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PRESERVICE TEACHERS' OPINION ABOUT DEVELOPING COMPUTATIONAL THINKING IN PRESCHOOL[1]

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Abstract: Computational thinking is important not only for the study of some disciplines, but also in everyday life. Research show that this competency should be developed starting from preschool. The research presented in this paper aimed to study Primary and Preschool Pedagogy specialization students' opinion and experience about including technological knowledge in preschool activities, emphasizing on developing computational thinking.

The results show that even if the respondents consider that the preschool activities can develop a positive attitude towards technological knowledge, they don't consider teaching the technology domain important in preschool and they have no experience with this. They have selected lack of methodological preparation and lack of necessary didactical tools as the main barriers in integrating technological knowledge in preschool activities. Only few respondents have a deeper insight into algorithms and one third of the respondents could give a correct algorithm for building a snowman. Respondents consider important to develop computational thinking in preschool using screen-free activities. One of the main methods to develop CT in preschool is using robots, but none of the participating students used a robot in their activities and only less than one fourth of the participants heard about educational robots.

Keywords: computational thinking, preschool, robots in education, STEM education

1. Introduction

Nowadays STEM (Science, Technology, Engineering, and Mathematics)/STEAM (Science, Technology, Engineering, Arts, and Mathematics) education has become very important for solving contemporary world's challenges. STEM/STEAM knowledge is essential not only in many careers, but also in everyday life.

In this paper the focus is on the preschool level which in Romania is the formal education for 3-6 years old children. Research show that children should be involved in STEM activities from their early years, as preschool is a sensitive period for developing elementary thinking competencies (Driscoll and Nagel, 2008). Children's early positive STEM experiences are important for developing skills which help them to face the challenges in their life (Lippard, Lamm and Tank, 2019) and significantly influence school performance (Watts, Duncan, Siegler and Davis-Kean 2014). STEM education in early years should be child-centered and problem based (Fridberg, Redfors, Greca and Terceño, 2022). It should be realized by hands-on activities which have a positive influence on children's perception towards STEM (Ortiz-Revilla, Greca and Meneses-Villagrá, 2021).

In Romania, the current Early Education Curriculum (Ministerul Educației Naționale, 2019) focuses on the holistic development of children, trying to find a balance between cognitive and personality development. There are several experiential areas included in the curriculum, among which environmental education, mathematics, household education can be considered as part of STEM. In the activities different experiential areas are integrated, the most successfully associated experiential fields are environmental knowledge and mathematics (Bálint-Svella and Zsoldos-Marchis, 2022). In the early education curriculum, the STEM Education is not mentioned, knowledge and competencies

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regarding Engineering are not included. There are some competencies connected with Technology are present in curriculum. In Romania future primary and preschool teachers are not trained in the Engineering and Technology domains, and they don't integrate these domains in their teaching activities (Zsoldos-Marchis and Ciascai, 2019). Pre-service preschool and primary-school teachers don't have any discipline during their BSc studies on STEM education, they have only separate disciplines for Mathematics, Science, and the teaching methodologies of these disciplines. The consequence is that more than half of the Preschool and Primary School Pedagogy specialization students participating in the study of Bálint-Svella and Zsoldos-Marchis (2022) are unfamiliar with the term STEM.

In the research presented in this paper the Technology domain is addressed and the focus is on an important competence belonging to this domain, the computational thinking. The aim of the research was to study pre-service teachers' opinion and experiences about developing computational thinking in preschool.

2. Computational thinking in preschool

In the definitions given for computational thinking (CT) the emphasis is on "thinking as a computer". Wing (2008, 3717.) defined CT as "taking an approach to solving problems, designing systems and understanding human behavior that draws on concepts fundamental to computing". It is important to notice that based on this definition, developing CT doesn't necessarily require the use of a computer, it is a competence which can be used in many areas of study. CT only focuses on the "scientific and cultural aspects of computing … not dealing with systems and tools, but with principles and methods" (Nardelli, 2019, 32.). Li and his coworkers (2020) even consider that CT is more about thinking than computing. But there are other definitions, for example that given by Relkin and Bers (2021), which emphasize more on the use of a computer in developing CT.

In the case of early education, CT is considered as the ability to abstract computational behaviors and identify bugs (Bers, 2018, 70.). CT is operationalized in preschool by algorithms, modularity, control structures, representation, hardware/software, design process, and debugging.

There are physical, virtual, and hybrid kits which help preschool children to develop CT (Yu and Roque, 2019). In physical kits all the components are tangible and the activities with them are screen-free. Virtual kits are usually mobile or computer applications. Hybrid kits have both tangible and virtual parts. Preschool children in many cases have too much screen time outside school environment, so programming on a computer is not considered appropriate by most of the preschool teachers. Thus, tangible kits are most preferable in preschool, from which button-operated robots are an ideal solution for developing computational skills without using a screen. Research show, that very young children can learn coding (Cejka, Rogers and Portsmore, 2006; Bers, González-González and Armas-Torres, 2019; Yang, Ng and Gao, 2022). Guided play with button-operated robots can develop CT skills by observing the robot's response on their coding, interpreting the robot's actions, and trying to tell the robot what action to undertake (Hall and McCormick, 2022). In order to guide the robot using coding the child needs to anticipate its action, to choose the right command, and monitor its response (Di Lieto et. al, 2017).

There are many robots designed for this purpose. There are robots which can be programmed by buttons from the back of the robot, as Bee-bot/Blue-bot or Colby mouse robot (Figure 1). These robot sets also have cards with the commands (go forward, go backward, turn left, turn right), so that the child can make a sequence of commands (an algorithm – a code) before programming the robot. Also, some boards divided in squares are given with these robots: the robot goes one square with one forwards or backward command (see the board for the mouse robot in Figure 1).

Figure 1. Robots programable with buttons: Bee-bot and Colby mouse robot

Another type of robot, KIBO (left picture of Figure 2) can be programmed by attaching wooden blocks which have pegs and holes (Bers, 2018). Each block represents a command (go forward, go backward, turn left, turn right, spin, light on, beep, wait for clap, etc.). This robot has more commands, that the previously presented ones. It also has some structures as repeat and if. As with KIBO quite complex coding knowledge and competencies can be addressed it is used in at least 43 countries worldwide (Sullivan, Bers and Mihm, 2017). Research show that preschool children are able to understand and use even looping and numeric parameters (Bers et. al, 2014) which can be programed with the KIBO robot.

A third type of screen-free robot is Cubetto (right picture of Figure 2), which has a board and instruction blocks to be placed on the board. The robot doesn't have buttons on the back, it can be programmed only using the board. An important feature of the robot is the function line (the bottom line on the board, see Figure 2) which allows the using of subprograms (Gadzikowski, 2018): there are four places in a special area of the board where up to four blocks can be placed and the sequence of these blocks is considered a subprogram. Then, when programming Cubetto, in the instruction line only the subprogram block must be placed instead of those blocks. The function line helps children to practice abstracting and modularizing (Yu and Roque, 2019).

Figure 2. Robots programable with linked wooden blocks (KIBO) or instruction board (Cubetto)

3. Methodology

The survey presented in this paper was conducted in the second semester of the 2021-2022 academic year among Preschool and Primary-school Pedagogy (PPP) specialization students at Babeș-Bolyai University, Romania. PPP specialization in Romania is a 3-year BSc level course.

The main goal of the research is to find out PPP students' experience and opinion about developing computational thinking in preschool, competence from the Technology domain of STEM education.

3.1. Research questions

This research tries to find the answers for the following questions:

1. What is students' opinion and experiences with technological activities, as part of STEM?
2. What prior knowledge and experience do students have about the algorithms?
3. What is students' knowledge and opinion developing computational thinking in preschool?

3.2. Participants

The participants of this study were 86 Primary and Preschool Pedagogy specializations students from Babeș-Bolyai University: 51 second-year students and 35 third-year students. In terms of gender distribution, 1 (1.2 %) of the respondents was male, this under representativeness of male students is typical for PPP student population.

PPP students participating in this study didn't have any subject related with technological education or algorithms. Third year students in the time of the survey were participating in a course related with computer assisted education.

3.3. Instrument

In the research an online questionnaire edited in Google Forms was used. It included 23 questions: 5 questions regarding demographic data, 7 questions about integrating technological knowledge - as part of STEM - in pre-school activities, and 11 questions about respondents' opinion about the importance of developing computational thinking in preschool. From the 18 questions related with the research questions 5 are open questions, the others are close questions as multiple choice or statements measured on a 5-level Likert-scale.

4. Results

The results are organized around the research questions.

4.1. Students' opinion and experience with technological activities in preschool

To find out students' opinion about the integration of technological knowledge in preschool activities, four statements were formulated. Students had to measure the value of these statements on a 5-point Likert-scale (from 1 – strongly disagree to 5 - strongly agree).

The means and standard deviation of the responses for each statement are summarized in Table 1.

Table 1. Means and standard deviations for each statement related with Technology in preschool

Statement	Mean	SD
It is necessary to introduce technological knowledge in preschool	3.09	1.150
There is no place for technological knowledge in preschool	2.27	1.238
In preschool, we can establish a positive attitude towards technological activities	3.60	1.187
Kindergarten technology tasks include the foundation of programming (planning, implementation)	2.89	1.253

The results show that students agree that a positive attitude towards technological knowledge can be developed in preschool, but the mean for this affirmation is only about the average. Students are not too convinced that technology should be taught in preschool, as the mean for this affirmation is below average. They are even less convinced about the affirmation that technological tasks which are implemented in preschool should give the basis for programming (planning, implementation). In the current Romanian Curriculum for early years (Ministerul Educației Naționale, 2019), technology

competencies are included, the pre-school period being the foundation phase for key competencies. In spite of this students' responses doesn't really support the development of technology competencies in preschool. This could be explained by the fact that they don't have experience in integrating technological knowledge in the activities, as 77 students (89.5%) have never tried to develop technological competencies of the children. Students who have used technological knowledge in their preschool activities were asked in an open question to describe what and how they have integrated. Analyzing answers show that they mix up technology education with using technology in education. So that their examples refer to the use of different digital aids by the teacher. This confusion could be another explanation why students are not so positive about integrating technological knowledge in preschool.

The next question asked respondents about the reasons that prevented them from planning activities based on technological knowledge. 31 respondents (40.3%) stated that the methodological preparation for planning such activities was insufficient, 25 students (32.5%) said that the lack of an appropriate didactic tool was the biggest obstacle, and 22 (28.6%) identified low self - confidence as a barrier. 82 respondents (95.3%) would like to learn about activities aimed introducing technological knowledge in preschool. This result is in concordance with Zsoldos-Marchis's and Ciascai's (2019) findings and highlight the importance of integrating technological activities – as part of STEM activities - in the training of future preschool and primary school teachers. Methodological knowledge for implementing STEM in preschool can be acquired efficiently with adequate training courses and mentoring programs (Uğraş and Genç, 2018; Chen, Huang, and Wu, 2021).

4.2. Students' knowledge and experience about algorithms

Algorithms are inherent in our daily lives, and we use algorithms in our activities daily. Nevertheless, it is often difficult to formulate/define the steps of an algorithm.

In the first question of this part, students were asked to give examples for activities that could be used to develop algorithmic thinking in kindergarten. 63 respondents (73.3%) gave such examples, which really can contribute to the development of the algorithmic thinking. Some examples are very general, just indicating the experiential fields which use algorithms, fields as mathematics, science, and arts. Others gave examples from the everyday routines, as morning routine, preparation for eating, etc. There are also good concrete examples, as using robots, making a handicraft following the steps indicated by teacher, building from blocks, etc.

To evaluate students' capacity for writing an algorithm for a well-known activity, students were asked to write down the steps of making a snowman. The following solution was considered as correct: 1. make three snowballs of different sizes, 2. place the middle ball on top of the largest, and then the smallest on top of it. 3. Put two eyes in the middle of the smallest, a nose, and a hat on the top. Of course, these three main steps have many steps inside, they can be considered as subprograms. Also, they are steps, which can be interchanged, so their order is not important, for example, someone can place first the noise, and then the eyes of the snowman. Only 28 respondents (32.94%) formulated the steps of the snowman-building algorithm correctly. Most of the respondents made the mistake of not describing the sequence of steps in enough detail.

As regarding students' previous experiences about algorithms, 61 students (70.9%) had only heard the term algorithm in math class, 13 (15.1%) learned programming, and 8 students (9.3%) stated that they had never learned algorithms. So that participating students have very limited experiences with algorithms and coding. But, at the same time, 80 (93%) of the respondents thought that early development of algorithmic thinking is needed.

4.3. Students' knowledge and opinion about developing computational thinking in preschool

Computational thinking is often linked with the use of the computers, but it can be very well developed with screen-free activities. Thus, respondents were asked to measure their agreement for three statements related with the activity type for developing CT on a 5-level Likert-scale (from 1 – strongly disagree to 5 – strongly agree). The mean and standard deviation for each statement is summarized in Table 2.

Table 2. Values of means and standard deviations for each statement

Statement	Mean	SD
To develop computational thinking, it is always necessary a computer	2.84	1.204
Computational thinking can be developed without using a computer	3.57	1.189
Computational thinking can be developed with paper-pencil based tasks	3.39	1.256

Based on the answers, it can be observed that the most agreed statement was "Computational thinking can be developed without using a computer". This is promising as one of the main reasons why preschool teachers don't consider it suitable to develop CT in preschool is limiting the screen-time. In Yavadav et. al (2014) research preservice teachers without training in CT were convinced that CT requires using computer technology.

58 students (67.4%) consider important the development of CT in preschool. Students were asked to give examples of activities that could be used to develop CT in kindergarten. 41 respondents (47.67%) gave a good example for developing CT. According to them, it is possible to develop CT with tasks based on algorithms, tasks based on problem solving, games based on a sequence of different steps. Two students also mentioned educational robots as a possible tool for development. But there are also students who answer incorrectly. For example, they said that computer thinking can be improved by showing the computer and its components. In some extent knowledge related with hardware and software is incorporated in CT, but not this is the competence that should be addressed in early years education. Another misconception of the respondents about developing CT is that it can be done with mathematics which is not in concordance with the conception of CT. The view of CT as solving mathematical problems was also mentioned in the research of Sands, Yadav, and Good (2022) and Avcı and Deniz (2022). Actually, CT is more related with algorithms and coding, and based on their examples given, almost half of the respondents understood that. In the research of Ari, Arslan-Ari and Vasconcelos (2022) early childhood preservice teachers didn't indicate high perception for integrating coding in preschool activities.

Because robots are frequently used in preschool activities for teaching algorithms and coding, students were asked if they had heard of educational robots. Only 19 student (22.1%) gave a positive answer. The robots they had heard are the Blue-bot/Bee-bot robot (18 students - 20.9%), Ozobot, Vex and Cubetto - mentioned by 5 students (5.8%) each. The other respondents are unfamiliar with educational robots.

None of the respondents used educational robots in their teaching. This result is in concordance with the fact, that in Romania, learning with educational robots is not yet widespread, and only extracurricular activities provide opportunities for this, especially for the school age group. Based on research findings from other countries, it would be timely to include computational thinking as a potential area for development in the preschool curriculum requirements. At the same time, appropriate means must be provided to develop this, for example by using educational robots. Moreover, it is possible to start the development of programming and computational thinking in preschool by developing and implementing programming tasks based on simple algorithms.

5. Conclusions

The research presented in this paper aimed to study Primary and Preschool Pedagogy specialization students' opinion and experience about including technological knowledge in preschool activities, emphasizing on developing computational thinking.

The results show that even if the respondents consider that the preschool activities can develop a positive attitude towards technological knowledge, they don't consider teaching the technology domain important in preschool and they have no experience with it. This could be explained by the

fact, that they confuse the inclusion of technological knowledge in activities with using technology as a digital aid during the activities. Lack of methodological preparation and lack of appropriate didactical tools are given as main barriers in integrating technological knowledge in preschool activities.

Only few respondents have a deeper insight into algorithms, only one third of the respondents could give a correct algorithm for building a snowman. Respondents consider important to develop computational thinking in preschool using screen-free activities. One of the main methods to develop CT in preschool is using robots, but none of the participating students used a robot in their activities and only less than one fourth of the participants heard about educational robots.

Based on international research, computational thinking should be developed starting with preschool. For this the Romanian Early Education Curriculum should be modified to include the development of CT. The results show the necessity of training pre-service teachers for teaching the technology domain, more particularly, for developing children's CT.

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