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Using Design-Based Research in a computational thinking and programming course with Pedagogy students

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Abstract: In this paper we approach the importance of Design Based Research (DBR) as a tool for redesigning learning architectures in extension courses aimed at the continuing education of Basic Education teachers in order to improve professional learning and promote the development of Technology, Pedagogy and Content Knowledge (TPCK) and its subdomains. Therefore, we present a qualitative research carried out during an extension course on computational thinking and programming language aimed at future teachers who will work in the early years of Basic Education promoted by the Federal University of Alagoas (Brazil). The research results showed that the DBR made it possible to redesign the course activities in a collaborative way, observing the participants' difficulties, which led to the beginning of the development of the TPCK by the researched group, requiring that skills in computational thinking and programming language evolve to that TPCK is fully developed and manifested in pedagogical practices.

I. Introduction

The Common National Curriculum Base (2018), BNCC, a new guiding document for Brazilian Basic Education, places as one of its general competences the insertion of digital culture in schools, as well as citing the use of technologies in the specific competences of the different curriculum components, teaching and learning process. In the characterization of the area of Mathematics and its Technologies, BNCC recommends for Basic Education that topics such as robotics, automation, artificial intelligence, programming and digital games be addressed.

Although the BNCC brings these curricular innovations related to technology and its themes, there are other factors that directly influence the implementation of these proposals in Brazilian public schools, such as the lack of equipment and teaching resources and lack of teacher training to apply the proposal in your classes. This issue is basically due to the lack of more effective public policies in relation to the insertion of technology in public schools of Basic Education, which implies a huge investment and generally the justification is that the existing resources are not sufficient, and in view of that, little is invested, which does not generate large-scale effects. On the other hand, it is necessary to reflect on the didactic resources that are used in these technological proposals aimed at Education in Brazil. In general, we have few technological didactic resources for teaching programming language that are genuinely Brazilian, that is, that are developed for the profile of Brazilian students and teachers, and thus, adapted foreign didactic resources are used. Thus, it is necessary to invest in software development considering the characteristics of the student and Brazilian education, considering the assumptions of Design Based Research and Learning Sciences - areas that have not yet been consolidated in Brazil as a field of research - which are fundamental to contribute to improve the teaching-learning process of topics such as computational thinking and programming language. Therefore, in this paper we present the results of a research that addresses Design Based Research (DBR) as a tool for redesigning learning architectures in an extension course on computational thinking and programming language aimed at the continuing education of Basic Education teachers of the State of Alagoas, Brazil, to improve professional learning and promote the development of Technology, Pedagogy and Content Knowledge (TPCK) and its subdomains.

II. Preparing teachers to work with technology and the importance of Design Based Research in teacher training courses

It is important to plan the training of Basic Education teachers in Brazil to use technologies in the teaching-learning process and the digital skills and abilities that need to be developed so that they can implement educational proposals in the classroom. It is necessary that the curricula of the Pedagogy and Licentiate Degree courses expand the workload of the subjects focused on the use of technological resources, deepening their approach in order to train teachers on the use of different resources even in their initial teacher training, as in general, in Brazil there is little emphasis on this aspect, and this is reflected in teaching practices. In general, the use of technological resources in the teaching-learning process has been emphasized in continuing education courses or refresher courses, which are often opportunities for many teachers to learn how to handle the resources, as many teachers were unable to develop handling skills when they were attending graduation (due to the short time that the courses devoted to practices with these resources) or they graduated at a time when these resources

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did not exist or were not yet used in the teaching-learning process of public Basic Education schools, therefore, there was no in his initial formation a discipline that addressed technologies in Education.

BNCC (Brasil, 2018) has ten general competencies as pillars to ensure the learning and development of Brazilian students in Basic Education. Among these ten general competences is general competence 5, which concerns digital culture, which is structured around three basic elements: digital literacy, digital literacy and digital fluency. This competency must be developed so that Brazilian students can understand and use digital information and communication technologies in a critical, reflective and ethical way in various social practices to communicate, access and disseminate information, produce knowledge, solve problems and exercise protagonism. However, the insertion of digital culture in the Brazilian school context is not only aimed at students, it also encompasses teachers. The BNCC (Brasil, 2018, p. 17) states that Brazilian teachers should be encouraged to "select, produce, apply and evaluate didactic and technological resources to support the teaching and learning process", integrating technology in their classes, renewing their pedagogical practices, and, in this way, bringing them closer to technological contexts that are part of the daily lives of students.

In this sense, Mishra and Koehler (2006) proposed a theoretical framework called Technology, Pedagogy and Content Knowledge (TPCK) stating that teachers need an integrated knowledge of technology, pedagogy and content to develop professional skills that allow the adoption of activities oriented towards the use of technology in the teaching and learning process of specific content in classes. The authors subdivide the TPCK into three subdomains: knowledge of technology (TK), which concerns knowledge about how to use hardware, software and associated peripherals, knowledge of technology content (TCK) which refers to knowledge about how to use the technology to represent and create content in diverse ways and the knowledge of pedagogy and technology (TPK) which concerns the choice of a technological tool based on the aptitude for the learning activity.

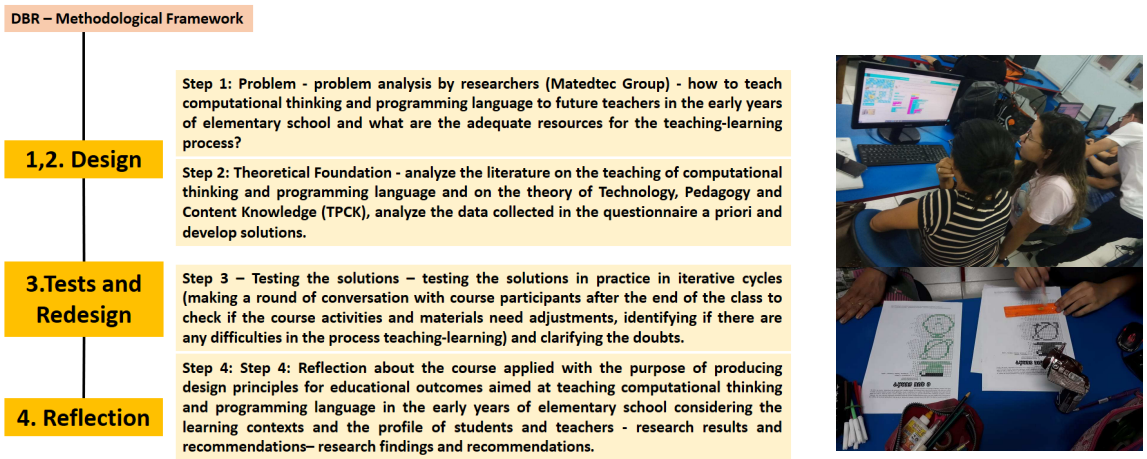
To improve the acquisition of integrated knowledge, Mishra and Koehler (2006) state that teachers must work collaboratively to redesign the curriculum for the TPCK approach, likewise breaking down beliefs and resistances regarding the use of technology in the classroom. Bennison and Goos (2010) also defend this integration with technology for teaching specific content through courses that enable the professional development of teachers, as they improve knowledge, understanding of the use of technological resources in classes and enhance skills. Drijvers (2015) emphasizes the importance of integrating the use of digital tools with activities that use pencil and paper (unplugged) in the teaching-learning process, demonstrating that these resources are complementary and not exclusive, and that neither one overlaps the other. Thus, considering the importance of computational thinking and programming language and its insertion in the early years of Basic Education in Brazil, we held an extension course with the purpose of improving professional learning and promoting the development of Technology, Pedagogy and Content Knowledge (TPCK) and its subdomains (with emphasis on TCK and TPK), enabling teachers in relation to computational thinking and programming language, and for that, we used Design Based Research to configure and redesign the extension course.

Design Based Research (DBR) is still little known and used in Brazil, being an approach that enables educational innovation from collaborative practices considering the needs and problems that teachers point out in their classrooms. There is disagreement regarding how to name the DBR, as there are authors such as Easterday, Lewis and Gerber (2014) who call it a process, Herrington *et al* (2007) claim that the DBR consists of a research approach and Barab and Squire (2004) argues that DBR consists of several approaches. Wang and Hannafin (2005) define Design Based Research as a systematic methodology and flexible aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings. We conclude that the DBR is an approach that implies a process of analysis, design (redesign), development and implementation, which is collaboratively built to trigger a pedagogical solution more suited to the characteristics of subjects and their contexts, contributing to the emergence of theories and design principles for the learning environments of schools, with the classroom being the most common and most used, which may extend to laboratories and maker spaces.

The themes of computational thinking and programming language in Brazilian public schools have always been addressed in a timely manner or through isolated projects, usually with few resources (lack of teaching material such as robotics kits, software, laboratories), but which promote a lot of engagement of the students in the proposed activities, stimulating their interest in participating in the classes. These themes are usually addressed in Mathematics classes because teachers are able to establish a direct relationship with the notions of logic. The computational thinking and programming language gained prominence after the publication of the BNCC (Brasil, 2018) when these themes were recommended to be developed in Basic Education. But, when placing computational thinking in the school context, it is necessary to remind teachers that they will design, apply the activities and select the didactic resources that will be used in pedagogical practices, and for that, teachers must develop skills to deal with the technological resources and also with the concepts that involve computational thinking. This contact with computational thinking should still occur in initial training, but if it

doesn't, continuing education is also a space for it to be developed along with the programming language. In this sense, considering the theoretical bases briefly exposed, we carried out a qualitative research with the purpose of contributing to the initial teacher education in relation to computational thinking and programming language, and for that, we raised the following research question: Which subdomains of TPCK the Will future teachers from the early years working in schools in Maceió (Brazil) be able to develop a course on programming language and computational thinking considering the contributions of DBR as an approach for setting up and redesigning the course based on the needs of the participants? To identify these TPCK subdomains that future teachers could develop, we designed and applied an extension course based on a cycle of DBR that we developed. This research qualitative was carried out during the month of August 2019 through an extension course that was a partnership between the Federal University of Alagoas and the Pedagogy course of a Private University in the city of Maceió, Alagoas, located in the Northeast region of Brazil. Below, we bring our cycle of DBR - Methodological Framework - developed for the extension course on computational thinking and programming language:

Figure 1 – Methodological Framework DBR Cycle (Lozada, 2019) and Extension Course classes on computational thinking and programming language



The DBR cycle that we developed allowed us to visualize the learning route for the development of the TPCK for future teachers and the movement of redesign and reflection on the activities developed for the course. In this cycle of DBR, we highlight the importance of the iterative process in which it was possible to make changes in course activities based on the needs of the participants.

The a priori questionnaire identified the profile of the course participants and the knowledge they had so that we could design the course adapting to their profile, and for that, we used Design Based Research (DBR), making previous tests of the activities that would be applied in the course and changes that were made throughout the application of the course with the collaboration of the participants. After critical and reflective analysis of the a priori questionnaire and cross-referencing with educational data, we designed the DBR cycle that we would go through to elaborate the activities that would be applied in the course, considering the technological infrastructure that public schools in Maceió had at the time the research was carried out, since most schools did not have technological resources and this aspect was essential for us to find an alternative so that future teachers (Pedagogy students) could develop computational thinking and programming language in their classes. The DBR cycle that we developed brings research into the problems and needs of teachers in Maceió, offering tools for improving teaching and for decisions in Education, especially those related to public policies for the implementation of technological resources in the teaching-learning process considering the real contexts of Maceió and its schools where teaching is offered. The course was taught in the computer lab and consisted of a theoretical and a practical part. The theoretical part addressed the fundamentals of computational thinking (decomposition, pattern recognition, abstraction and algorithm) and programming language (language by blocks and by script) for Basic Education and the practical part consisted of unplugged activities (with activities of pencil and paper) and plugged in (with programming activities using Scratch, Code and Kodable). Of the 30 enrolled in the course, 23 completed it.

III. Findings and Discussion

The survey data collection instruments were questionnaires (three questionnaires: a priori, intermediate and a posteriori) and activities (unplugged and plugged in). The a priori questionnaire indicated that 57.1% had already heard and read about the programming language and 33.3% had never heard the programming language. We

highlight some answers from the intermediate questionnaire: Regarding having had some difficulty with unplugged activities, 11.1% said they had no difficulty, but one of The activities in which they presented difficulties were in the pizza ordering algorithm activity, which involved mathematical calculations about the value of the pizza, and in the pizza delivery activity, which involved the calculation of the time spent in moving from one place to another. About understanding the notion of algorithm, 57.1% said they understood the notion of algorithm; about understanding the notion of programming logic, 66.7% said they could understand and 33.3% said they understood more or less. About understanding programming language types (by syntax and by blocks), 66.7% said that they understood the programming language by syntax and by blocks. About the game "Paper computer programming with the human robot" that was played in the University courtyard: 28.6% said they had difficulty understanding the commands, 14.3% said they had difficulty organizing the programming sequence, 23, 8% said they had difficulty understanding how it is performed (how the human being moves in the space given from the commands). Regarding learning objects, 52.4% considered the Kodable to be an easy level, about the Bee Code, 33.3% had no difficulties with the commands, 42.9% more or less understood the commands. Regarding Code Angry Birds, only 9.5% had difficulties in understanding the block commands and the sequence. About the a posteriori questionnaire, we highlight some questions and their answers: about the Scratch level, 78.3% considered it to be of average level and 56.5% managed to learn the commands, with 43.5% learned more or less the commands, what we had already seen during classes and conversation circles when they talked about the difficulties. About the commands with which they had the most difficulties, they pointed out the following: 30.4% with the sensor command, 26.1% with the variable command and 17.4% with the operator command.

From the results of the course, we were able to identify some aspects that are essential to reflect on teacher education in the Pedagogy course: the responses to the intermediate questionnaire, to the a posteriori questionnaire and the dialogue in the conversation circle during the iterative process of the DBR demonstrated that that group of students in the Pedagogy course had little ability to program and this is due to the lack of contact with the language of programming and computational thinking and basic notions of logic, in addition to not being able to associate the composition of an algorithm in a situation of the day daily life with a typical language of writing an algorithm with sequences and commands (formalization of the programming language); it was easy to identify errors in the execution of commands by the course participants, but they had some difficulty in correcting them, as the writing of the algorithm demands a logical sequence with specific commands that were often not fully understood by the participants. The lack of contact with digital learning objects for learning the programming language triggered the beginning of the development of knowledge of technology content (TCK) which refers to knowledge about how to use technology to represent and create content in different ways and the knowledge of pedagogy and technology (TPK) which concerns the choice of an aptitude-based technological tool for the learning activity. The evidence of these subdomains in the questionnaires and in the activities was evident when they showed improvement in the understanding of most of the commands and in the performance of the activities. This advance stems from the DBR cycle, with the iterative process that allowed Pedagogy students to present suggestions for changes and adjustments in activities and clarification of doubts, in a collaborative redesign movement, without harming the level of activities. Finally, we consider this work as a starting point for other actions that promote teacher training on computational thinking and programming language, recommending that this work is also carried out by the education departments in training processes that expand to schools during their working hours. collective pedagogical work (HTPC), as the development of the TPCK is an ongoing process.

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