CODING AS LITERACY: CASE STUDIES AT PRE-PRIMARY AND ELEMENTARY SCHOOL

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Abstract

This paper presents two case studies under development within project “KML II – Laboratory of technologies and learning of programming and robotics for pre-school and elementary school”. Using a multiple case study approach, KMLII is working with educators and elementary school teachers towards the development of learning activities that integrate computational thinking, coding and robotics with the curriculum. Participants are experimenting with both unplugged and plugged activities, including coding with ScratchJr and Scratch (only for elementary schools). Data is being collected from educators/teachers’ logs and through remote observation. Results from case studies will inform the development of a framework for the introduction of computational thinking, programming, and robotics in the training of undergraduate and in-service educators and elementary school teachers and the design of a competence profile for education professionals in these areas.

Keywords: Coding, Pre-School, Elementary School, Computational Thinking, Robotics.

1 INTRODUCTION

The present study focuses on the introduction of computational thinking, coding and robotics activities in both pre-school (3-5) and elementary school (6-10) (1st cycle of basic education - 1st CEB, in official terminology), within a cross-curricular approach. This project emerges in the context of public policies aiming to introduce coding in elementary education [1] and a previous research project dedicated to pre-school [2]. In both cases, pre and elementary school, approaches to computation, as well as other technological subjects, are considered from a cross-curricular perspective. Regulations frame technology teaching in initial years within a “globalizing dimension of education”, in which technology constitutes an instrumental component in the support of learning goals across the curriculum [3]. It also considers universal access and inclusion for all students [4] and equal opportunities [5]. Programming and robotics may offer hope for all children to achieve their full potential and effectively participate in a fully inclusive society.

Project “KML II - Programming technologies and learning laboratory for pre-school and elementary school in Portugal” was born in the context of a growing concern with the Portuguese education system’s response to the development of these competences. This concern emerges across different initiatives, namely: Iniciação à Programação no 1.º Ciclo do Ensino Básico[1], Programação e Robótica no Ensino Básico - Probótica[2], as well coding and robotics school clubs[3]. These initiatives have been developed by the Ministry of Education’s technologies team (ERTE-DGE)[4] and implemented through its competence centres for the integration of ICT in education[5], as well as by partnerships with universities.

Despite these, guidelines for the development of pedagogical practices that integrate coding with the curriculum are still required. While it is clear that, similarly to ICT [1], a cross-curricular approach applies, initiatives developed so far brought coding to school, but not primarily to classroom work. Rather, coding and robotics were mainly offered on a complementary basis. Furthermore, a consultation of grey literature [6]–[8] shows coding initiatives were implemented in very diverse ways,

[1] https://www.erte.dge.mec.pt/iniciacao-programacao-no-1o-ciclo-do-ensino-basico

[2] https://erte.dge.mec.pt/noticias/programacao-e-robotica-no-ensino-basico-probotica

[3] https://erte.dge.mec.pt/cpr-clubes

[4] https://erte.dge.mec.pt/

[5] https://www.erte.dge.mec.pt/centros-de-competencia-tic

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taking into account, notably, the different resources used. Executed with no allocation of specific resources, these initiatives rely on existing ones. This was particularly impactful regarding robotics, which, contrary to desktop computers, were not broadly available. Nonetheless, internet access problems are frequently reported[6].

Project's KML II main purpose is to address this gap, developing knowledge that informs the implementation of cross-curricular pedagogical practices that operationalize and provide adequate answers for the inclusion of all students. This research intends to study how to integrate programming and robotics in pre-schools, or kindergartens, and elementary schools, through a transversal intervention in all the areas of knowledge. This will allow the development of a research-based framework, able to support the formulation of a proposal of intervention extended to the Portuguese national context. For this project, a physical and a mobile laboratory were designed, equipped with tablets and robots, which facilitate, on one hand, the initial, postgraduate, and continuous training of teachers and, on the other hand, the accomplishment of several case studies throughout Portugal.

2 METHODOLOGY

Using a multiple case study approach [9], project KML II is working with 11 preschool educators and 17 primary school teachers, in 8 different Portuguese districts, towards the development of learning activities that integrate coding into the curriculum. The project delivered, in 2019, a national wide training action for in-service educators and primary school teachers [10], [11], focused on unplugged computational thinking, coding and robotics learning activities. Educators and teachers who completed the training and were interested in participating in case studies were selected based on the following criteria: being assigned as principal teacher/educator of a given class, having obtained permission to participate from headteachers and parents, commitment to implement activities integrated across the curriculum. An invitation letter was sent to interested participants and a compromise statement signed. Implementation was organized under three stages: 1) planning of at least three activities for each of the approaches considered, notably unplugged computational thinking, robotics and programming, according to each schools' and classroom's educational and curricular project; 2) implementation of at least three activities per school term; 3) collection of data.

During the 2019-20 school year, participants experimented with both plugged and unplugged activities, conceived and developed by educators and teachers, according to each schools' and classroom's educational project. For this period, data was collected through activity logs, fieldnotes, image and video records. Data was primarily collected through an online log of activities, registered by educators and teachers. An online form was provided, organized in four sections: introduction (presentation of the form and its objectives), description of activity (request of information describing the activity performed), evaluation of activity (request of information results and evaluation) and file sending (photos, videos and other supporting documents). The form was designed based on lesson planning templates, developed and used in the training action for in-service educators and primary school teachers delivered by KML II in 2019 [10]. The purpose of the activities' log was to allow the research team to follow the work and form a clear picture of its development.

Alongside this log, an online community was created with the purpose of providing a space where participants could share and discuss their practices. A Moodle instance was made available through the learning environment established for the training action. This community was structured in the following sections: news board, two generic forums (social and doubts), three thematic forums (computational thinking, coding and robotics), resource repository and moderator forum (exclusively for trainers, hidden for participants). However, after the first school trimester, it was complemented with two WhatsApp groups, as participants expressed the need for timely feedback, in the course of preparing, developing and evaluating activities.

Field observations conducted by the research team were planned to occur during last term of 2019-20 school year but delayed due to the interruption of school activities, in the context of COVID-19 pandemic. Observation of activities are now foreseen for 2020-21 school year, but dependent on conditions to be established. For each activity, researchers are expected to collect data on type of

[6] https://www.publico.pt/2020/01/17/sociedade/noticia/melhoria-internet-escolas-prioridade-faltam-equipamentos-professores-1900742

activity, methodologies and results, as well as apply the "PTD Engagement Checklist for Children" (figures 1 and 2)[7].

PTD checklist was developed by DevTech Research Group at Tufts University, (https://sites.tufts.edu/devtech/ptd/). Based on the PTD framework [12], it was designed for a variety of settings in which children engage with technologies. It presents six sections, each one dedicated to one behavior described in the framework and measured through a 5-point Likert scale. It may be used to observe a group of children's or an individual child's interaction with technologies, multiple times during a lesson or on a single occasion. To be implemented in this project, and after authors' permission, the checklist was translated to Portuguese, as presented below.

Comunicação	1 Nunca	2 Quase nunca	3 Ocasionalmente	4 Frequentemente	5 Sempre	N/A Não observável
As crianças observam e/ou envolvem-se com o trabalho umas das outras - As crianças observam enquanto outras trabalham num projeto - As crianças expressam-se através dos seus projetos - As crianças tocam ou brincam com os projetos umas das outras enquanto trabalham						
As crianças brincam e falam umas com as outras - As crianças falam ou fazem sinais umas às outras - As crianças perguntam umas às outras o que estão a fazer, pedem que lhes passem utensílios, etc. - As crianças partilham ideias umas com as outras						
As crianças conversam, de forma verbal ou não-verbal, com os adultos - As crianças conversam, acenam com a cabeça, etc. quando os adultos param para as deixar responder						
Comentários:						
Colaboração	**1 Nunca**	**2 Quase nunca**	**3 Ocasionalmente**	**4 Frequentemente**	**5 Sempre**	**N/A Não observável**
As crianças partilham utensílios/materiais - As crianças usam os materiais e devolvem-nos quando terminam - As crianças não "acumulam" materiais que não estão a usar - Muitas crianças tocam e usam os mesmos materiais em simultâneo						
As crianças trabalham juntas num mesmo projeto ou objetivo - As crianças estão ativamente envolvidas na mesma brincadeira/trabalho - As crianças adicionam elementos ao mesmo projeto - As crianças assumem diferentes papéis enquanto trabalham em conjunto						
O facilitador convida as crianças a trabalhar em conjunto - O facilitador sugere que as crianças procurem ajuda junto dos seus pares						
Comentários:						
Construção de comunidade	**1 Nunca**	**2 Quase nunca**	**3 Ocasionalmente**	**4 Frequentemente**	**5 Sempre**	**N/A Não observável**
As crianças partilham trabalho com outros - As crianças mostram o trabalho aos pares, aos membros da comunidade ou aos facilitadores - As crianças exibem o seu trabalho algures no espaço (ou pedem/autorizam o facilitador para o fazer)						
As crianças trabalham em projetos relacionados com o seu meio local -As crianças usam tecnologia em projetos que se relacionam com a sua escola, casa ou meio local - As crianças leem livros, colocam questões, ou representam festividades locais, eventos ou localidades -As crianças criam projetos que ajudam outros						
As crianças são afáveis e amistosas umas com as outras - As crianças perguntam umas às outras sobre a família ou falam sobre outros detalhes pessoais (ex.: "vi a tua irmã no corredor") - As crianças riem e brincam juntas						
Comentários:						

Fig. 1. PTD Engagement Checklist for Children translation to Portuguese - part 1

[7] PTD Engagement Checklist for Children is licensed under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License. To view a copy of this license, visit http://creativecommons.org/licenses/by-nc-nd/4.0/.

Criação de conteúdo	1 Nunca	2 Quase nunca	3 Ocasionalmente	4 Frequentemente	5 Sempre	N/A Não observável
As crianças vão buscar ferramentas e materiais sem grande necessidade de ajuda - As crianças pegam em materiais ou ligam os computadores sem necessidade de ajuda - As crianças abrem caixas ou trazem ferramentas de forma autónoma - As crianças usam a tecnologia como se estivessem no recreio (orientado pelas crianças, de forma aberta) em vez de numa cerca para bebés (orientada pelo adulto e de forma fechada)						
Há locais no espaço para apresentar ou documentar o trabalho das crianças - Existem imagens e explicações do seu trabalho - Existe um espaço para permanência de trabalho em curso						
O facilitador modela a criação de conteúdo - O facilitador trabalha em projetos juntamente com as crianças, ou ajuda quando solicitado - O facilitador partilha os seus erros abertamente e modela como lidar com eles - O facilitador encoraja as crianças a focarem-se mais no processo do que no produto do seu trabalho						
Comentários:						
Criatividade	**1 Nunca**	**2 Quase nunca**	**3 Ocasionalmente**	**4 Frequentemente**	**5 Sempre**	**N/A Não observável**
As crianças observam, tocam ou manipulam os objetos no espaço - As crianças passam os dedos sobre uma almofada macia ou seguram contas de vidro contra a luz - As crianças fazem comentários sobre as propriedades de um objeto (ex.: “esta madeira é áspera”)						
As crianças usam vários materiais enquanto trabalham num único projeto - As crianças usam arames, brilhantes e pano numa colagem - As crianças misturam materiais de diferentes áreas (ex: blocos com objetos que resultam de trabalhos manuais)						
As crianças experimentam diferentes abordagens numa mesma tarefa - As crianças experimentam fita cola, clipes e pistolas de cola quente para prender papel - As crianças tentam construir uma torre numa mesa, numa cadeira e numa almofada						
Comentários:						
Escolhas de conduta	**1 Nunca**	**2 Quase nunca**	**3 Ocasionalmente**	**4 Frequentemente**	**5 Sempre**	**N/A Não observável**
As crianças manipulam ferramentas/materiais com cuidado - As crianças seguram/usam tesouras, vidro, etc. com cuidado - As crianças devolvem os utensílios perigosos de maneira segura depois de os utilizarem						
As crianças revelam respeito pelo espaço - As crianças limpam os materiais após acabarem de trabalhar - As crianças correm riscos, mas usam o mobiliário, a tecnologia, etc. de formas seguras						
As crianças respeitam-se mutuamente - As crianças revezam-se, partilham materiais e dão espaço umas às outras - As crianças mostram sinais de caráter (ex.: abraçar alguém que está a chorar, ajudar alguém a arrumar)						
Comentários:						

Fig. 2. PTD Engagement Checklist for Children translation to Portuguese - part 2

Considering regulatory guidelines already issued by Portugal's Ministry of Education[8], it is likely researchers will not be allowed to visit fieldsites. In this case, we foresee a remote fieldwork approach [13], based on remote observations and focus group techniques. Observations are still in preparation and dependent on the toolkit to be arranged. Nonetheless, considering the possibility of using smartphones, we would expect to collect a series of field events [14] and, in the context of focus groups, discuss a sample of events with participants, including children. The PTD checklist will be applied with field events and results triangulated [15] with data from focus groups. Another possibility to be considered it to use smartphones to involves children in data collection, using camera or voice recording app to take photos, make videos or voice memos about their everyday practices.

The concept of field event emerged within internet studies with the purpose of redefining fieldsites, in light of the fluidity of geographical and temporal boundaries brought by digital technologies [14]. As such, it proposes to "understanding the field as a collection of 'events' that are "co-created within specific practices" (p. 4), by researchers, study participants, and ICTs. Hence, its aim is to clarify the role of ICTs in fieldwork, in contrast with considering that devices and platforms are communication tools that facilitate contact without influencing it, mirroring fieldwork in a digital context.

[8] https://www.dgeste.mec.pt/wp-content/uploads/2020/07/Orientacoes-DGESTE_DGE_DGS-20_21.pdf

Each participant received one kit of robots and rotational access to tablets[9]. Tablets[10] were previously configured with anonymized email accounts and apps installed (ScratchJr[11], robot apps). According to previous training completed by participants, pre-school educators were expected to work with ScratchJr and primary school teachers also with Scratch[12]. Both are free programming languages and platforms developed specifically for children, but while Scratch demands reading and writing skills, ScratchJr was adapted for non-literate children, based on visual codes. Nonetheless, ScratchJr is considered suitable for an initiation to coding with Scratch. Scratch project further includes an active and disseminated[13] online community, where users may access, share and remix projects.

Robots were made available in the context of a sponsorship[14] and kits were composed as described below.

Preschools: two units of COKO, tangible blocks-based programable robot[15] (figure 3); two units of DOC[16], programable through direction and action buttons (figure 3).

Elementary schools: two units of DOC; one unit of MIND[17] - programmable with buttons, a blocks-based interface (app), includes voice modulator and a pen for drawing; one unit of RoboMaker Start, assembling robot with blocks-based interface (app); one unit of Cyber Talk[18], assembling robot, with voice modulator and blocks-based interface (app).

Fig. 3. Tangible blocks and directions/actions buttons

Fig. 4. Blocks based programming interfaces

For the present study, which focuses on coding's integration with school curriculum, and considering previous research [16], robots are differentiated based on programming interfaces, notably: tangible blocks-based robots, visual blocks screen-based robots, button-controlled robots. While other categorizations are mentioned in the literature [17], this typology focuses on two central aspects: how children engage with robots and how this engagement promotes learning. In this regard, an interesting

9 The project had limited availability of tablets, having created a request system with the support of regional partners, who kept tablets made available by the project and managed requests. Whenever possible, partners and participants took initiative to access resources elsewhere, notably school clusters, municipalities or others.

10 SPC TABLET GRAVITY 10.1" QUADCORE IPS 4G 2GB 16GB, Android

11 https://www.scratchjr.org/

12 https://scratch.mit.edu/

13 https://scratch.mit.edu/statistics/

14 The project is supported by Clementoni, https://www.clementoni.com/en/

15 https://www.clementoni.com/pt-en/67604-coko-o-meu-primeiro-robo/

16 https://www.clementoni.com/pt-en/67285-doc-robo-educativo-falante/

17 https://www.clementoni.com/pt-en/67528-mind-designer/

18 https://www.clementoni.com/pt-en/67625-cyber-talk/

approach is also proposed by Gaudiello and Zibetti, considering three pedagogical paradigms: learning robotics, learning with robotics, and learning by robotics [18]. While the wide variety of robots, their distinct features, systems, functions, and interaction possibilities, makes a comprehensive classification hard to achieve, this framework broadly encompasses hardware, software and modes of interaction with robots.

3 EXPECTED RESULTS

The purpose of the case studies is to characterize how programming can be integrated into pre and elementary education, across different areas of knowledge. Specifically, it aims to identify appropriate methodologies, distinguish factors that promote children's involvement and well-being and recognize necessary teaching skills. Data collected will be submitted to thematic analysis [19] with the purpose of identifying key themes and dimensions for the integration of these approaches in preschool and elementary school settings. Understanding and discussing these categories is expected to set out practical guidelines for pedagogical practice.

KML II further encompasses a survey of primary school teachers and educators training needs in technology, programming and robotics. A questionnaire with a representative national sample was designed and implemented to understand training needs in this area. Data from this survey is currently under analysis. In a second phase, data will be collected through focus groups with teachers and educators and triangulated with survey results. This work is developed by KML II project's partner University of Évora[19].

Triangulation of results from the study of training needs and case studies will inform the development of a framework for the integration of computational thinking, programming and robotics activities in the training of undergraduate, in-service educators and primary school teachers. Finally, results will inform the design of a profile of childhood educators and primary school teachers, as a mediator in the integration of learning programming and robotics in their educational contexts. Hence, this work is expected to have a positive impact at the national level in higher education teacher education degrees and, consequently, in the contexts of pre and primary school education.

Finally, together with an evaluation of the training action developed within this project [11], [20], results will inform the development of a Massive Open Online Course (MOOC) for initial and in-service training of professionals in this area. This product is expected to broaden the scope of the training and research undertaken, with a view to encompass a wide range of professionals from the Portuguese education network. This network currently includes 16.277 educators and 30.178 elementary school teachers (1st CEB), according to data from 2019[20]. This work is developed by KML II project's partner Open University[21].

4 CONCLUSIONS

This paper presented the context and methodological approach of the study of learning activities developed within project "KML II – Laboratory of technologies and learning of programming and robotics for preschool and primary school". KML II has two main objectives: (a) to propose a training framework for curricular units of educational technology, in the courses for teacher training in higher education and in-service training; b) to design a profile of the childhood educator and elementary school teacher as mediator in the integration of programming and robotics learning in educational contexts. Within this context, the work presented here will contribute to these goals by setting out guidelines for pedagogical practice in preschool and elementary school settings, as well as benchmark existing practices.

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[19] https://www.ciep.uevora.pt/

[20] PORDATA.Source: DGEEC/ME-MCTES. Latest update: 2020-06-30. https://www.pordata.pt/DB/Portugal/Ambiente+de+Consulta/Tabela.

[21] https://lead.uab.pt/

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