

Architecture, Design and Computer Science: Professional Training for Elementary School Teachers

Andréa Quadrado Mussi¹, Luisa Fernanda Nercolino Deon¹ and Amilton Rodrigo de Quadros Martins²

1. Postgraduate Program in Architecture and Urbanism (PPGARQ) of the Polytechnic School at Faculdade Meridional (IMED), Passo Fundo/RS, CEP 99070-220, Brazil

2. Laboratory of Education Science and Innovation, Faculdade Meridional (IMED), Passo Fundo/RS, CEP 99070-220, Brazil

Abstract: Studies show that contemporary teaching methodologies are based on skills and competences directed to different areas of professional practice, such as Architecture, Design and Computer Science. Collective learning spaces gain strength, stimulating the development of new skills by users. The Digital Manufacturing Laboratories (Fab Labs) and Makerspaces are entering the school environment and starting a movement for change in traditional education. Although they are seen as potential drivers for higher quality education, the lack of specific training for teachers in the face of new digital information and communication technologies, especially in basic education, becomes limiting in the development of new active methodologies. Thus, this study aimed to develop a training dynamic for basic education teachers, addressing the use of tools and equipment for digital manufacturing and prototyping, 2D and 3D modeling applications and software, and programming and electronics. The methodology consists of literature review, followed by the action research method with two workshops given through an online and synchronous platform. The importance of incorporating creative and innovative methodologies in education is understood, and above all, there is a dynamic, planned and effective structure, geared towards the orientation of teachers.

Key words: Digital fabrication, computational thinking, active learning, professional training.

1. Introduction

In recent years, technology has become one of the main communications and information tools, being increasingly present in the user's daily lives. These technological movements drive transformations in different contexts, scenarios and scales. In teaching environments, the use of new learning methodologies focusing mainly on 21st century skills and demands is being addressed through 2D and 3D modeling, digital fabrication and prototyping, programming and electronics with games, among other possibilities that develop critical thinking, innovation and the ability to solve problems in the practice of "learning by doing" or "learning from experiences".

Some studies indicate current teaching methodologies in development, or in some cases already implemented

in the basic school curriculum, are supported by skills and competences directed to different areas of professional practice, such as Architecture, Design and Computer Science. There is similarity of the activities inherent between the areas of study of Architecture and Design, with elementary school, such as, for example, the ability to create concepts and connections between spatial, geometric, functional elements and materials, through actions such as drawing, modeling, collage, spatial organization, among others, as shown in Fig. 1 [1].

The area of Computer Science can be observed in activities of reasoning, logic and programming, contemplating dynamics and activities in the mathematics and engineering subjects [2].

Playful activities focused on children's development, with the teacher as a knowledge mediator, can be observed since the 19th century, with the teaching approach of Friedrich Froebel [3]. The renowned

Corresponding author: Andréa Quadrado Mussi, professor, research fields: co-design, design process, and parametric design.

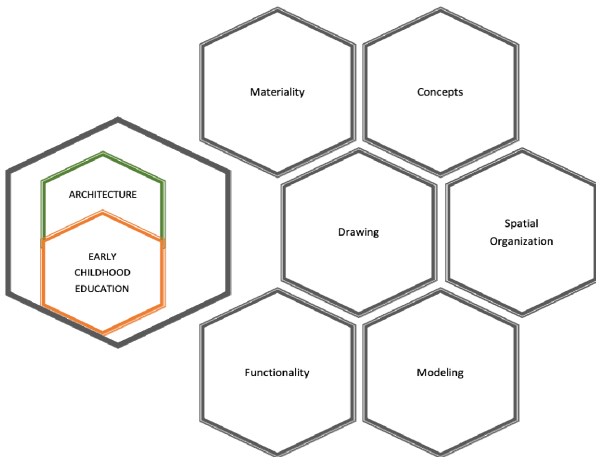


Fig. 1 Structure of the Codesign process.

Source: Authors (2020).

pedagogue did some work in the field of architecture, gained recognition as an educator, through the creation of his own teaching methodology, focused mainly on preschool. With a focus on “learning by doing”, Froebel appropriated the constructive relationships of geometry, color, dimension and nature, to make a set of educational materials called gifts (Fig. 2), subject to co-creation through manipulation, in which children could freely learn concepts in a practical way [1, 3].

Currently, the search for the child’s autonomy in

the learning process continues in motion. New tools, equipment and platforms have been added to school utensils traditionally present in the classroom. Materials such as colored pencils, crayons, scissors and glue, gain new allies in the construction of knowledge, with the use of smartphones, tablets, 3D pens, online games, software, applications, robotics and electronics kits, among others.

In addition, equipments such as 3D printers, laser cutting machines and CNC (Computer Numeric Control) milling machines, previously found only in large industries, are currently available to the population through collective spaces for learning and knowledge exchange. Fabrication Laboratory (Fab Labs) and Makerspaces, are nomenclatures that define such spaces, which enable the creation and manufacture of products with low-cost materials.

Based on the “DIY” (Do It Yourself) culture, the Maker Movement, gained strength with the popularization of digital manufacturing equipment, and became collaborative spaces in the search for the autonomy of creation, manufacture and modification of products, where different professionals and students

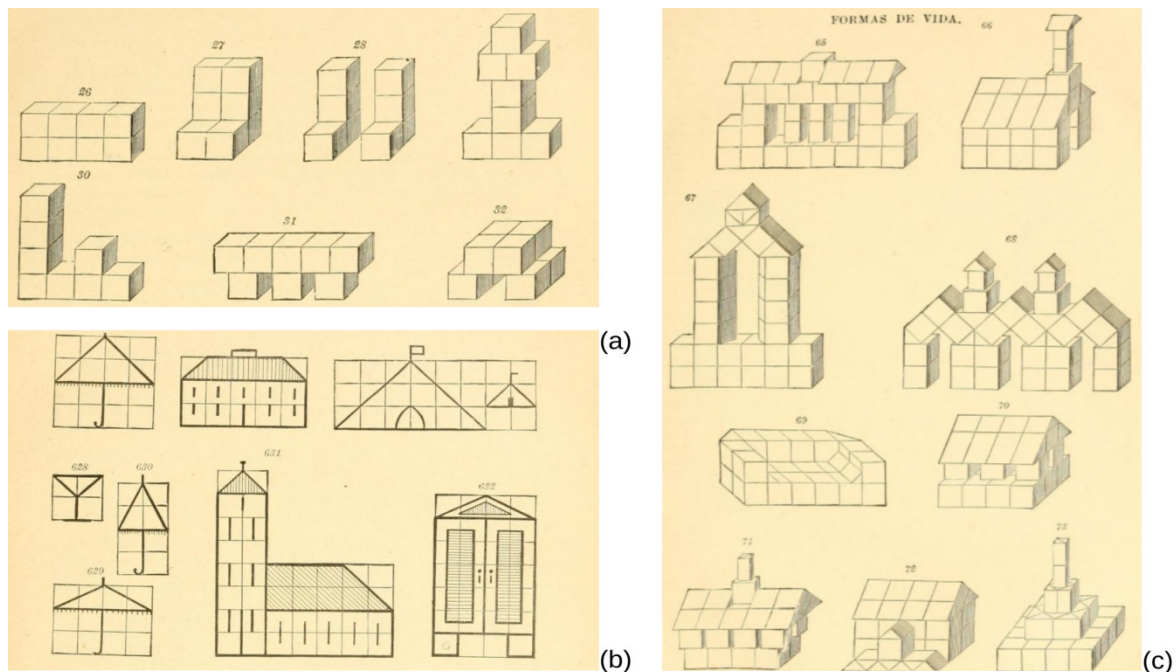


Fig. 2 Gifts: (a) initial representations with cubes; (b) forms relation between objects and buildings; (c) constructive relations made with the forms.

Source: Authors (2020).

can interact and exchange experiences [4, 5]. Likewise, Fab Labs promote learning through innovation and the creation of projects or products. They are prototyping spaces, structured with digital tools and equipment, which allow you to join or not a global network to share projects, research and knowledge with enthusiasts of the theme, through an online platform [6]. Although they follow different organizational views, Makerspace and Fab Labs promote integration between different cultures, aiming at the creative and productive empowerment of the user, without age restrictions.

The digital manufacturing and prototyping process, developed in Fab Labs, is a contemporary practice encompassing different scenarios, present in formal, non-formal and informal environments. Such flexible and collaborative spaces when associated with the school environment, promote new learning models. This, in different perspectives, brings students closer to the real world context and allows them to learn through experiences [7].

The formal spaces are those directed by a progressive teaching structure organized in a curricular matrix, based on national guidelines and used in schools and colleges. It also defines non-formal spaces as flexible, dynamic environments with collective actions, commonly found in museums, libraries, Makerspaces, Fab Labs and science centers, with no precedent for hierarchical norms such as those applied in formal education [8]. The dimension of the informal environment represents the usual spaces of the individual's daily life, in which the natural process of lifelong experiences takes place, shared with family, friends and co-workers [9].

It is important to reflect on the benefits of the school having digitally manufactured equipment available for the curriculum, preparing students for the current demands of the job market, with regard to more creative, innovative professionals and entrepreneurs [10], as shown in Fig. 3 The new possibilities of educating and learning in the face of

digital technologies, contemplate the perspectives of a decentralized production, which has been shown to be necessary in the most diverse world realities [4].

However, even with the dissemination of Fab Labs and Makerspaces, it is difficult for schools to have access to such digital technologies, in a progressive and integrated way to the school curriculum [11]. It also points out that many educational institutions are limited to activities rarely found in computer labs, without perspectives aimed at gaining knowledge. In addition, numerous addresses were found by teachers, when approaching innovative teaching methodologies through Fab Labs and Makerspaces, without any guidance on the possibilities related to both the use of software and the use of equipment, including curriculum standards [12].

Although Fabs Labs can expand teaching perspectives and consequently train more qualified professionals when considering the demands, scenarios and current processes in the labor market, such transformations seek more skills in relation to digital communication and information tools, especially for teachers and administrators educational, since young

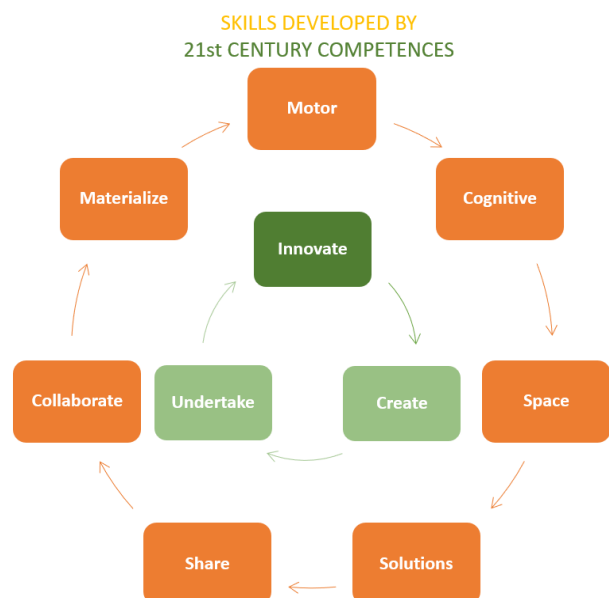


Fig. 3 Makerspaces and Fab Labs potentialities in the scholar environment.

Source: Adaptation of Blikstein [7]; Blikstein [11]; Bacich and Moran [10].

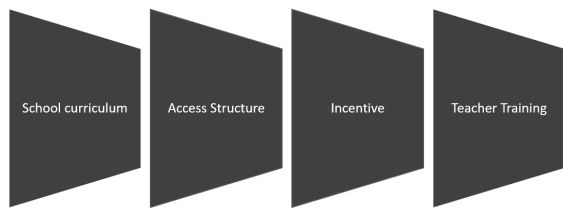


Fig. 4 Barriers and limitations found in Makerspaces and Fab Labs.

Source: Adaptation of Blikstein [11]; Santos et al. [2]; Andersen and Pitkanen [3]; Rossi et al. [12].

people are increasingly adapted to manipulating new technologies [13]. In addition, the inexistence, or even the low quality of specific training for teachers, regarding the possibilities of effective and methodological use of technologies integrated into the school curriculum, especially preschool, acts as a limiting mechanism in the expansion of knowledge [2]. It also points out the lack of physical structure and equipment, as well as the frequent instability of connection to the internet system, how to be overcome, especially in Brazilian education [2]. Fig. 4 indicates some of the main barriers that can limit the effective development and potential of activities in Makerspaces and Fab Labs.

The promising opportunities for use, taking advantage of such technological environments, demand a dynamic, planned and effective structure, geared towards the orientation of teachers [14], in which some competences and skills are exercised by professionals of architecture, not only for its familiarity with software and digital equipment, but also for its ability to create concepts and connections between spatial, geometric, functional and material elements, as well as the architectural design of the school space.

In view of the numerous challenges and limitations generated by the diffusion of new technologies, as well as, considering the potential of connections understood by the experts between different areas of professional activity, and also, aiming at a society based on collaborative processes, it was designed as the objective of this work to develop a training dynamic for teachers at a preschool, using the

Co-design method.

Co-design is a design method carried out with the user and not just for its use, considered in all design stages [15-17]. With the active involvement of users, the progress of the process naturally becomes an instrument for generating knowledge, capable of understanding their real needs, as well as defining objective guidelines with perceived values for the proposed action [15, 18]. The experiment aims to propose different exploratory scenarios, alluding to the new digital technologies and their possibilities in relation to the school curriculum, contemplating the student's development.

Topics such as computational thinking, programming, electronics and maker culture are some examples of active learning addressed in the workshops conducted by the research group, focusing on the interaction between an elementary education institution and a higher education institution, featuring the promotion of institutional interdisciplinarity.

2. Methodology

This work consists of a qualitative approach using the action research method, through the realization of two workshops applied for teachers and coordination of an elementary education institution, especially for students of early childhood education, who assist children between two and six years old.

The architect-led design process, in itself, is conceived as a personalized action, which takes advantage of the creative, problem-solving and spatial skills of professionals, to meet the needs of users through their participation in the stages of the program [19].

Considering the authors' placement, and also reflecting on how architecture professionals can positively affect the school environment in addition to the architectural project, this dynamic sought through Codesign to debate and co-create scenarios that could combine new technologies with activities as well as their perspectives.

Thus, for the progress of the activities proposed for this work, professional architects, computer scientist and the perspectives and collaborations of teachers of the elementary education school were considered. So together they could discuss the possibilities of co-creating active methodologies, based on Maker culture and flexible teaching and learning environments, taking Makerspaces and Fab Labs as an example.

In this research, an in-depth literature review was initially carried out on the applicability of new technologies in flexible teaching and learning spaces. This technique allows us to understand the relationships of information that are disseminated or under development, which is consistent with the new technological educational approaches, despite being mostly supported by Maker culture and Fab Labs, and these have been in movement since the past decade, their reflections on Brazilian education still take place in a singular and limited way [20].

The activity took place in two virtual meetings, through an online communication and interaction platform, and involved the participation of eighteen professionals in the area of education, being teachers and coordinators of early childhood education. The dynamics were given by two mediators, and the first workshop was attended by a communication scientist, with contributions in the experiences of Active Learning, Computational Thinking and Maker Education.

The educators actively participated in the dynamics, both in the debates promoted by the theme addressed, as well as in the manipulation and exploration of artifacts that were distributed in educational physical kits, organized by the teachers. The kits brought together objects that ranged from toys produced with digitally manufactured equipment such as the 3D printer and laser cutting machine, to the handling of digital tools, such as the 3D pen and Arduino board.

All kits included a usage protocol consisting of a step-by-step assembly (printed and digital), in the case

of toys and objects, and an instruction manual, for unplugged computer board games, in addition to tutorial videos made by the researchers. The installation instructions for the software and applications used for modeling and programming in the second dynamic, were made available in the same way, with a step-by-step installation through tutorial videos and digital material. In addition, prior to the virtual meetings, the participants received support material and an introduction to the theme they worked on, consisting of a text for reading and two institutional videos on the general context of Computational Thinking and Socioemotional Skills through Computational Thinking.

Using the field research method, two questionnaires were applied to the participants, called the Pre-Workshop Questionnaire and the Post-Workshop Questionnaire. The first consists of nineteen questions, eight of which are closed questions, two multiple choice questions and nine open questions. The questions list the knowledge about Computational Thinking, World and Digital Culture and their potential, knowledge and use of digital tools and platforms, software and educational applications. The data were sampled in the period from 07/03/2020 to 07/07/2020, and their answers arrived via e-mail to the authors.

The Post-Workshop Questionnaire covered questions based on the first application (Pre-Workshop Questionnaire), in order to map and analyze pre- and post-dynamic movements, with the particularity of each participant. The questionnaire comprised sixteen questions, five of which were closed questions, two multiple choice questions, and nine open questions. Their sampling took place in the period from 07/16/2020 to 08/10/2020, and similar to the previous one, their answers arrived via e-mail to the authors.

This field research method, made possible an extensive data capture, besides allowing its categorization and interpretation, generating new knowledge on the studied subject [21, 22].

2.1 Unplugged Computing Workshop: Maker Culture, Computational Thinking, World and Digital Culture

The first workshop took place on 7/9/2020, lasting 3 h, using an online platform synchronously. The activity started with a theoretical approach on the theme of experience of Flow, Computational Thinking, Codesign as a co-creation process between different areas of teaching, Fab Labs and Makerspace as flexible teaching and learning environments, methods and tools for digital learning.

Then, the educators were divided into simultaneous rooms on the online platform, to proceed with the second stage, called Mão na Massa. Each participant received a physical educational kit (Fig. 5) with support materials.

The division of the groups took place according to the proposed activities, as shown in Table 1, following the order shown in Fig. 6. During the hands-on stage, the two mediators accessed each of the six simultaneous rooms online, to support the proposed activities. The activity lasted approximately 50 min.

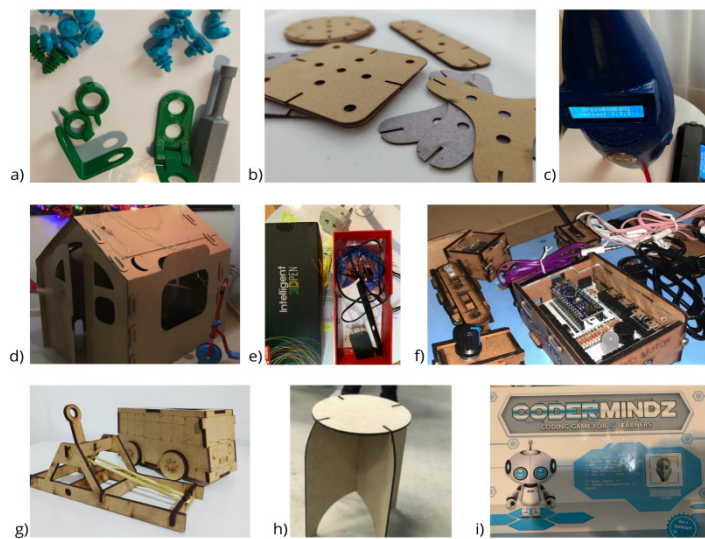


Fig. 5 Educational kits for participants: (a) Screw Kit; (b) fitting game; (c) Brezobomba; (d) Cardboard House; (e) 3D pen; (f) Arduino Beta Kit; (g) Toy Maker; (h) side table; (i) Board game.

Source: Authors (2020).

Table 1 Kits and materials for the hands-on activity proposal.

Group	Kit Material	Quantity	Used Protocols
Board game	CoderMindz board game	1	Original physical board game manual
3D pen	One color 3D pen	1	Instructional video
	3-color 3D pen	1	Instructional video
Screw kit	Construction screw, made in 3D printer with PLA (polylactic acid)	3	Instructional video
Maker toys	Parts made in laser cutter in MDF (medium-density fibreboard) 3 mm, for making a bus, a catapult and a spinning top	4	Physical assembly step by step
Snap-in objects and games	Parts made in the laser cutter, for the construction of a side table and an MDF fitting kit	3	Self-explanatory
Casa de papelão e Brinquedo Maker	Parts made in the laser cutter, for the construction of a cardboard one and a bus in 3 mm MDF	2	Self-explanatory
Programming and electronic	Arduino Beta Kit	2	Digital instructional videos and material
	Brezobomba	1	Digital instructional videos and material

Source: Authors (2020).

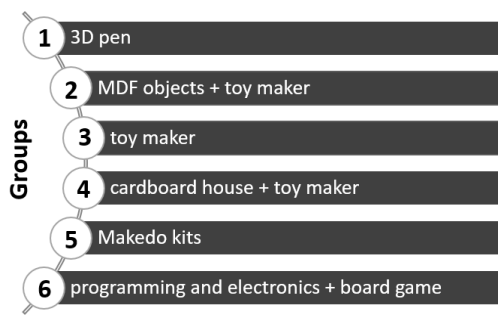


Fig. 6 Division of the groups for the hands-on activity.
Source: Authors (2020).

This moment of exploration of the materials was directed, so that the participants were involved as actors in the active process through new teaching methodologies, allowing them to experience learning through experiences.

Then, for the next stage, 30 min of debate was foreseen, in which a member of each group reported how it was the experience of exploring the artifacts of the educational kit. Participants reported new discoveries through the handling of materials, as well as the difficulties and problems encountered during the process.

At the end of the first workshop, in addition to the debates about the learning possibilities present in new digital technologies, the communication and virtual interaction platforms used were listed in the debate.

2.2 Programming and Electronics Workshop: Scratch Jr, Scratch Online, S4A and Makers Empire 3D

The second workshop took place on 07/16/2020, and as in the first edition, lasted 3 h, using an online platform synchronously. On this day, the objective of the meeting was to approximate the applicability of 2D and 3D modeling, programming, electronics and games in the educational environment, through the manipulation of software and applications.

This proposal addressed the applications Scratch Jr, Scratch online and Makers Empire 3D, in addition to the S4A software. Scratch Jr is a free application that can be used offline, focusing on the programming language with blocks, through the development of cognitive and creative skills of children between 5 and

7 years old [23]. Online Scratch, on the other hand, is available for access directly through the internet browser, without the need for downloading, which allows the creation and sharing of virtual projects [24].

Makers Empire 3D is an application focused on design and technology skills, which aims to support the basic school curriculum in the development of skills such as innovation and critical thinking, through 3D modeling [25]. Finally, S4A is a simple programming software with free download, which interacts with the Arduino board and allows the creation of several projects in the area of programming and electronics [26].

In the first stage, the participants were able to create a game interface in Scratch online, with explanation and guidance from the mediators. The proposal was to create a maze with programming of the direction arrows (Fig. 7).

Subsequently, the group explored the Scratch online tools and their possibilities (Fig. 8), such as creating a story through programming. Actions of choice of scenario, choice of characters, dimensions and inclusion of narrative, were contextualized.

The next application used was Makers Empire 3D, in which participants were initialized in 3D modeling. The application provides a learning path, where each function is presented in a playful and self-explanatory way, permeating the manipulation possibilities offered (Fig. 9).

Finally, concepts about programming and electronics were briefly listed in the exploration of the S4A application (Fig. 10). All steps of approaching, contextualizing and manipulating applications and software, lasted an average of 20 to 30 min.

Following, some discussions regarding practical activities and questionnaires applied with the participants will be presented. This stage aims to relate the concepts and information raised by the literature review, with the practices and debates listed in the activities carried out in the Workshop, in order to bring theory to practice.

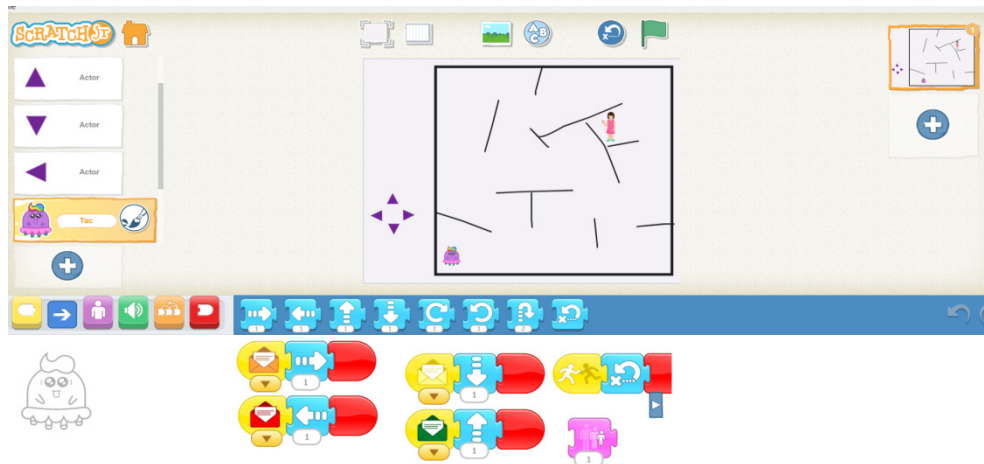


Fig. 7 Exploring the application Scratch Jr.
Source: Authors (2020).

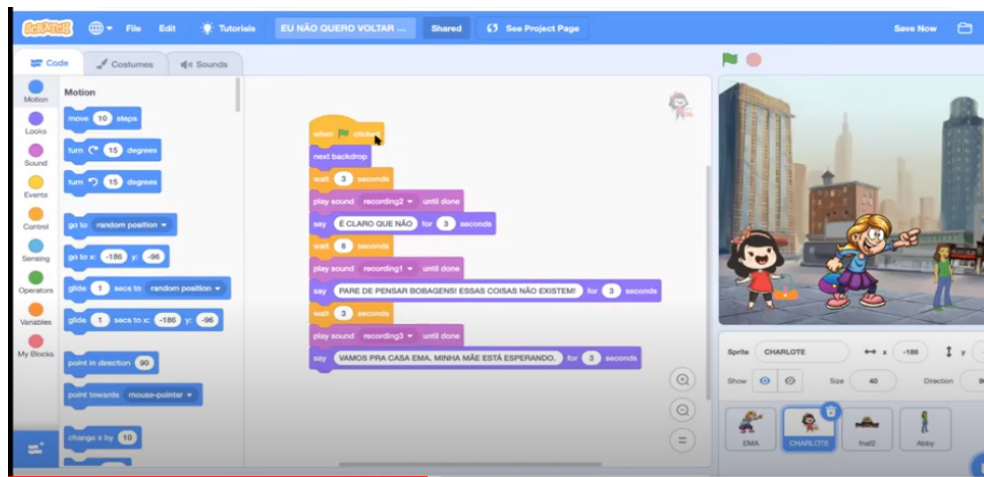


Fig. 8 Exploring the application Scratch online.
Source: Authors (2020).

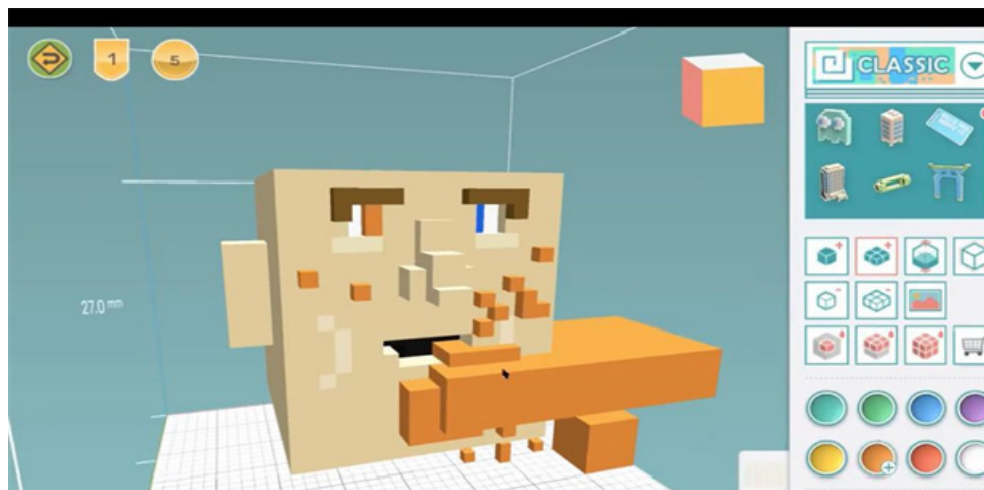


Fig. 9 Exploring the Makers Empire home platform.
Source: Authors (2020).

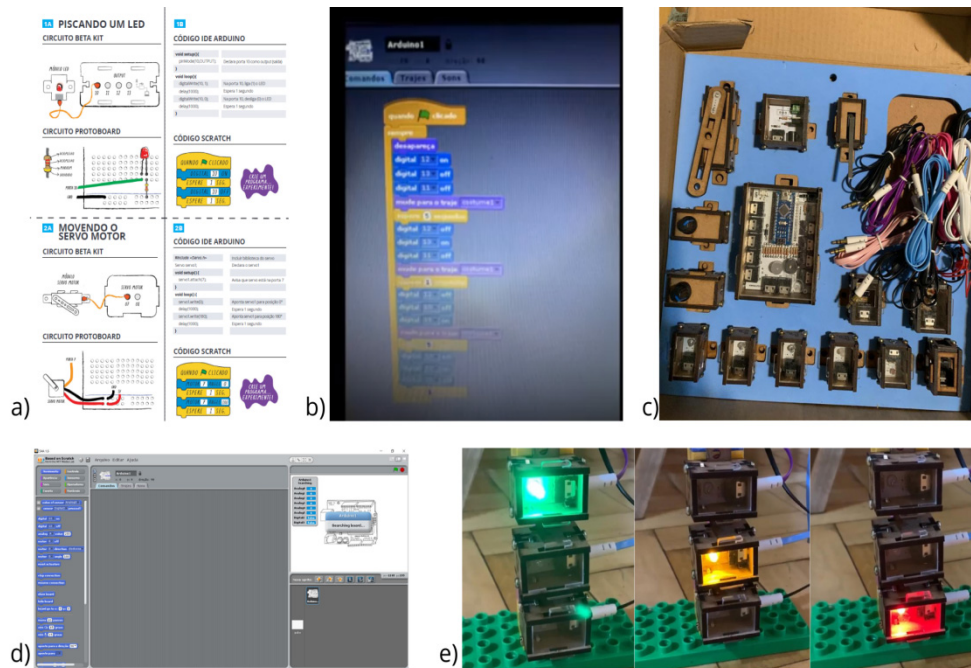


Fig. 10 Work plan of the S4A software: (a) assembly guide; (b) software programming; (c) physical kit; (d) software workspace; (e) finished.

Source: Authors (2020).

3. Results and Discussions

The theoretical approach planned for the beginning of activities in the first workshop (Workshop unplugged computing: maker culture, computational thinking, world and digital culture), introduced the concepts about new technologies and their possibilities. The dynamics organized for the second workshop (Programming and Electronics Workshop: Scratch Jr, Scratch online, S4A and Makers Empire 3D), allowed a look which focused on the construction of educational content, through interactivity, collaboration and playfulness. Participants shared ideas and experiences about the possible applicability of these digital platforms in the basic curriculum.

3.1 Workshop Professional Training through Pedagogical Practice

Initially, teachers and coordinators followed the presentation of examples of toys built through digital fabrication and prototyping, using a 3D printer and laser cutting machine.

As for the debates, some participants related the images of Fab Labs and Makerspace shown in the theoretical context, with spaces present in their homes. One participant reported that from her perception of materials and hand tools found in the environments shown initially, she could consider her home a Makerspace, in which her children appropriate materiality to create artifacts. In addition, they also linked images of the environments used as examples of Fab Labs and Makerspace, with spaces present in Do-It-Yourself videos produced and consumed by children, and found on digital video sharing platforms.

Thus, in an analysis of the concepts of formal, non-formal and informal environments [8, 9], and also considering the contributions that manufacturing and digital prototyping are current practices being present in different scenarios and scales [7], initially reported in this research, it is understood that the dynamics carried out in conjunction with early childhood education, is configured as an activity of manufacturing and digital prototyping in a formal teaching environment, since it aims to train educators

and combine new digital technologies with the school curriculum.

The non-formal teaching environment, on the other hand, is observed in the examples covered in the presentation of the first workshop. The Fab Labs and Makerspaces images registered by the authors were taken as references, from a visitation experience in flexible teaching and learning spaces in international museums. In this way, the presence of Fab Labs and Makerspaces in non-formal teaching environments is understood. The concepts of informal environments are present in the speech of some of the participants, where they report that in their homes, that is, informal environments, children have autonomy in the creation and construction of artifacts through hands-on activities with the use of different materials.

Regarding the exploratory process of the educational kits called hands-on, we observed the engagement of all participants in discovering new possibilities for implementing active methodologies in basic education. The construction of maker artifacts, the manipulation of digital tools, as well as the manipulation of unplugged computer games, extended the pedagogical knowledge, through the transformation of theories into tangible and manipulable objects.

The participants questioned the manufacturing processes, materials used in making the toys arranged in the kits, dimensions, possibilities of use and disposal of digital equipment and tools. They indicated the need for specific and comprehensive training, regarding the manipulation and management of 2D and 3D modeling software. This fact is in agreement with the position of Santos et al. [2], Andersen and Pitkänen [13], and Lorenzin [14] referring to the importance of specific qualification for education professionals in the face of new digital technologies, corroborating for a higher quality and comprehensive teaching of the current demands of more creative, innovative and entrepreneurial professionals.

Alluding to the connections between the skills

and competences of the areas of Architecture and Design, with basic education [1], this can be observed in the training offered to the educators and coordinators of the school in question. It indicates the language of the geometric shapes portrayed in children's drawings, as a learning instrument in the initial teaching classes, and also listed as conceptual and material graphic representation in the formation of Architecture and Design, contemplating 2D and 3D modeling. Geometric shapes were present in the dynamics, both in the tangible materials, such as the assembly and construction artifacts, as well as in the manipulation and programming of the software and applications made available to the participants.

Relationships such as critical thinking, creativity, problem solving, among others, belonging to the daily life of the designer, whether in the area of Architecture, as in the area of Design, are observed in the development of active methodologies with the use of new technologies.

3.2 Pre-Workshop Questionnaire

The Pre-Workshop questionnaire was conducted prior to the reading of the support material and the first meeting with the participants, thus, their responses were not oriented or directed. This method does not aim at an evaluative approach, but rather, to explore the knowledge, expectations, experiences, confidence and enthusiasm of teachers and coordinators, in activities involving technological materials and equipment, as well as, to identify themes and areas of interest, for future activities.

Initially, the participants were invited to express the concepts they understand about Computational Thinking. As these are open questions, the answers cover different contexts. Thus, to make the concepts compatible, it was appropriate to analyze the terms mentioned by the participants, framing the same and similar words, as well as the number of citations, as shown in Table 2. Words were considered mentioned two or more times.

Table 2 Frequency of words mentioned in Pre-Workshop Questionnaire.

Words	Frequency
Think	6
Problem	6
Technology	6
Computation	6
Understand	2
Digital	2
Solve	5
Resolution	4

Source: Authors (2020).

It is observed that of the total of eight words most cited in the answers, five are verbs. In addition, other verbs such as contributing, building, formulating, searching, planning, organizing, interacting, involving and processing, were mentioned by the participants, but with only one mention. Thus, in a general analysis of the responses, it is considered that the initial perception of the participants regarding the concept of Computational Thinking, is directly linked to some action, which aims to achieve a final objective (Fig. 11).

Thus, it is observed, in fact, that the initial understanding of the term is linked to the act of perceiving a problem, followed by proposing and

contributing to the solution of a problem, through a strategy appropriating the use of digital technologies.

Then, the participants explored the concepts of the Digital World theme. The answers were very similar, but two basic concepts were indicated, as shown in Fig. 12. The first is something tangible, being electronic devices and equipment, present in contemporary daily life, taking as an example: smartphones, television, computers and tablets, assigned the role of information vehicle, and sometimes linked to terms such as digital and technology. The second concept is about digital interaction platforms, capable of exchanging knowledge, experiences and learning. Among those cited are social networks, online games, courses platforms, digital training and education and search platforms.

When questioned about the term Digital Culture, the participants indicate how users use such digital equipment and platforms. It is observed that, as in the previous term, the concepts of Digital Culture are linked to the act of communicating and interacting between peers. Thus, it is clear that the participants relate the Digital World and Digital Culture, as a technological process (Fig. 13).

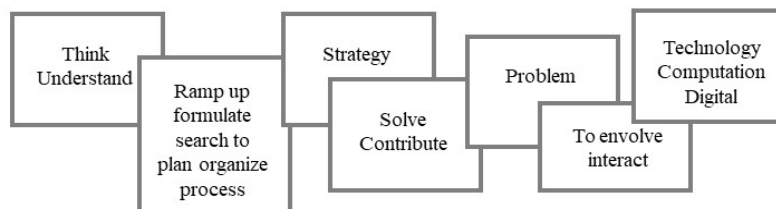


Fig. 11 Perception of concepts about computational thinking.

Source: Authors (2020).

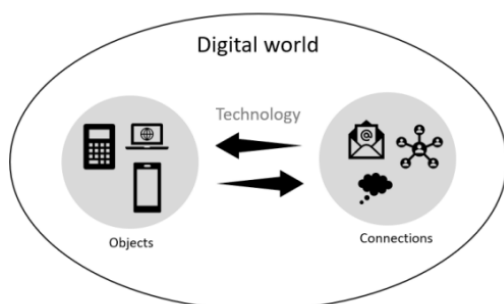


Fig. 12 Digital world concepts.

Source: Authors (2020).

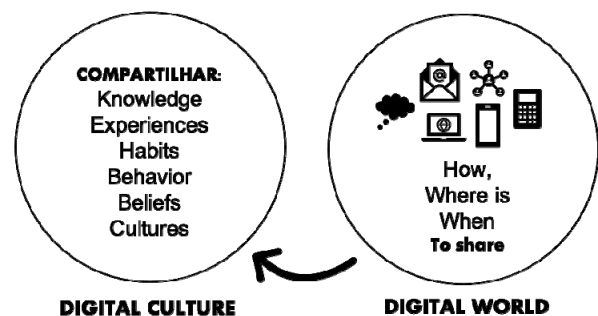


Fig. 13 Digital world and digital culture process.

Source: Authors (2020).

Table 3 Frequency of words mentioned in Post-Workshop Questionnaire.

Words	Frequency
Problems	10
Technology	1
Computation	4
Solve	7
Resolution	5

Source: Authors (2020).

The first configures all digital communication and interaction equipment and platforms, and the second is how these users share their experiences, considering the different customs and beliefs

3.3 Post-Workshop Questionnaire

The Post-Workshop questionnaire was applied at the last meeting and aimed to understand whether there was a change in the perception of the participants regarding the concepts they worked on in theoretical and practical activities.

After analyzing the responses on the topic Computational Thinking, framing the same and similar words, and comparing them with the results found in the Pre-Workshop Questionnaire, it is clear that the words “solve” and “resolution” had an increase in the frequency of citations by the participants, as shown in Table 3.

The theme Computational Thinking was initially presented to the participants in a theoretical way, as the act of solving/problem solving. This fact justifies the increase in the frequency of citations of the words described above.

Another important factor to be highlighted is the mention of some words that were not mentioned in the first questionnaire, such as: Analog; Human and People. In addition, words such as Computation, Digital and Technology, were cited less frequently, or none at all, as is the case with the word Digital, which in the first questionnaire had two citations and in the Post-Workshop questionnaire there was no mention in answers.

Likewise, this change in perception is in line with the fact that the dynamics provided a moment of

reflection and theory on the topics covered. In addition, teachers were invited to explore both tangible materials, as well as software and applications that promote Computational Thinking. With that, they understood that Computational Thinking is not only linked to a technological mechanism, but that it can also relate to the activities present in the individual’s daily life.

For the terms Digital World and Digital Culture, the responses maintained the same pattern of concepts as the first questionnaire. It is believed that these are themes present in the participants’ daily lives, since the school appropriates the recommendations of the BNCC (National Common Base Curriculum), which is a norm of national scope, which guides the formation of Brazilian school curricula [27].

The BNCC indicates the need to consider these current concepts in order to strengthen new institutional skills, aiming mainly at the full development of students [27]. The Digital World theme is addressed in the regulations, such as the act of disseminating information through different digital mechanisms, which can be physical, such as smartphones and tablets, as well as virtual, taking as an example: social networks, websites, applications, software, among others. The foreseen contents and learning, as well as the form of their appropriation, characterize the concept of Digital Culture [27].

4. Final Considerations

In fact, the technological bias moved different sectors and scenarios, adding innovation to traditional practices and creating collective learning spaces. The Digital Fabrication Laboratories and Makerspaces gained strength, and are no longer a means of production and creativity accessible only to large companies, being currently available to the community and entering the school environment.

The study sought to report a theoretical and practical approach to the training of teachers and school coordinators, in view of the new technological

tools available, exploring objects, tools, software and applications for modeling, programming and electronics, as well as, with the application of questionnaires before and after the dynamics, allowing the understanding of the participants' perception on the listed themes.

The relationship between technology and education is indispensable, and this collaborative methodology is essential in the development of skills as an individual before society. The collaborative action between professionals from different areas of activity, enabled the debate about the possibilities of co-creating educational guidelines in flexible teaching and learning environments, especially in the areas of Architecture, Design and basic education, where active methodologies are commonly amenable to application.

It is concluded that, although the technologies are great allies in education and that the Fab Labs and Makerspaces promote learning through experiences, there is a need for progressive integration with the curricular norms, as well as specific training for professionals in the area of basic education, referring to the new digital technologies of communication and information, allowing the autonomy of the professionals before the creation of ludic activities for the student's learning. In this way, Architects, Designers and Computer Scientists can actively collaborate in the educational environment, especially in the training of teachers, considering their expertise.

The movement of national policies such as the BNCC is perceived, in movement to form norms focusing on an innovative school curriculum, aiming at a higher quality education. However, it is known that BNCC is not mandatory, but a guideline, that is, it is the responsibility of the Basic Education Institution to build activities that contemplate such approaches. Thus, the integration between Higher Education Institutions and Elementary Education Institutions, has great relevance to initiate and continue actions and projects that address such educational themes, which,

as exposed at the beginning of this work, express great educational potential when allied when doing pedagogical.

With this, the activity achieved a satisfactory result and will be worked on in future research, promoting training and education for teachers from educational institutions, in public and private schools, through the exchange of experiences between different professionals.

Acknowledgments

This study was financed in part by the CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior-Brasil)-Finance Code 001, CNPq (National Council for Scientific and Technological Development) and Foundation for Research Support of the State of Rio Grande do Sul (FAPERGS). We extend our thanks to the research group of NITAU-IMED (Innovation and Technology in Architecture and Urbanism) at the PPGARQ (Postgraduate Program in Architecture and Urbanism) of the Polytechnic School at IMED (Faculdade Meridional).

References

- [1] Angelo, A. G. S. 2015. "Considerações sobre um campo conceitual comum entre a formação básica escolar, projeto e as tecnologias de modelagem e fabricação." Accessed 14 March 2020. https://www.teses.usp.br/teses/disponiveis/16/16134/tde-07032016-155459/publico/alex_garciarev.pdf. (in Portuguese)
- [2] Santos, E. R., Soares, G., Dal Bianco, G., da Rocha Filho, J. B., and Lahm, R. A. 2016. "Stimulus to Computational Thinking: A Proposal for Elementary School." *Revista Latinoamericana de Tecnología Educativa* 15 (3): 99-112.
- [3] Arce, A. 2002. *A pedagogia na "era das revoluções": uma análise do pensamento de Pestalozzi e Froebel*. Campinas, São Paulo: Autores Associados. (in Portuguese)
- [4] Agustini, G. 2014. "O momento dos laboratórios como espaços de criatividade, inovação e invenção." In *De baixo para cima*, edited by Costa, E., and Agustini, G. Rio de Janeiro: Aeroplano, 192-218. (in Portuguese)
- [5] Costa, C. O., and Pelegrini, A. V. 2017. "O design dos Makerspaces e dos Fablabs no Brasil: um mapeamento

- preliminar.” *Design e Tecnologia* 7 (13): 57-66. (in Portuguese)
- [6] Eychenne, F., and Neves, H. 2019. *Fab Lab: A vanguarda da Nova Revolução Industrial*. São Paulo: Editorial Fab Lab Brasil. (in Portuguese)
- [7] Blikstein, P. 2014. “Digital Fabrication and ‘Making’ in Education: The Democratization of Invention.” In *FabLabs: Of Machines, Makers and Inventors*, edited by Walter-herrmann, J., and Büching, C. Bielefeld: Transcript Publishers.
- [8] Gadotti, M. 2005. “A questão da educação formal/não-formal.” In *Droit à l’éducation: solution à tous les problèmes ou problème sans solution?* Sion (Suisse): Institut international des droits de l’enfant, 1-11. (in Portuguese)
- [9] Marandino, M. 2017. “Faz sentido ainda propor a separação entre os termos educação formal, não formal e informal?” *Ciência educação, Bauru* 23 (4): 811-6. (in Portuguese)
- [10] Bacich, L., and Moran, J. 2018. *Metodologias Ativas para uma Educação Inovadora: Uma abordagem teórico-prática*. São Paulo: Penso editora. (in Portuguese)
- [11] Blikstein, P. 2016. “Viagens em Troia com Freire: a tecnologia como um agente de emancipação.” *Educação Pesquisa* 42 (3): 837-56. (in Portuguese)
- [12] Rossi, D. C., Bordim, L. L., and Stefanin, T. 2020. “Metodologias ativas, ensino por projetos e as novas formas de estartar processos criativos na interface do deign.” In *Movimento Maker e Fab Labs: design, inovação e tecnologia em tempo real*, edited by Rossi, D. C., Gonçalves, Juliana A. J., and Moon, R. M. B. São Paulo: FAAC, 26-30. (in Portuguese)
- [13] Andersen, H. V., and Pitkänen, K. 2019. “Empowering Educators by Developing Professional Practice in Digital Fabrication and Design Thinking.” *International Journal of Child-Computer Interaction* 21: 1-16.
- [14] Lorenzin, M., Assumpção, C. M., and Bizerra, A. 2018. “Desenvolvimento do currículo STEAM no ensino médio: a fromação de professores em movimento.” In *Metodologias Ativas para uma Educação Inovadora: Uma abordagem teórico-prática*, edited by Bacich, L., and Moran, J. São Paulo: Penso editora, 199-219. (in Portuguese)
- [15] Magnusson, C., Hedvall, P., and Caltenco, H. 2018. “Co-designing together with Persons with Visual Impairments.” In *Mobility of Visually Impaired People: Fundamentals and ICT Assistive Technologies*, edited by Pissaloux, E., and Velázquez, R. Berlim: Springer, 411-34.
- [16] Sanders, E. B.-N., and Stappers, P. J. 2008. “Co-creation and the New Landscapes of Design.” *Co-design* 4 (1): 5-18.
- [17] Mussi, A. Q., Silva, T. L., Zardo, P., Silva, J. L., Pazini, E. Z., Ferri, M. B., and Moreira, D. 2019. “Welfare Increase Tools for Blind and Visually Impaired People: inclusive Design and Tactile Model.” *Arquitetura Revista* 15 (1): 1-14.
- [18] Caixeta, M. C. B. F., and Fabricio, M. M. 2018. “Métodos e instrumentos de apoio ao codesign no processo de projeto.” *Ambiente Construído* 18 (1): 111-31. (in Portuguese)
- [19] Willis, D., and Woodward, T. 2010. “Diminishing Difficulty: Mass Customization and the Digital Production of Architecture.” In *Fabricating Architecture*, edited by Corser, R. New York: Princeton Architectural Press, 178-208.
- [20] Gil, A. C. 2002. *Como elaborar projetos de pesquisa*. São Paulo: Editora Atlas. (in Portuguese)
- [21] Gerhardt, T. E., and Silveira, D. T. 2009. *Métodos de Pesquisa*. Rio Grande do Sul: Editora UFRGS. (in Portuguese)
- [22] Martin, B., and Hanington, B. 2012. *Universal Methods of Design: 100 Ways to Research Complex Problems, Develop, Innovative Ideas, and Design Effective Solutions*. EUA: Rockport Publishers.
- [23] Scratch Jr. 2020, Accessed 10 August 2020. <https://www.scratchjr.org/about/info>
- [24] Scratch. 2020. Accessed 10 August 2020. <https://scratch.mit.edu/explore/projects/all>.
- [25] Makers Empire. 2020. Accessed 11 August 2020. <https://www.makersempire.com/>.
- [26] S4A. 2020. Accessed 9 August 2020. <http://s4a.cat/>.
- [27] Brasil. MEC - Ministério da Educação (Org.). 2017. Base Nacional Comum Curricular. Brasília, 2017, <http://portal.mec.gov.br/conselho-nacional-de-educacao/base-nacional-comum-curricular-bncc>.