game, with no doubt about which movement they should perform. Fig. 11 outlines some of the paths taken by students in the digital game.

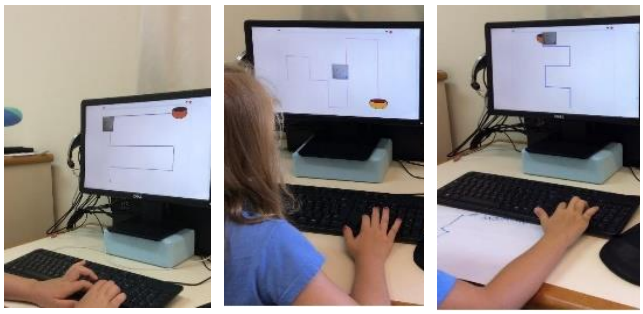

Fig. 11. Digital Game

For each stage of the game, all students were observed by the researchers, and videos were recorded during the stages. The duration of each activity depended on the pace of each student, the number of students, and the difficulties encountered, whether cognitive or motor.

The next section describes some conclusions obtained with the development of the game and with the observations made through the described methodological procedures.

V. Conclusions

As already described, the understanding of laterality is essential, as it is from there that the child and/or the adult are in space and time, perceiving the direction in relation to themselves and others. In this way, the integration between the Physical Education and Informatics disciplines allowed us to combine physical activities to develop laterality with a digital game. Initially, it was thought that teachers could build the game and then present it to students. However, as the research progressed, it was realized that student participation would be essential.

It is interesting to highlight some of the actions that this research provided to Early Childhood Education students: (i) exploring relationships and everyday practices using concrete elements; (ii) building associations and activities, as it is in childhood that the child begins to establish his first relationships and representations from the elements that surround him (people and objects); (iii) become familiar with the structure of the BNCC, through practices and experiences that favor the construction of meanings about themselves, the world around them and their peers.

The developed game served as a resource of pedagogical support for Physical Education classes, providing the development of laterality, body knowledge, learning through play, curiosity, and children's participation always. In addition, the authorship of the students in the activities developed was fundamental, because, when they saw the game for the first time, they realized the result of their productions, becoming protagonists of their learning processes.

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