University of Tartu
Faculty of Social Sciences
Institute of Education
Curriculum for Educational Technology

Chrysoula Kapsali Moschovaki

IMPLEMENTING COMPUTATIONAL THINKING ACTIVITIES IN A GREEK KINDERGARTEN

Master's thesis

Supervisor:
Associate Professor of Educational Technology
Leo Aleksander Siiman, PhD

Tartu, 2025

Implementing Computational Thinking Activities in a Greek Kindergarten

ABSTRACT

This study investigates how Greek kindergarten teachers design and implement computational thinking (CT) activities for kids, the type of CT concepts, practices, perspectives and scaffolding offered and children preferences. The research methods comprise teachers' diaries, videos' analysis and interviews.

The results indicate that most activities were unplugged, while the plugged ones included Bee-Bot programming and activities on the interactive whiteboard. Most activities were developmentally appropriate and all CT concepts, practices and perspectives were covered except for loop, iteration and generalisation. Teachers mainly employ modelling, guiding through questioning, task decomposition and positive feedback, while children prefer specific design features (reenacting, collecting props, moving on the squares) and less programming tasks. The outcomes can assist CT educational practice for the early years.

Key words: Computational Thinking, pre-school education, plugged-unplugged activities, CT concepts and practices, teacher's scaffolding.

Table of contents

1. Introduction

The development of Computational Thinking (CT) has been the focus of considerable research and various definitions of the term are offered. Initially, such definitions were tied to the field of Computer Science and referred to the ability of a person to solve a problem (Wing, 2011). Shute *et al.* (2017, p. 142) after reviewing several research papers defined CT as the thinking skills a person is required to have "to solve problems effectively and efficiently" and be able to reuse such solutions in other contexts, which are not necessarily computerized. Moreover, apart from formulating problems, the learner must learn how to decompose a problem in smaller parts and sequence them to reach a solution (Bers *et al.*, 2022).

One reason for promoting CT is that is prepares children for the digital society, ensuring their active participation and future employment and it is considered as one of the 21st century skills (Bers *et al.*, 2022). The digital transformation of society needs citizens who can function in an information-based economy. Citizens who are critical thinkers, who can communicate and collaborate with others, solve problems, are creative and productive in innovative ways, are able to learn rapidly changing technologies, act in a responsible manner and when needed take initiatives. In line with this, a strategic priority of the European Commission (2020) is computing education who stresses at the Digital Education Action Plan 2021-2027 that it contributes to the digital transformation of society.

Moreover, the ability to solve complex problems in a technological world is important for students. It has been suggested that CT is not limited to programming since the Computational Thinking strategies can be transferred in other contexts, such as mathematical problem solving or solving complex problems in other contexts of our everyday life (Wing, 2011). Children with a lack of related learning experiences are at risk of being marginalized in the future (OECD, 2023).

Researchers advocate the integration of CT in the early years for two reasons. Firstly, interventions in the early years are usually more effective and have a lasting effect. Such interventions can foster mental dispositions that can facilitate at a later age the acquisition of foundational CT skills (Bers *et al*., 2022). Secondly, from a social equity perspective its integration in early childhood education can tackle the issue of underrepresentation of girls in STEM due to social stereotypes that impact their perceptions and their employment choices. Research has illustrated that there are no

differences in girls' interest or competence in relation to CT activities compared to boys in early years' settings (Bati, 2022).

Research points out that teachers have limited knowledge of CT and how to implement it with learners K-12 years old (Sands *et al.*, 2018). However, when they receive training, their interest increases and they try to implement activities in the classroom (Martins *et al.*, 2023). Therefore, investigating how teachers in early years settings design and implement CT activities is an important topic and moreover, how they manage to support young children's understanding and their successful engagement in such tasks.

2. Theoretical overview

2.1. Theoretical framework

The study adopts a sociocultural perspective where children learn through their interactions with significant others and in the case of early childhood education these are their teachers and more competent peers. On the other hand, technology and language are the cultural tools used during interaction that assist children's learning, while the structure of the activity and the quality of language interaction have a profound impact on the mental function of the child (Vygotsky, 1978).

The ability of the teacher to diminish the difficulty of the task and guide children's thinking, functions as a scaffolding for their learning, while both language, gestures and other nonverbal cues can facilitate a shared understanding (Wang *et al.*, 2020). The teacher who can intervene within a child's zone of proximal development will assist the internalization of knowledge. What the child was initially able to achieve with the teachers' support now s/he can manage more autonomously (Vygotsky, 1978). However, achieving a shared understanding is not an easy task since a teacher needs to take into consideration children's prior knowledge and be flexible enough to affectively motivate and cognitively adjust the conversation to maintain their interest, while ensuring their understanding (Wang *et al.*, 2020).

The development of CT is cognitive challenging for young children. According to Piaget theory, children from two to seven years old are at the preoperational stage, their symbolic thinking is developing yet they are not capable of logical thinking. Their working memory is limited and the process of their thinking relies mostly on what they can perceive (Lightfoot *et al.*, 2022), which teachers have to take into account. Moreover, CT activities with or without the use of technology need to be

developmentally appropriate. Young children need to actively be engaged in hands on activities, which are appealing, playful, creative, allowing them to be in control, empowering them while supporting their learning (NAEYC & Fred Rogers Center, 2012). On the same track, the positive technological development framework, which guides the formation of educational programs using new technologies, suggests that such programs should allow content creation, foster creativity, communication and collaboration, community building and choice of conduct (Bers *et al.*, 2022). These six C's ensure that a learner has agency, is motivated, participates actively and can express him/herself in creative ways within a collaborative learning environment.

2.2. Computational Thinking frameworks

Bers *et al.* (2022) considers that young children should become aware of seven big ideas related to Computer Science. Organizing things in order (algorithm), breaking a task into smaller pieces (modularity), identifying patterns, repetitions, cause effect (control structures), creating models and use symbols (representation), digital devices, robots are not magical but programmed by humans (hardware/software), seeking solutions, trying them out and persevere when things don't work out to reach a satisfactory solution (design process), identifying errors and correcting them (debugging). Based on these ideas a curriculum was developed entitled 'coding as another language' with the notion that coding should be taught simultaneously with other literacy skills (Relkin *et al.*, 2021). On the other hand, Shute *et al.* (2017, p. 142) after reviewing the literature identified six facets of the concept applicable for K-16 school settings: "decomposition, abstraction, algorithm design, debugging, iteration and generalization".

However, given that CT handles abstract concepts and a systematic approach to problem solving, it is evident that the implementation of such tasks is cognitive challenging for young children Therefore, evidence on what is developmentally appropriate and feasible to implement in early childhood education is needed. A recent review from Zeng *et al.* (2023a) tackled this issue examining the research outcomes of 42 empirical studies in early childhood settings with children from 2 to 8 years old who proposed a three-dimensional framework for the development of CT applicable for the early years (see Figure 1 from Zeng *et al.*, 2023a). Based on Brennan's and Resnick's (2012 cited in Zeng *et al.*, 2023a) previous work, their framework includes CT concepts, practices and perspectives (see Table 1).

Table 1. Concepts, practices and perspective of CT activities

CT Concepts	
Control flow/structures	It refers to instructions that must be executed in a specific order (sequence). It also includes loops, conditionals, events
Representation	Symbols may represent movements, sounds, images etc.
Hardware/software	The machine executes sets of instructions by a software application to complete specific tasks
CT practices	
Algorithmic thinking	Creating commands, putting them in order with the purpose of completing a task
Pattern recognition	Seeking similarities, patterns
Abstraction	Focusing on the important elements of a task/problem etc., leaving aside elements that are not essential
Debugging	Identifying errors that impede successful completion of a task
Decomposition	Breaking a task into smaller components
Iteration	Repeating a set of instructions to find the most effective one
Generalizing	Being able to apply effective solutions to new contexts
CT perspectives	
Expressing and creating	Approach technology as a creative means of expression
Connecting	Collaborating with others to solve problems, sharing and seeking feedback
Perseverance	Despite failures, being able to continue, seeking solutions
Choices of conduct	Being able to make decisions on how to behave

2.3. Research evidence on Computational Thinking in early childhood education

2.3.1. Computational Thinking and early learning outcomes

A systematic review of 26 studies in early childhood reported both cognitive and non-cognitive outcomes from CT educational interventions (Su & Yang, 2023). The cognitive outcomes varied considerably, suggesting that children were able to acquire CT concepts and practices (sequence, debugging, loops, conditionals, decomposition, algorithm design, pattern recognition, missing symbols, symbol shape puzzles) through activities targeted to their level of understanding and with adult's support. It has been also suggested that the development of CT impacts positively a child's executive functions therefore fostering self-regulation (Myers, 2021 cited in Bers *et al.* 2022).

Additionally, non-cognitive outcomes were achieved such as children's critical thinking, collaboration, communication skills and their creativity if they were engaged in creating an artifact. However, the researchers stress the lack of reliable assessment tools validated for this age range (Su & Yang, 2023).

2.3.2. Tools for Computational Thinking activities

A review of studies in early childhood reports the use of a variety tools such as KIBO (6 studies), Bee-Bot (3 studies) and coding platforms on screen devices with the most

popular being ScratchJr (5 studies) (Su & Yang, 2023). According to their affordances, children engage in diverse ways with an impact on their learning outcomes.

Digital games/puzzles software applications are more close-ended and usually focus on developing concepts related to cause effect, sequence, logic and problem solving (Sullivan & Bers, 2019, in Bers *et al.*, 2022). On the other hand, there are open-ended coding and programming environments that can be implemented more playfully. One of the most popular is the ScratchJr, which allows children to create characters, backgrounds, add voice and sound, create stories, animated collages and others (Bers *et al.*, 2022: 26). Robotics' kits on the other hand have the advantage of offering a hands-on experience to children. Three popular robots are the Bee-Bot, the KIBO and the Code-a-pillar. Research on the use of Bee-Bot with children from 5 to 6 years old has shown significant gains in "visual spatial working memory and inhibition skills" (Di Lieto *et al.*, 2017 in Bers *et al.*, 2022, p. 28).

A popular categorization of CT activities depends on whether a device is being used. Unplugged activities do not use any device, rather they use materials such as cards, tangibles objects, table games and the plugged ones (e.g., pedagogical robots, ScratchJr) (Saxena *et al.*, 2020). Following recommendations from World Health Organization or the American Academy of Pediatrics there is a movement of presenting unplugged approaches through which children can develop CT without exposure to screens (Bers *et al.*, 2022). Following this line, Lee *et al.* (2023) suggest an integrated approach where children are engaged in an active, meaningful and playful way through various unplugged activities. They propose various activities that support decomposition (puzzles and block, planning an event, handwashing), abstraction (Simon says and Who am I? games, storytime), pattern recognition (sorting and patterning, daily routines sequences) algorithm design (recipes, treasure hunts, tying shoelaces). Additionally, examples are given on how stories and daily activities can be used to motivate children's interests on the concept of sequence and engage them in coding practices (Lee & Junho, 2019).

2.3.3. Implementing Computational Thinking activities

Empirical studies describe a variety of activities with the use of both unplugged and plugged activities. A recent study encouraged children from 3 to 6 years old to create their own artifact as part of a problem-solving situation and then create an animation video illustrating the stages of their art-making. Children created their art with the use

of geometric paperboards. They were encouraged to decompose it and write down its components, create a storyboard illustrating the sequence of its creation, take photos of each stage with the use of geometric shapes and then assemble them for creating the video. Young children were able to plan and create a complex digital artifact while fostering Computational Thinking in a developmentally appropriate way (Leung *et al.*, 2024).

Saxena *et al.* (2020) implemented a series of unplugged and plugged activities with 11 children from 3 to 6 years old in a kindergarten with the purpose to document their outcomes. The unplugged activities included creating patterns with Lego, sequencing stories or daily routines, a child becomes a robot and the other child gives verbal instructions on how to move (Tic-Tac-Toe), direction games with cards, songs with reenactment for language development (stop, turn around). The plugged activities were related to the use of Bee-Bot as children had to apply a series of commands for the robot to reach its destination while avoiding obstacles. The outcomes indicate that all children successfully completed the activities related to pattern recognition and sequencing, yet not all of them were able to comprehend some of the vocabulary (left/right). Children from 4 to 6 years old were able to use algorithms to guide the robot, however the younger ones (3 and 4 years old) had more difficulties for mental representation of the route to be followed by Bee-Bot, especially when it had to turn. Saxena *et al.* (2020) maintains that children need more training in directional language and teachers need to differentiate activities according to children's level of understanding. Similar outcomes were also reported in another study with older children 5-6 years old, who were able to create algorithms with a Bee-Bot as well as fix errors using the strategy of decomposition (Angeli & Valanides, 2020).

Another study examined the debugging processes of 526 children from 4 to 6 years old when using Bee-Bot in Greek kindergartens. Thirty educators received beforehand a 3-hours' training and materials for implementing different scenarios (e.g., reaching a destination, avoiding obstacles). Each child had to verbally describe the route the Bee-Bot had to follow, then create the algorithm using cards of symbols (arrows, go, clear) and finally program it to execute the algorithm. By observing the movement of the robot children had to recognize if an error occurred, try to identify it and correct it, reprogram it and check the outcome once more. To facilitate the detection of an error, teachers encouraged kids to follow a step-by-step process and cross check each part of their algorithm against the Bee-Bot movement. The study indicated that two types of

mistakes were observed: syntactic ones, which were related to difficulties in using the 'go' and 'clear' command and logical errors, which were related to difficulties in relation to orientation and direction commands. Overall, children debugged up to two times when correcting their algorithm. The researchers report that most of the mistakes were logical errors, while younger children made more syntactic ones compared to their older classmates. The outcomes of this study indicate that when children try to correct their algorithm they mostly make orientation and counting mistakes especially when the task is complex (Misirli & Komis, 2023).

A research study by Zeng *et al.* (2023 b) examined how a teacher implemented CT activities through analysis of videos, interviews and lesson plans. The outcomes point out that the teacher had a good understanding of CT concepts but limited understanding of practices and perspectives, which were reflected in the way the activities were implemented. The activities were highly structured and the teacher was able to support children during their engagement with the tasks but less effective in using differentiated instruction during pair programming (Zeng *et al.*, 2023b). The outcomes highlight the need for teachers' further professional development for acquiring a deeper understanding of CT. An example is the implementation of a curriculum-based professional learning program comprised of 6 workshops and afterwards proceeded to class implementation. The twenty-five preschool teachers that participated reported higher CT understanding while their beliefs, attitudes and self-efficacies were significantly improved. Interestingly, in schools where teachers shared practices and worked as a team reported greater confidence in their ability to implement CT activities successfully (Saxena & Chiu, 2022).

2.3.4. Teachers' scaffolding

In many studies, information on how the teacher supported children has not been provided. A few studies though mentioned how adults support children during their task engagement, such as questioning, giving detailed instructions, guiding and supporting them (review in McCormick & Hall, 2021). An exploratory study examined teachers' scaffolding when children were engaged with CT activities. The teacher participated in small group activities as a collaborator and facilitator, provided high support scaffolding through closed questions to guide children's thinking, gesturing and pointing, especially during debugging. The teacher supported children's understanding of 'trial and error' through examples with tangible objects and provided low support scaffolding using

more open questions. When testing a solution kids had to make predictions, while the teachers rephrased their wordings to make their language comprehensible. Moreover, children's motivation was prompted beforehand by encouraging them to take care of the caterpillar (e.g., giving her a name and creating her house) and managed to formulate the end goal of the task so that children can grasp what they had to do (help the caterpillar 'Rapunzel' get the food) (Wang *et al.*, 2020).

Scaffolding during programming was also examined by Angeli and Valanides (2020). During that process (scaffolding) they encouraged children to use two strategies (i.e., visual aids and cards with arrows) to represent the algorithm or in pairs they created a written record of commands, which the teacher wrote down. Both types of scaffolding were beneficial during programming the robot. All children benefited from both types of scaffolding, however, girls benefited more from the written record, while boys benefited from the use of cards. Finally, the researchers justified that these outcomes are due to the fact that girls are better in language intelligence, while boys are in visual-spatial intelligence.

2.4. Aim and objectives of the study

The review of the literature highlights Computational Thinking as a way of thinking that students need to acquire even from an early age to participate successfully in a digital society where technology will be part of their everyday life. Policy makers in Greece have incorporated programming within the curriculum of early childhood education for children from 4 to 6-years old without explicitly mentioning the concept of CT (Penteri *et al.*, 2022). On the other hand, researchers stress that CT is a significant competence that young children need to develop and therefore early years educators face the challenge of implementing it in school settings. Given that most teachers have a limited understanding of the concept, the task becomes even more demanding as teachers should also consider the constraints posed by children's developmental level and be able to design activities that are developmentally appropriate for young children.

Bearing all these in mind, the aim of this study is to examine how teachers in a public kindergarten school in Greece design and implement activities, which foster the development of young children's Computational Thinking and how they support children's understanding and successful engagement in CT tasks. Therefore, the research questions of the study are as follows:

1. What type of CT activities kindergarten teachers implement?

2. Which CT concepts, practices and perspectives are fostered through the implementation of CT activities?
3. What type of scaffolding does teachers provide to children during their task engagement?
4. What type of CT activities (plugged/ unplugged) children prefer and how do they justify their preferences?

3. Methodology

3.1. Sample

The study adopted purposeful sampling by selecting a kindergarten that was knowledgeable in the specific field of the study and therefore could provide rich information (Cohen *et al.*, 2008) on how computational thinking is implemented in the early years. As part of the annual school development project, the staff wished to develop a computational thinking program that was based on research outcomes. Given that, I contacted the principal of the kindergarten and after a staff meeting, they accepted the study proposal.

The kindergarten is located in an island in Greece, situated near the city center and has enrolled 30 pupils in two classes (12 in one class & 18 in the other) aged 4 to 6 years old (2 are 7 years old). The school also offers an Integration Class for students with special needs, providing extra support to those in need (30% of kindergarten pupils are with special needs; 5 with autism, 1 nonverbal autistic child, 1 child with Down syndrome, 1 child with dyspraxia, and 1 child with language impairment), who were proportionally integrated in each class (4 & 6 in each class).

The compulsory program spans from 8:15 to 13:00 and the optional one continues up until 16.00. There are posted 7 female teachers (3 early years' teachers & 4 special needs teachers), however 2 special needs teachers are not available every day, 1 is available 2 times per week, while the other 3 times. There is also a teaching assistant who is responsible for the student with Down syndrome. Apart from the teaching assistant, all teachers hold a Bachelor Degree in Early Childhood Education, 4 of them have a Master Degree in Special Education, and 1 holds both a Masters and a Doctorate (PhD).

Three of these teachers are very experienced, while 2 of them implemented in the past children's activities related to programming. The kindergarten has good

technological infrastructure (e.g., laptops, interactive whiteboard, Bee-Bot) and all teachers have a good background knowledge in ICT.

3.2. Data collection

The methodology of the study follows a mixed approach, since both qualitative and quantitative research methods were used. The data (i.e., teachers' diaries, children's interview, teachers' group interviews and video recordings) was analyzed in a qualitative way yet some descriptive statistics are also given. The use of three different data collections methods can triangulate findings and increase the credibility of research outcomes (Cohen *et al.*, 2008).

3.2.1. Teachers' diaries

Teachers' diaries where records of everyday activities are kept is a valuable resource for illuminating the "enacted curriculum" and teaching practices. It has also been supported that it is a "reliable and valid way to measure instruction" (Rowan & Correnti, 2009, p. 126).

In the particular kindergarten each class keeps a diary, and teachers log all the implemented activities at the end of each day. Such records show the nature of activities teachers design and implement with preschoolers. However, the diaries are simple notebooks and problems occurred if the activities were not explicitly described. For this reason, the teacher responsible for the school development program collaborated with the researcher. The selection of activities from diaries was done by her and provided clarifications if necessary. Furthermore, some of the activities were also uploaded to the school website illustrating further how activities were implemented.

3.2.2. Video recordings

The use of video in research enables the capture of rich in detail data and is considered as most useful for studying interaction processes in contexts such as communication between teacher-child and among children during activities (Penn-Edwards, 2004; Knoblauch *et al.*, 2014). It is a useful tool for retaining data that is difficult to be kept as notes (Jewitt, 2012) as it can be replayed as many times as necessary, allowing the researcher to focus on details (Knoblauch *et al.*, 2014).

With the cooperation of the kindergarten teachers, three computational thinking activities were recorded by them without the researcher's presence and were shared for further analysis.

3.2.3. Children's individual interviews

Children were individually interviewed with the purpose to take into consideration their perspective on CT activities. Twenty-four interviews were conducted in May and photos of three activities were used to assist each child to recall the activities. As young children's language proficiency varies considerably, the teacher had to adapt her questioning according to each child's level of understanding in order to obtain their point of view. The photos and questions are available in Appendix I.

3.2.4. Group interviews

With the use of group interview we can understand the experience and ideas of the teachers. It is suitable for qualitative approaches as it supports the shared wisdom of participants, it encourages conversation between participants, and it is easier to understand the topics in which interviewees agree or disagree (Fox, 2000).

In this study a semi-structured interview was conducted with the use of open-ended questions, which allowed teachers to express their views and experiences of the implementation program. There was a set of written questions (acting as a guide) from the researcher, but there were adapted according to teachers' responses and the issues that emerged from the participants during the discussion. This tactic facilitated both the interviewer and the interviewees and gave more flexibility to express themselves and elaborate their thoughts.

Three group interviews were realized face to face and were recorded after teachers' consent. The interviews were transcribed (see Appendix II), while the researcher kept notes during the interview.

3.3. Data Analysis

3.3.1. Content analysis of activities

The data analysis is based on the content analysis of activities teachers provide from their diaries. The selection was made by the teacher who is responsible for coordinating the *"Computational thinking program"* of the kindergarten. The analysis of each activity was based on the three-dimensional framework for the development of

computational thinking (CT) applicable for the early years (Zeng *et al.*, 2023) and prior studies of the field (Saxena *et al.*, 2020; Lee *et al.*, 2023). The unit for data analysis is the activity and each one was coded at five levels:

- Level one: Type of activity (plugged with the use of technology (Bee-Bot, camera, laptop, IWB) or unplugged without the use of technology).
- Level two: Nature of the activity. The activities were grouped in Tic Tac Toe, worksheet, Bee-Bot, IWB, movement activity, arts, story, activity with objects, and others. Others include making videocalls watching a video that shows parts of a modern art painting composed in sequence, identifying parts of the Greek flag, reciting names of arrows left, right, forward, backward, sequencing routines.
- Level three: It refers to the CT concepts fostered by the design and implementation of the activity illustrated in Table 2.

Table 2. Coding of CT Concepts

Sequence	Put images in sequence, sequence commands during Tic Tac Toe and Bee-Bot activities, creating algorithms, making patterns
Conditionals	Making decisions while taking into account different variables. e.g., Planning means of transportation to visit different places in Greece while taking into account their availability and their geographic position. Worksheets: identifying the missing variable.
Events	Cause effect activities. It includes games such Simon says, movement games (e.g. one clap stand, two claps we sit, three claps we fell on the floor), fruits (e.g. change chairs, lemons, oranges, fruits), cause effect events during story making.
Representation	It included all activities that children used the arrow cards to make an algorithm
Hardware/software	The machine *executes* instructions set by a software application to complete specific tasks. e.g., Making videocalls

- Level four: It refers to the CT practices children were engaged during each activity (see Table 3).
- Level five: It refers to the CT perspectives that the activities seek fostering children (see Table 4).

The reliability of the study depends on the consistency of coding implementation (Cohen *et al.*, 2008). To ensure reliability, the coding of activities was done by two persons, the researcher and one teacher. Discrepancies were noted and further discussed to achieve agreement.

Table 3. Coding of CT practices

Algorithmic design	Creating commands, putting them in order with the purpose of completing a task. e.g., Creating an algorithm with cards, putting images/ events in sequence, reconstructing a picture from numbered pieces, following steps in treasure hunt, Tic Tac Toe, Bee-Bot activities, movement activities with a sequence of arrows in various directions or sequence of numbers
Pattern recognition:	Seeking similarities, creating patterns with different objects, with movements or in art activities
Abstraction	Focusing on the important elements of a task/problem, etc. leaving aside elements that are not essential. e.g., creating story maps, creating titles for stories, games (e.g. Simon says).
Debugging	Identifying errors that impede successful completion of the task for example Bee-Bot to reach a specific destination or errors in algorithms created with cards in Tic Tac Toe
Decomposition	Breaking a task into smaller components. E.g., Identifying the parts of a snowman made by shapes. Cutting down a destination into smaller parts Cutting down their name into letters

Table 4. Coding of CT perspectives

Expressing and creating	Approach technology as a creative means of expression (CT art activities, creating stories)
Connecting	Collaborating with others to solve problems, sharing and seeking feedback (group activities where children have to collaborate)
Perseverance	CT activities that are time consuming and cognitive demanding (e.g. programming activities).
Choices of conduct	Being able to make decisions on how to behave. Open activities where children can set their own goals and decide how to implement the activity

3.3.2. Analysis of video recording and interviews

Four focal child (3 four & 1 five years old) were observed during task engagement in a programming activity. The researcher recorded and analyzed the difficulties each child faced and the scaffolding provided by the teacher to overcome misunderstandings.

From the interview transcripts, teachers' opinions per question were compared, illustrating further points of agreement and disagreement and issues of interest that emerged from their comments. From children's interviews, the analysis focuses on children's preferences and the justifications of their choices.

3.4. Ethical issues

According to the regulations of the Ministry of Education, Religious Affairs and Sports, an application was submitted to the kindergarten Principal with the purpose to conduct research and an official permit was obtained. Teachers agreed to grant the researcher access to the activities described in their diaries, videorecord three activities, conduct

children's individual interviews and participate in a group interview. Furthermore, parents' consent was requested for the video recordings, while ensuring anonymity of all participants. The kindergarten has also requested parents' permission for uploading photos of activities on the school website. Finally, the research outcomes will be disseminated to the kindergarten staff, who will use them as part of their annual school improvement project.

4. Results

4.1. Type of CT activities

From teachers' diaries we extracted 131 activities, the majority of which were unplugged (78.6%). The nature of designed activities also indicates how children are engaged. In particular, 26% are worksheets, 15.3% movement activities, 9.9% activities carried out with a Bee-Bot, 9.2% Tic Tac Toe activities, 9.2% activities with object manipulation (making patterns), 7.6% IWB activities, 7.6% art activities, 3.8% story creation, 2.3% concept maps, while 9.2% concerns 'Others' (e.g., sequencing routines, decomposing the Greek flag, sending and responding to video messages, reciting arrows 'Front', 'Left', 'Right' etc.)

4.2. CT concepts, practices and perspectives

Figure 1. Concepts, practices and perspectives of CT activities.

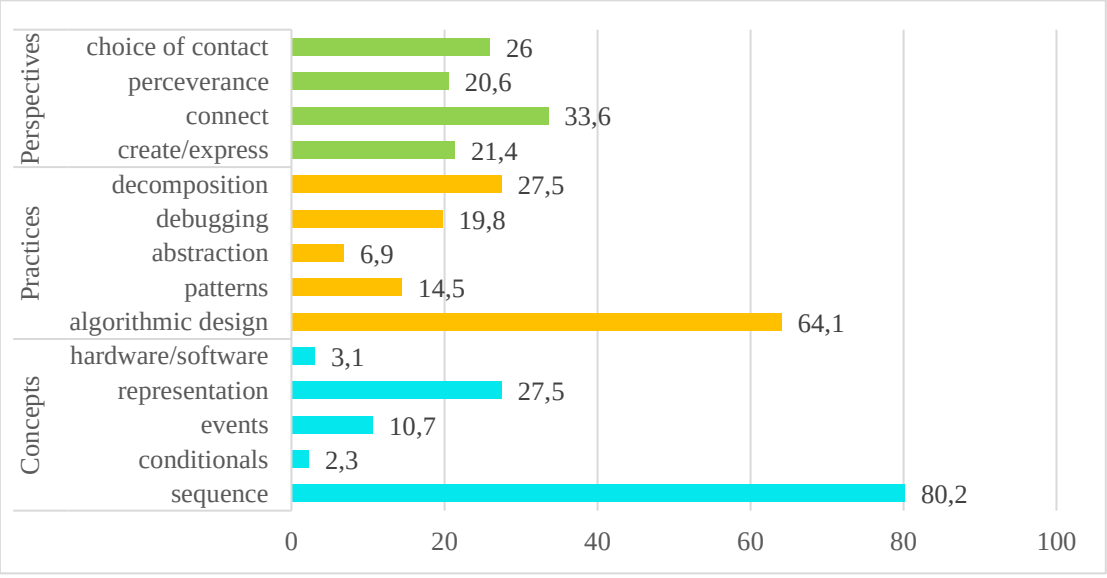

Figure 1 illustrates that the activities mainly foster the concepts of sequence (80.2%) and to a lesser extent those of representation (27.5%) and events (10.7%), while the concepts of conditionals (2.3%) and hardware/software are even fewer (3.1%). In

relation to computational practices, the activities are mostly related to algorithmic design (64.1%), while the proportion of other practices are considerably less (decomposition 27.5%; debugging 19.8%; patterns 14.5%; abstraction 6.9%). The CT perspectives fostered by the implementation of activities were cooperating, communicating and sharing with others (connect 33.6%), deciding what to do (choice 26%), creating or expressing (21.4%) and perseverance (20.6%).

4.3. Teachers' scaffolding

To examine how teachers support children when engaging in computational activities we first videorecorded and then observed the interaction of each teacher with children. The analysis of videos has shown that these teachers adapt the activities to children's level of understanding. For example, for the four years old usually, they have to program the Bee-Bot to move in a straight line without turning left or right. In addition, all teachers scaffold the process with gestures, pointing, modeling, thinking aloud, regulating children's figure movements when pressing the buttons, providing positive feedback and celebrating when they achieve their goal.

The following extracts illustrate further the supporting strategies teachers apply to support a child's efforts in algorithmic design.

4.3.1. Teacher 1, Child 1 (4-year-old), 14-10-2024

The child has to program Bee-Bot to reach the initial of her name (Figure 2).

Figure 2. Programming Bee-Bot to reach name initial.

T[1]-*What would you do?*

C-(The child goes to press the buttons.)

T-*Wait* (puts her hand over the Bee-Bot). *How many steps does it have to take?*

C-(Does not respond.)

T-*One, two, three* (points at each square while counting). *Now press.*

C-(The child carefully presses the forward button once, while the teacher counts 'one',

[1] T: Teacher; C: Child.

and then ‘twice’ and ‘three’ times.)
T-*Now press the green button* (the Bee-Bot starts to move). *Did it get there?*
C-(Laughs satisfied with the fact that the Bee-Bot reached her name.)
T-*Well done!! Bee-Bot got it.*

In the above extract, the child is very young and is not able to count. Therefore, the teacher models the process by pointing and counting the squares the Bee-Bot has to follow to reach the card with the initial of her name and assist counting when pressing the buttons on Bee-Bot.

4.3.2. Teacher 1, Child 2 (5-year-old), 14-10-2024

The teacher initially adjusts the card with the initial of a boy’s name in front of the Bee-Bot.
C-*I want it to be difficult!*
T- *Do you want it to be more difficult? Ok* (changes the card’s position to a nearby column therefore, Bee-Bot has to turn).
C-(Immediately presses the front button three times and then the turn right button).
T-*It will turn and then …*
C-(Presses the ‘Go’ button and the Bee-Bot starts moving).
T-*You did it until turning right. The robot turns and stops. Now, what will you do?*
C-(Presses the button while the teacher describes what he does.)
T-O*ne, two and then go* (the Bee-Bot reaches the final destination).
C-(Smiling.)
T-*It caught it!*

In this case, the child requests a more demanding task and the teacher responds accordingly. The child works quite autonomously without even thinking aloud and manages to program the Bee-Bot to move three steps forward and then to turn. Teachers’ assistance was minimal and follows the child’s lead by describing what he did in the second part of programming.

4.3.3. Teacher 2, Child 3 (4-year-old), 10-4-2025

In this activity, two children collaborate. The first one chooses the ‘egg’ and the second one selects the starting point, the route Bee-Bot will follow to collect an egg and then program the robot. Children then shift roles. The following example shows how the second child programmed Bee-Bot.

Figure 3. Child's route planning of reaching the pink egg.

T- *Show me with your finger how Bee-Bot will reach the egg.*

C-(The child shows a long route, figure 3).

T-*Ok. Let's think about what you should do. Let's reach this point here. First press 'Cancel'.*

T-(The child press 'Forward' once and then 'Go'.)

T- *Now what should the Bee-Bot do?*

C-(The child presses the 'Right' button 5 times.)

T-*Lets' see what will happen now. Wow it turns around itself!*

C-(Approaches to press the button.)

T-*Wait a minute. Count how many steps it needs to go.*

C-(Points one, two, three, four, five, six, seven.)

T- *Press the 'X' button.*

C-(Presses the 'X' button and seven times the 'Forward' button.)

T-*And* (press) *'Go'.*

C-(Presses the 'Go' button.)

T-*What should it do to reach the pink egg?*

C-(Presses 'X' and says) *turn*.

T-*Make her turn.*

C-(Presses the turn 'Right' and 'Go'.)

T-*It turned but it did not move forward. What should you do?*

C-(Presses the 'Forward' button.)

T-*and then the green.*

C-(Presses the 'Go' button. The Bee-Bot reaches the egg.)

T-*Well done!!*

This teacher initially asked children to plan the Bee-Bot's movements. If the route was extended and/or had lot of turns she encourages the child to break down the route to smaller parts (decomposition) and program each part separately. The teacher allows the child to make mistakes and expresses verbally her curiosity about what will happen. With her behavior she reinforces the idea that it is normal to do mistakes and

encourages the child to think of alternative solutions. It was observed that children usually forget to use the x button to delete previous commands but also to press go for the robot to move and the teacher reminded it to each child.

4.3.4. Teacher 3 Child 4 (4-year-old), 21-1-2025

In this activity one child has to move the car according to an algorithm created beforehand by having cards with arrows. The car collects pieces of various shapes, which children will use afterwards to make a snowman (see Figures 4 & 5).

In the beginning, young children face difficulty understanding that arrows may represent specific directions. In the following case, one child turns the arrows towards the direction he wanted the car to follow. By changing the orientation, the turn left arrow was perceived as moving forward and created an algorithm with this understanding (see Figure 6).

Figure 4. Robotcar collecting snowman parts.

Figure 5. Snowman collage.

T-*This says, 'Turn left', 'Turn left'.*

C-(The child ignores teacher's clarification and moves the car according to his understanding of the algorithm.)

T-*Let's start it from the beginning, let's do it together. What is the starting point?*

C-(Points at it.)

T-*Right* (pointing with her finger). *From there you have to go forward.*

C-(The child moves the car.)

T-*Which card should you use?*

Figure 6. Child's algorithm with cards.

C-(Picks the green one.)

T-*Perfect. Then where do you want it to go?* (another child interferes but the teacher requests to let him make the choice)

C-(Picks another green card.)

T-*Move it forward.*

C-(Moves the car one stop forward.)

T-*If you want to go there what do you need to do?*

C-(The child picks the yellow card representing 'Turn left'.)

T-*Perfect. Turn it.*

C-(Turns the car to the left.)

T- *Then?*

C-(Picks the green card.)

T-*Perfect, move forward.*

C-(Moves the car one step forward.)

(When the car collects the two shapes the teacher celebrates the positive outcome and praises with animated voice the child.)

T-*Perfect, well done!*

To tackle the misunderstanding the teacher decomposed the problem and guided the child step by step. Each movement of the car was followed by the correct card therefore the structure of the algorithm was composed gradually. This facilitated the child's understanding of how cards represent directions (green arrow 'Forward', yellow 'Turn left', red 'Turn right'). When children completed the task of collecting all shapes using algorithms, they created a big snowman (see Figure 5).

4.4. Children's preferences of CT activities

Seeking children's preferences on what features made the task attractive, children were interviewed individually. Three photos of two unplugged activities were used and one from a plugged. The unplugged were two Tic Tac Toe activities where children had to create algorithms with cards. In the first one, a child dressed as 'snowman' was programmed to move to reach its friend, while the second 'robotcar' had to be moved by a child to collect parts of a snowman. In the plugged activity, the Bee-Bot had to collect Easter eggs. During the interview, each child had to initially recall the activities,

how it was played and then the teacher requested them to choose their most favorite one.

With the assistance of the photos, children were able to recall the activities and describe what they had to do and then to select their favorite activity. From the 24 interviews, 14 children selected the Bee-Bot, 5 children the robotcar and 5 children the snowman. When asked to justify their preferences, most children in Bee-Bot said that they liked collecting eggs. When the teacher asked them if they liked the most pressing the buttons and making it move or the eggs' collection, some explained that they preferred collecting the eggs while some said both. Furthermore, one child said that *"She is cute"* (referring to the Bee-Bot), while another one said that she loved her. The nonverbal autistic child was not interviewed but was fascinated with Bee-Bot as it made sounds, his eyes were glowing when moving and always wanted to press the buttons to make it move.

In relation to using the robotcar, two children liked it because after collecting the snowman parts they created a very big snowman (collage), one child said that she liked walking among squares and using the cards to show how the robotcar could move, another said that she likes robots and the last one was unable to give a justification. Two children who selected the snowman said that they liked that a child was dressed up as a snowman, while the remaining claimed that s/he liked the game, that his best friend was dressed up and that the snowman was good. All children mentioned that using direction cards to program robotcar or the snowman was not a difficult task.

4.5. Teachers' interviews

The three interviews examined teachers' experiences in relation to CT and their perspectives on children's engagement in such activities. Those with the least teaching experience had the opportunity to observe or being involved with programming activities during their university studies, while the most experienced ones mostly acquired their knowledge through online searching, especially during the Covid shutdown when emergent remote teaching was implemented. Through sharing innovative practices with other colleagues, they started designing and implementing programming activities. The first seminar on CT took place this academic year by the person responsible for the school improvement project, who collected evidence from various research studies and organized in-service training for the school staff. Therefore,

most teachers prior to their training did not have a clear understanding of the concept of CT but had experience in programming activities.

Teachers mentioned that children are acquainted with technology and this facilitates their engagement as they usually are interested in such activities. Bee-Bot is mentioned as an appealing means of technology for young children as it moves, makes sounds and has flashing eyes. However, most activities are unplugged and teachers state that designing appealing activities for young children is not an easy task. Teachers mention features such as children creating something (e.g., the snowman), being actively engaged (e.g., having to move according to the directions given by the cards), reenacting stories where they have to meet challenges to assist the story heroes (e.g., create patterns, follow algorithms to free a snowflake that was trapped in a castle) and using appealing props. The challenge is designing them in a playful way to motivate children's engagement.

Teachers are satisfied with children's participation as they become more competent, now that they have acquired experience from the various activities. Children with special needs and younger children were also able to participate with teachers' support and guidance. Most children faced difficulty in understanding the concept of left and right, which however when linked with points of reference of the classroom (e.g., turn towards the door or towards the library) children were able to participate successfully. The complexity of the task was also mentioned in particular, if the child had to follow a longer route with lots of turns then more support was needed.

5. Discussion

The aim of the study is to examine how kindergarten teachers foster the development of CT and how they support young children's understanding of concepts and engagement in computational practices. For this research, 131 activities were retrieved from teachers' diaries, as well as three teachers' videos and 24 children´s interviews and three group interviews with teachers were recorded and analyzed.

5.1. The nature of CT activities designed by teachers

The outcomes point out that most activities were unplugged, which complies with suggestions for the use of tangible materials and hands-on experiences without the use of technology (Lee & Junho, 2019; Saxena *et al.* 2020). Most activities were related to worksheets and movement activities. Worksheets usually followed Tic Tac Toe or the

use of Bee-Bot where children have to identify a specific route with arrows. A big proportion was related to movement activities where children had to jump according to a series of arrows pointing to different directions or creating number lines with their bodies. Tic Tac Toe concerns unplugged activities where children had to create algorithms, which either a child had to execute following specific steps or through object manipulation (e.g., moving a robot car). Bee-Bot activities were popular plugged activities where children program a robot to move accordingly. Activities with object manipulation were usually activities related to creating or identifying patterns. There were also IWB activities, which mostly included digital puzzles, sequencing images to create a story or a life circle, playing Bee-Bot online. In addition, there were a few art activities (e.g., making patterns, creating snowmen with shapes), creating story books by sequencing images of stories, creating concept maps of stories and others. Teachers were therefore able to design and implement a variety of CT activities the majority of which are similar to other studies implemented in early childhood settings (Lee & Junho, 2019; Leung *et al.*, 2024; Saxena *et al.*, 2020; Angeli & Valanides, 2020; Yang *et al.*, 2024).

5.2. CT concepts, practices and perspectives fostered by the activities

The analysis points out that the concept of sequence, creating a succession of steps to achieve a task is by far the most frequently observed which complies with prior studies (Zeng *et al.*, 2023a). On the other hand, representation which refers to the use of symbols to represent particular actions of movement and events' activities, highlighting cause effect relationship, are the other two CT concepts fostered although to a much lesser extent. The concept related to the operation of hardware/software and conditionals were rarely observed, while the concept of loops was not identified in any activity. Some of the above concepts are challenging for young children whose memory skills and logical thinking skills are still limited (Lightfoot *et al.*, 2024).

In relation to CT practices, children were engaged in activities where they mostly had to design algorithms and to a lesser degree to decompose, debug, create patterns and abstract (focusing on important information, e.g., story maps). The practices of iteration and generalization were not possible to be identified from the information retrieved from teachers' diaries.

Furthermore, teachers design many activities, which encourage collaboration among children, sharing with others, expressing themselves through arts, creating

stories, programming tasks within appealing contexts (e.g., assisting the Bee-Bot or story heroes to find solutions) and interacting with the IWB surface. For example, in most programming activities teachers encouraged collaboration in groups of four. One child is the robot or moves an object, another child creates the algorithm and another pair of children examines the algorithm beforehand to identify errors before its execution and debug it. Afterwards, they point to each arrow indicating the movement the child-robot has to follow.

Teachers mentioned that children were interested and eager to participate, thus the perspectives of connecting and creating were fostered through such activities. In addition, a lot of activities (Tic Tac Toe, Bee-Bot) were those that required either the use of higher order thinking skills (i.e., representation, debugging) or required engagement through a series of sessions for their completion (e.g., creating storybooks, video recording of an art activity). Such complex activities foster the development of young children's perseverance. It should be noted though that a significant proportion of activities (e.g., 26% of worksheets) were done individually, were close-ended and do not seem to foster any of the above perspectives. On the contrary, a lot of tasks (Tic Tac Toe, Bee-Bot activities, creating storybooks, art activities) allowed children to make choices. During programming, children could select the entry point, the end point and the route they wished to follow or create artifacts (e.g., snowman) and take decisions about the content of their stories.

5.3. Teachers scaffolding of children's engagement during CT practices

The videos' analysis illustrates that teachers adapt the difficulty of the task according to children's level of understanding. For younger students, programming tasks are easier, while for older ones more challenging. Therefore, teachers were able to intervene within each child's zone of proximal development (Vygotsky 1978). Children were also able to adapt the task to their perceived level of competence. For example, some children selected more extended routes with lots of turns during programming activities.

Teachers design interesting tasks that attract children's attention and motivate their participation and perseverance when errors occur. The design of such activities was appealing to children who were looking forward to helping the Bee-Bot to collect the eggs, to help the snowman to visit his friend without going near the sun, move robotcar to pick various pieces to create a snowman. Teachers constantly provide positive feedback and celebrate when a child achieves his/her goal.

It should be noted though that teachers' scaffolding varies from modelling thinking aloud processes in novel tasks or for the younger children who had difficulty counting or regulating their movements when programming the Bee-Bot or creating algorithms with cards. They guide their thinking either through a series of closed-ended questions or with the use of non-verbal cues (e.g., gesturing, pointing). In other cases, teachers break down a task in more manageable parts and assist children's process of thinking (e.g., decomposition). Teacher 2 for example was particularly open to allowing children to make mistakes and observe their outcome, while encouraging them to seek alternative solutions. Similar strategies are also mentioned in another research (Wang *et al.*, 2020). In addition, teachers constantly reminded of the use of 'Delete' and 'Go' buttons, which children frequently seem to forget to use, a finding that has also been observed in another study due to children's limited memory and self-regulating skills (Misirli & Komis, 2023).

5.4. Young children´s preferences of CT activities

Some children initially stated in their interviews that they liked all activities, yet when forced to select their favorite one, the majority selected the Bee-Bot. Interestingly, most children explained that they liked collecting eggs. When requested to clarify if they liked that they pressed the buttons and made the robot move or collect the eggs children did not alter their response, but some replied both. It is most likely that the particular response was guided mostly by the teacher's questioning. In the unplugged activities, the experience of having a child dressed up as a snowman or creating a snowman with the pieces collected by robotcar seems more appealing to children than the use of cards to direct movement. Their responses indicate that the attractiveness of a task is defined by specific design features (e.g., dressing up, creating an artwork, collecting easter eggs, moving on the squares) and much less in terms of the programming task (e.g., pressing buttons or using cards and following directions). The features mentioned by children comply with teachers commenting about the importance of creating playful activities where children are active, creative and engaged in fantasy play through story reenactment, which motivates children's engagement. Children's preferences and teachers' comments are in accordance with recommendations made by experts for technology integration in early childhood education who state that such activities should be developmentally appropriate (NAEYC & Fred Rogers Center, 2012).

Apart from cases where children could not provide justifications, a few children selected an activity in terms of appearance (e.g., Bee-Bot is cute), character features (e.g., he is good) or personal feelings towards the main character of the activity (e.g., because he is my best friend). Such responses reflect the characteristics of preschool children's thinking who are in the preoperative stage of their development. The outcomes comply with evidence of young children's animistic thinking (e.g., objects are alive), while their difficulties in logical thinking affect their ability to reason (Lightfoot *et al.*, 2024). Additionally, their emotions during task engagement also impact their preferences.

5.5. General discussion

In conclusion, teachers in the particular school seem to be able to design appealing activities that cover all facets of CT, concepts, practices and perspectives except for loop, iteration and generalization. A range of activities were implemented, the majority of which were developmentally appropriate as they offered hands-on experiences, they were mostly open, some allowed young children's creative expression and movement. Teachers were able to scaffold children's thinking and their performance. Children experience pleasure from successfully performing the task therefore fostering their motivation towards novel activities. Children's preferences towards the activities are due to the particular design features and less to the programming task itself, while using cards to create algorithms was not considered as a challenging task. The use of groupwork seems to diminish the degree of difficulty and reduce errors as two children check the algorithm and debug it beforehand ensuring successful task completion. Following the positive technological development framework (Bers *et al.*, 2022), the outcomes of the study point out that most implemented CT activities facilitated learner's agency, as children were motivated, participated actively, expressed themselves in creative ways within a collaborative learning environment and allowed choice of conduct highlighting the quality of educational experiences offered to children.

5.6. Study limitations and suggestions for further research and practice

A major advantage of the present study is the collection of data from various sources (i.e., teachers' diaries, videos, teachers and children's interviews), the close collaboration with one teacher during the coding of activities, which triangulates findings and increases the reliability of the particular outcomes. Furthermore, children's

perspective is also taken into consideration to clarify what activity feature is most appealing to them. The selection of the kindergarten is also ideal, as the development of CT has been chosen for the present year as the school improvement project, teachers were experienced, having implemented in the past similar activities. On the other hand, the study has limitations as it focuses on one school setting, therefore the outcomes cannot be generalized. Further research based on class observation is needed and evidence from more schools to substantiate what type of activities assist children's CT combined with the assessment of CT skills for the effectiveness of such practices.

Finally, the outcomes of the current study could have implications for educational practice. Notably, developing teachers' awareness of how specific design features can make CT activities more appealing for young children and how specific activities can foster particular concepts, practices and perspectives. The outcomes of the current study is one of the few that examined the particular issue within an early childhood setting, illuminating the feasibility of implementing such activities to children 4-6-year-old. Further research in collaboration with practitioners is needed in designing effective activities that can facilitate all facets of CT in a developmentally appropriate way.

Acknowledgements

I thank my supervisor Dr. Leo Siiman for his support, comments and suggestions throughout the course of this dissertation.

My sincere gratitude is extended to the kindergarten teachers who accepted me in their classes and to the kids who were simply delightful to observe and converse with. Without their collaboration this study would have not taken place.

Author's declaration

I hereby declare that I have written this thesis independently and that all contributions of other authors and supporters have been referenced. The thesis has been written in accordance with the requirements for Master thesis of the Institute of Education of the University of Tartu and is in compliance with good academic practices.

29 May 2025 Chrysoula Kapsali Moschovaki

References

Angeli, C., & Valanides, N. (2020). Developing young children's Computational Thinking with educational robotics: An interaction effect between gender and scaffolding strategy. *Computers in Human Behavior*, *105*, 105954. https://doi.org/10.1016/j.chb.2019.03.018

Bati, K. (2022). A systematic literature review regarding Computational Thinking and programming in early childhood education. *Education and Information Technologies*, *27*(2), 2059-2082. https://doi.org/10.1007/s10639-021-10700-2

Bers, M., Strawhacker, A., & Sullivan, A. (2022). The state of the field of Computational Thinking in early childhood education. *OECD Education Working Papers*, No. 274. OECD Publishing. https://doi.org/10.1787/3354387a-en

Cohen, L., Manion, L., & Morrison, K. (2008). *Research methods in education* (5th ed.). Metaixmio [In Greek].

European Commission (2020). *Digital Education Action Plan (2021-2027)*. *Resetting education and training for the digital age.* Retrieved from https://bit.ly/3JJK8O7 & https://bit.ly/45sooT9

Fox, N. J. (2000). Using interviews in a research project. In N. Mathers, N. J. Fox, & A. Hunn (eds.), *Research approaches in primary care* (pp. 113-134). Radcliffe Medical Press/ Trent Focus.

Jewitt, C. (2023). *An introduction to using video for research*. NCRM Working Paper. NCRM.

Knoblauch, H., Tuma, R., & Schnettler, B. (2014). Video analysis and videography. In Flick, U. (ed.), *The SAGE handbook of qualitative data analysis* (pp.435-449). Sage. https://doi.org/10.4135/9781446282243.n30

Lee, J. & Junho, J. (2019). Implementing unplugged coding activities in early childhood classroom setting. *Early Childhood Education Journal, 47*, 709-716. https://link.springer.com/article/10.1007/s10643-019-00967-z

Lee, J., Joswick, C., & Pole, K. (2023). Classroom play and activities to support Computational Thinking development in early childhood. *Early Childhood Education Journal*, *51*, 457-468. https://link.springer.com/article/10.1007/s10643-022-01319-0

Leung, S. K., Wu, L. J., & Li, J. W. (2024). Children's knowledge construction of Computational Thinking in a play-based classroom. *Early Child Development and Care*, *194*(2), 208-229. https://doi.org/10.1080/03004430.2023.2299405

Lightfoot, C., Cole, M. & Cole S. R. (2022). *The development of children*. Gutenberg [in Greek].

Martins, E. C., da Silva, L. G. Z., & de Almeida Neris, V. P. (2023). Systematic mapping of Computational Thinking in preschool children. *International Journal of Child-Computer Interaction*, *36*, 100566. https://doi.org/10.1016/j.ijcci.2023.100566

McCormick, K. I., & Hall, J. A. (2021). Computational Thinking learning experiences, outcomes, and research in preschool settings: A scoping review of literature. *Education and Information Technologies*, 3777-3812. https://doi.org/10.1007/s10639-021-10765-z

Misirli, A., & Komis, V. (2023). Computational Thinking in early childhood education: The impact of programming a tangible robot on developing debugging knowledge. *Early Childhood Research Quarterly*, *65*, 139-158. https://doi.org/10.1016/j.ecresq.2023.05.014

NAEYC & Fred Rogers Center (2012). *Technology and Interactive Media as Tools in Early Childhood Programs Serving Children from Birth through Age 8.* Retrieved from https://bit.ly/43xOgKL

OECD (2023). *Empowering young children in the digital age*. *Starting strong.* OECD Publishing. https://doi.org/10.1787/50967622-en

Penn-Edwards, S. (2004). Visual evidence in qualitative research: The role of videorecording. *The Qualitative Report*, *9*(2), 266-277.

Penteri, E., Chlapana, E., Melliou, K., Filippidi, A., Marinatou, T. (2022). *Curriculum for early childhood education - Expanded version* (2nd ed.). Institute of Educational Policy [in Greek]. Retrieved from https://iep.edu.gr/el/nea-ps-provoli

Relkin, E., de Ruiter, L. E., & Bers, M. U. (2021). Learning to code and the acquisition of Computational Thinking by young children. *Computers & Education*, *169*, 104222. https://doi.org/10.1016/j.compedu.2021.104222

Rowan, B., & Correnti, R. (2009). Studying reading instruction with teachers logs: A tool for assessing transformative learning processes. *Educational Researcher, 38*(2), 120-131. https://doi.org/10.3102/0013189X09332375

Sands, P., Yadav, A., & Good, J. (2018). Computational Thinking in K-12: In-service teacher perceptions of Computational Thinking. In M. S. Khine (Ed), *Computational Thinking in the STEM disciplines: Foundations and research highlights* (151-164). Springer. https://doi.org/10.1007/978-3-319-93566-9_8

Saxena, A., & Chiu, M. M. (2022). Developing preschool teachers' Computational Thinking knowledge, attitudes, beliefs, and teaching self-efficacies: A curriculum-based professional development program. *Frontiers in Education, 7,* 889116. https://doi.org/10.3389/feduc.2022.889116

Saxena, A., Lo, C. K., Hew, K. F., & Wong, G. K. W. (2020). Designing unplugged and plugged activities to cultivate Computational Thinking: An exploratory study in early childhood education. *The Asia-Pacific Education Researcher*, *29*(1), 55-66. https://doi.org/10.1007/s40299-019-00478-w

Shute, V. J., Sun, C., & Asbell-Clarke, J. (2017). Demystifying Computational Thinking. *Educational Research Review, 22,* 142-158. https://doi.org/10.1016/j.edurev.2017.09.003

Su, J., & Yang, W. (2023). A systematic review of integrating Computational Thinking in early childhood education. *Computers and Education Open*, *4*, 100122. https://doi.org/10.1016/j.caeo.2023.100122

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Wang, X. C., Choi, Y., Benson, K., Eggleston, C., & Weber, D. (2020). Teacher's role in fostering preschoolers' Computational Thinking: An exploratory case study. *Early Education and Development*, *32*(1), 26-48. https://doi.org/10.1080/10409289.2020.1759012

Wing, J. (2011). Research notebook: Computational Thinking-What and why? *The Link.* Retrieved from https://bit.ly/43zxvyU

Zeng, Y., Yang, W., & Bautista, A. (2023a). Computational Thinking in early childhood education: Reviewing the literature and redeveloping the three-dimensional framework. *Educational Research Review*, *39*, 100520. https://doi.org/10.1016/j.edurev.2023.100520

Zeng, Y., Yang, W., & Bautista, A. (2023b). Teaching programming and Computational Thinking in early childhood education: A case study of content knowledge and pedagogical knowledge. *Frontiers in Psychology*, *14*, 1252718. https://doi.org/10.3389/fpsyg.2023.1252718

Appendix I. Children's interviews

Interviews 28-30 April 2025

Context: Bee-Bot

Which game do you like the most and why?

Kid 1: The little robot. Because it was very big. It was difficult to fix him. I liked that he walked on the tiles.

Kid 2: The snowman. I liked that we played the snowman.

Kid 3: The Bee-Bot. It had a bigger path, and I liked that I was pressing the buttons.

Kid 4: The Bee-Bot because it's nice that it collects eggs.

Kid 5: The Bee-Bot. I didn't like the other classroom.

Kid 6: The Bee-Bot because it walks.

Kid 7: The Bee-Bot that is moving.

Kid 8: The little robot because I like robots, I liked that we put the arrows.
The Bee-Bot because we were pressing the buttons and it was going forward.

Kid 9: The little robot because we had to play and be happy that we fixed the snowman.

Kid 10: The snowman. I liked the snowman (he means the disguise) but the teacher didn't make me one.

Kid 11: The snowman because he is nice.

Kid 12: The Bee-Bot because you may press the buttons.

Kid 13: The Bee-Bot because it finds eggs. I liked it because it could move (with guidance).

Kid 14: The Bee-Bot because when we press it the sound it makes is like 'tik-tik' and afterwards we take the eggs and we can play freely.

Kid 15: I liked all of them. At the Bee-Bot, I liked that we collected the eggs. I liked that I pressed all the buttons and it was moving.

Kid 16: All of them. The Bee-Bot because I love it.

Kid 17: I liked the snowman because it was Kid 21 and he was my best friend at the other school.

Kid 18: The Bee-Bot because it collects eggs.

Kid 19: The Bee-Bot because this game has colorful eggs. I liked the Bee-Bot and the eggs.

Kid 20: The little robot because it sees them.

Kid 21: The Bee-Bot because we are guiding it,

Kid 22: The snowman because someone was the snowman (the disguise),

Kid 23: The little robot. I don't know.

Kid 24: The Bee-Bot because it's sweet and goes wherever we tell it.

You liked that you made it move?

Yes.

Interviews 28-30 April 2025

Context: Bee-Bot

What did you play at this game? How Bee-Bot functions?

Kid 1: I don't remember. We press the button and then go. It collected eggs.

Kid 2: It went to take the egg, the purple one. I pressed X, then go and it went to the pink egg.

Kid 3: We were putting the egg and it had to get it. I was pressing the button, then go (button) to make it turn.

Kid 4: I was pressing the buttons here.

Kid 5: It was taking eggs. I was pressing the buttons and it went there that I wanted.

Kid 6: We press buttons and it moves.

Kid 7: It sounds like 'bim-bim', it moved and it got the egg.

Kid 8: We were guiding the Bee-Bot to go to the egg, to the color the teacher said. We were pressing the buttons and afterwards I pressed the go and it walked to the egg to help the rabbit.

Kid 9: It had to go at the color of the egg and at the height the egg was. I was pressing buttons, I counted 7 buttons, and I pressed go and it started moving to the way I led.

Kid 10: It collects eggs. I used buttons, I pressed them and went to the egg.

Kid 11: To go from here, from here (points with the finger). I pressed blue and red (eggs).

Kid 12: The Bee-Bot to follow the blue (egg), has to climb 3 times and one, two times right, it begun to shout.

Which egg Bee-bot had to follow?

This, this or this.

Kid 13: We were pressing buttons and I was finding the eggs. It was easy.

Kid 14: We had to take the eggs and find the other couple. We press the buttons and afterwards we were winning the eggs. It did 'tik- tik'.

Kid 15: Teacher said to take the small blue egg. Bee-Bot went by pressing 4 times (the directional buttons) and after the green go and afterwards I took the egg.

Kid 16: It was collecting eggs. Forward, in the middle and after green (she means the site of the buttons)

Kid 17: It was taking the eggs (he didn't remember its name). We pressed the arrow from above, pressed the yes (he meant the go button) and it started.
Was it difficult?
No.
Was nothing difficult to you?
A bit but afterwards I made it.

Kid 18: You press the buttons and Bee-Bot moves.

Kid 19: Teachers was telling me the color of the egg and we were pressing the buttons and the Bee-Bot was going to the colors! We pressed the forward 6 times and then Bee-Bot catches it.

Kid 20: It moves.

Kid 21: We had to lead the Bee-Bot to take a suitcase and we had to keep the suitcase. I had to press, it had 4 buttons, one that leads (forward, back, right, left). If we haven't done perfectly, we can press X and you can press again the button to move.

Kid 22: It had to find an egg. We counted the boxes and then as many boxes as the number on the front right said and then it reached the egg. Easy!

Kid 23: Bee-Bot was looking for them and going underneath and grabbing them. It had some buttons and we pressed them and it was going. We were pressing them and everything would end, we were pressing a medium green one and it was starting.

Kid 24: Teacher was telling us where to go and I was guiding the Bee-Bot. Above it has buttons that we were pressing and it moved. It found the egg and then another kid did.

Interviews 28-30 April 2025

Context: Snowman and little robot

What the little robot was trying to do? And what did you do with these cards? Were the cards difficult?

Kid 1: **-**

Kid 2: There was a driver (the kid who was responsible for the cards). He makes cards to go to the snowman. With steps (showing the steps it had to take)

Kid 3: We were putting the arrows and the little robot had to take a piece of the snowman. The cards to turn and go forward.
Were the cards difficult?
No

Kid 4: I was putting arrows, and the snowman moved to meet his friend. Yes. For the arrows, snowman was sticky and I couldn't put.

Kid 5: To follow the arrows.
Were the cards difficult?
No.

Kid 6: I was using the arrows, they were showing to the car where to go. It's easy

Kid 7: -

Kid 8: We were putting arrows to him. We were telling him to go (the arrow) do not step to the bacteria.
And it followed them (the arrows)?
Yes.
Was it difficult?
No, it's very easy. I go straight ahead and then right.

Kid 9: He had to put the arrows and go forward... Turn, forward...
Were the cards difficult?
A little but not that much

Kid 10: Arrows to go to the snowman. The cards were very easy.

Kid 11: He shows with the finger the floor game.

Kid 12: We were putting an arrow (shows with the finger the path).

Kid 13: We were putting the cards. It had to follow the cards (it showed them the way). It was easy. We made the cards and it found all the pieces.

Kid 14: We had these arrows and it moved with the directions. It was easy! We helped it with the cards.

Kid 15: We had to put the go's (shows the card), 4 times go, the snowman had to walk 4 times.

Were the cards difficult?

No, it was not difficult.

Kid 16: We were telling him one forward, one back at the snowman.

What the cards are doing?

Forward, forward (2 times forward), I don't know, with these the snowman moves.

Kid 17: We put the arrows and the snowman started. They were easy.

Kid 18: The Cards were for the snowman to move. It was easy.

Kid 19: We were putting the arrows, the snowman was following the arrows to go to his friend.

Were the cards difficult?

No, it was easy because I'm 5.5 (years old).

Kid 20: Arrows. He was seeing the arrows (with my guidance).

Kid 21: We, the kids, were putting the arrows. I had to walk to read the arrows. It was a little difficult but I made it.

Kid 22: Because we had the arrows, they were showing where to go. We put at him (the robot) the arrows and the little robot arrived at the hat.

Were the cards difficult?

No, a little… it wasn't. The yellow (card) was difficult because I was confused, if it was left or right.

Kid 23: I tried not to step on these (the suns), we were putting arrows and when the snowman saw them, he was going to them.

Kid 24: We were putting the arrows and they were showing him where to go to find the snowman. They mustn't lead him to the sun because he was melting. Some kids moved him, they were going with him. They were searching to find a piece.

Did they use cards?

Yes.

Was anything difficult for you?

No, nothing it was easy. Not at all.

Appendix II. Teachers' group interviews

Interview with teachers from class 1 (5/5/2025)

I:[2] So. The first question is, did you know the concept of computational thinking before this study?

T2: Yes. What do you mean before this study?

I: This program that you did (computational thinking), and where did you learn or hear about it before?

T3: Basically, we have learnt everything on our own.

T2: We had heard about various groups from the Internet that deal with such seminars.

T3: Because we liked them basically, we got involved.

T2: Here are some seminars on eTwinning that are held on these. However, most of them we had heard from the Internet.

T3: Yes.

I: Yes, so you haven't been trained in computational thinking in the past and, I don't know, did you mention seminars?

T2: Officially no.

I: But you did a seminar this year I think.

T2/T3: Yes.

T2: I think it's the first time that such a seminar has been held.

T3: First time organized like this.

T2: It all started with the coronavirus when we needed to use new technologies and because we didn't know, back then, it was done in groups, everyone was very involved in all this because we knew almost nothing and because we liked it, we got involved and one thing led to the other and we learned the most from there.

I: Okay, I understand. How the kids responded to the activities in your opinion?

T3: The kids really like it.

T2: And they are also the kids of technology. It is better to give them this than the traditional one. I think they are tired of it now.

I: Why?

T3: They grew up with computers and they are interested in them.

[2] I: Interviewer; T: Teacher/interviewee.

T2: It's what we used to do, we learned it at universities. Little by little, I mean we have to put all this into our lives, but not just do this, but it has to be definitely in the program.

I: What were the main difficulties that the children encountered during the activities? Was it easy for them to use the arrow cards, for example?

T2: Yes.

I: How do you usually use these cards?

T3: However, the children did not have any difficulty using the cards.

T3: They are having difficulties. Let's say, the straight lines, which are the cards in front and back, are easy. Right and left, that we can't say right and left, because they don't know it very well yet, but if we say, for example, in the closet or if we use a fixed reference point, let's say on the board, they can. What they are having difficulty with even now, while we have done a lot of work, is, let's say now in the Bee-Bot, for example, when we are straight and we have to turn at the same point and then move on. This makes it very difficult for them.

T3: This is the only thing.

I: In all activities or only in activities with cards?

T3: Everything that has to do with arrows makes it difficult for them.

I: Anything else that was difficult for them besides those arrow cards?

T2: I don't think so. Do you remember anything else from what we've done?

T3: I'm trying to remember but I think it's just the arrow paths.

I: Okay.

T2: Okay, let's say we make a program. I don't know if that's in your topic.

T3: Algorithms, you mean.

I: And isn't that the thing with the cards an algorithm?

T2: Yes. And they can also make an algorithm themselves. Older children can do it much easier. Younger ones still need a little work, but if you start with them, you'll slowly get to a point where they can come up with an algorithm for you too.

I: And how did the children with special needs respond to these activities?

T3: At first, they had difficulty. However, after several examples and always with guidance from the kindergarten teachers. They will not do it alone, but if the kindergarten teacher is nearby, they participate.

T2: With help.

T3: Yes.

T2: It gives them pleasure.

I: Which computational thinking activities did the students enjoy the most in your opinion and what is it that makes them attractive?

T3: I think with the Bee-Bot more.

T3: The other thing we played was with the Snowman and with the dramatization. I believe that there must be a motivation. We are playing a game. With the aim of achieving something, do you understand what I want to tell you? The motivation, because if there is no motivation and you start it without any purpose, that is, we do it to achieve. For example, what did we have to do at the beginning, remember?

T3: With Snowdrop.

T2: That we wanted to free it (the snowdrop) and we had to go through many tests that had all this, algorithms and computational thinking, they liked it very much. I believe that this will pique the interest of the children. Moreover, it is also the way you will convey it to the children. Depending on how you say it, the children will respond to whatever you tell them, as long as you tell them.

T3: And you also have the appropriate images to show them what they will do. These images should be attractive.

We had, let's say, the tower that was a closed Snowflake. We're not saying that you're just going to get the snowflake on top of the table.

T3: The kids played some roles. Do you understand? I mean, I believe that they can respond to anything as long as you find the right way to tell them.

I: OK after completing the program, have you noticed any difference in the students' skills?

T2: Yes, it has been a lot of time now since we dealt with it, but I think if we put them through something like this, I think it will be much better.

T3: They can now do activities with the Bee-Bot more easily.

T2: And they understand more things.

I: Which tools and platforms were your favorites for implementing these computational thinking activities?

T3: What do you mean?

I: Which tools did you use that were your favorites? I guess you liked Bee-Bot, but did you use anything else that you might have liked?

T2: We used Bee-Bot a lot, and its application on the computer.

I: So, it has an application on the computer, okay.

T2: We didn't use the computer a lot. We mostly played games without the computer. We didn't stay on the computer that much. They were activities without the computer, we mostly played with Bee-Bot.

T3: On the computer or not though.

T2: But I don't know if that's what you want.

I: Tools or the platform and whatever else.

T2: The other one is with the algorithms that they would make an algorithm (the kids). It was the little artists that had tools with an algorithm. This app is called the little artists I think.

I: Okay. Were there any tools that were missing that didn't allow you to effectively implement the computational thinking activities?

T2: No.

I: So, you had everything. Great. Were there any challenges in integrating the computational thinking activities into your teaching strategy?

T3: Look, we play games with Bee-Bot in almost all the subjects we use.

I: Did you have any difficulty, any challenge?

T2: The challenge was at the beginning.

T3: To find activities.

T2: To adapt the program we wanted, so that it would be attractive to the children and to the level of the children's learning. This was a little difficult and we didn't know how much it would succeed, but I believe that it did succeed, it didn't tire us particularly.

T3: Generally, there are no ready-made activities for kindergarten with computational thinking. That's the only thing.

T2: You have to make them yourself.

T3: That's all.

T2: It just helped us a lot that we as a school are familiar with it. We work on computational thinking every year at school. In addition, our old children are already familiar with it and along with the old, the new ones are also progressing. If a colleague who has not dealt with this topic, I think s/he will have too many issues.

I: So that was the challenge, to design them.

T2: Yes.

T3: Yes, the design.

I: Can computational thinking activities be integrated into your educational practice or are there limitations?

T2: No, I don’t think so.

T3: I think they can if they are appropriately adapted.

T2: They have to be within the children’s capabilities.

I: Are you confident that you can integrate computational thinking activities again? Or do you think there are still gaps or challenges?

T2: If you're involved in this subject, new things keep coming up. Moreover, I think that every time we see something new that we haven't done and we say “oh, how cool to do that too”.

T3: There are always challenges of course, but we're just in a good level.

I: And how would you further upgrade computational thinking activities in the future?

T2: How would we upgrade them? Hmmm…

T3: How would we upgrade them?

T2: We did some things. I think that next year we can add more things. So, let's say, now an algorithm has some features. We did some of them, I think next year we can add some other features. Got it? And make it richer.

I: So, you would enrich the existing activities. Would you also do new ones?

T2: Both.

I: That's it, thank you very much. Anything else you want to add?

3: No. I hope we helped you.

I: Thank you.

Interview with two special needs teachers from class 1 (5/5/2025)

I: Did you know the concept of computational thinking before this program, before this research?

T4: When I was studying at the University of Patras, we dealt with it a lot. We saw Bee-Bot and generally other robots as well like Thymios.

I: I don't know it.

T4: It works with sensors, I mean it detects on the floor, and they liked it a lot. In the summer they did a program, which I don't remember exactly the name, and all schools of Patras were gathered, and they did several games. For example, we had a theme. We were taking the planets and Thymios needed to follow a path or clap to make it stop, so I knew a bit how it works in robots etc.

I: Ok and what form had Thymios? Was it a little robot man?

T4: Imagine Thymios was a white square and it has different sensors down at the side. Let's say, below there was a line, a path actually with black tape which had gaps. It stopped when it found a gap and the kid had to find the rest of the gap or we had for them a square which had inside the planets and Thymios needed to go to earth for example and it (a kid) was going in front of it to stop it (Thymios) so that another sensor gets activated to make it change side. Or for example to make it stop you had to clap 2 times. It was adjusted accordingly, and you put also Lego on the top of it so you could shape it.

I: So, you had heard all of these things from the university.

T4: Not as computational thinking but it was this thing.

I: Ok. And what about you?

T5: When I was at the university there were no robots, not even computers to be honest. I finished in 1997. Mathematics was related to computational and we did it to simple teachings and practices but not for computational thinking. I think I have heard of it in the last years in seminars but not anything special.

I: Okay. In addition, where did you hear or learn about it? Through your job, through a seminar or anything else?

T5: Seminar.

I: Ok.

T4: And at work, they were using it a lot (computational thinking). It's my third year at the job but I can say they were using it but not that much with the cards. Here

what we did was more practical apart from the use of robot, but the others were using mostly the robot.

I: Okay. Have you been trained to computational thinking concepts before? For example, through a seminar, in-service training, but without counting the seminar you attended this year.

T5: That's what I was going to say.

T4: It hasn't happened before in such detail etc.

I: And how did kids respond to these activities?

T5: They were very interesting. It was something different, they participated, and they didn't face many difficulties.

T4: Each time it was on the theme of the day so it would last longer, but once robot entered, they were getting enthusiastic of course. In my mind, the last years, I believe many kids do something similar in the afternoon.

I: At home?

T4: There are many labs where they go that's what I have understood. They already know.

T5: I have thought that they are familiar with already and kids are now familiar with technology, so for sure they like the little robot, but generally I think that interdisciplinarity has played a significant role on how you practice with movement, mathematical thinking, you can practice several things. You can produce a story and they like it.

T4: They like it a lot. Someone puts some things in an order and then they can see when their classmate performs it, what will be the result.

T5: ... to produce something. I think this is what plays a significant role.

I: Which were the difficulties that kids faced throughout the activities? For example, was it easy to use the cards with the arrows? Usually, how do you use them?

T4: They didn't face many difficulties. Maybe some kids with left and right direction.

T5: We were using a point of reference. For example, at the right side there is the wall, at left the side of the door. So, we had this point of reference that was helpful to them.

I: So instead of right or left you were saying "towards there".

T5: We were repeating right and left, to get used to it, but the direction of "what is there" helped them. For example, what's at the right side.

I: Ok. How kids with special needs corresponded to them?

T5: I think satisfactorily and even better. Maybe S… (boy with autism).

T4: Yes S. is generally more hesitant. When we were at the dining tables when we were using the Bee-Bot, he was participating, with the cards he didn't participate

I: What about the other kids?

T4: St. likes it

T5: Now that I think of it again, I think you are right; it didn't work out so well. Yes St. (another boy with autism) participated easier, S, so and so and St. not all the time.

T4: St. I think generally in the activity with the cards, once he sees the robot, he participates. I remember it when playing at the tables. Nevertheless, at the part with the cards, he had the tendency to destroy it once he started to get bored.

T5: He wanted to leave.

T4: Yes.

T5: He couldn't stand it much time. E… (nonverbal boy with autism) didn't participate, we just made the path. He touched it but for a while. No, maybe it didn't go that well now that I think of it. Only St. corresponded somehow better. It was a bit stressful for the teachers as well. There were too many people, the camera, the whole equipment that maybe tuned them out.

I: We talked about S… and St... One time I saw M... (boy with down syndrome) and he did really well.

T4: He likes it, but he is also calmer generally. I remember him at the tables with the robot.

I: Okay. Which computational thinking activities did kids enjoy more? What made them appealing? What do you think?

T4: For sure whenever there was the robot and another appealing one that we did was at the carpet where we created a story. There were parts of a snowman, and they had to "fix" it. To gather all together its parts and complete it. A second kid was coming which helped to examine if this order of actions will give us a result.

T5: Especially when they create something and when there is feedback, this keeps them interested and they participate.

I: After the completion of the program, have you observed any difference at children's skills?

T4: We have used many related worksheets. With the arrows they have thought more of the path. However, since then we haven't done anything again, regarding robots.

T5: I believe over time they have been getting more mature.

I: Okay, thank you very much.

Interview with teacher and special needs teacher from class 2 (7/5/2025)

I: Did you know the concept of computational thinking before this study?

T6: I didn't know it in that much detail. The truth is, I hadn't read it extensively or heard much more about it. Now and with an informative seminar, I had learned some more things and about how we can integrate it into the context of the age group that we have here at school.

T7: Personally, I saw the term when I completed the selfie for teachers after participating in an e-twinning seminar. I was curious because the curriculum does now mention it.

I: Ok, have you been trained in the concept of computational thinking in the past with seminars or in-service training, but without what you did this year?

T6: The truth is that to a very small extent. Maybe not at all, because we have often referred to technologies and tools that we can use simply as a concept so we had not been so analytically dedicated to this topic. Nevertheless, it is certainly part of other things that we had seen in school and afterwards. Indeed, in school it did not exist as a term. Not as a course, nor do I remember it as a topic. Mainly it was the technologies in the course that we simply did. We did so many things that some ideas were similar to this.

T7: Personally, I haven’t any training at the university, as I am much older. I also didn’t participate in any seminar related to computational thinking. However, I was curious to learn more and I searched a lot through the internet so I had some idea. I prepared the seminar for the school after reviewing research and practical applications mainly from articles.

I: How did the children respond to these activities?

T6: Whenever it has technology, which is part of the teaching, it is something very interesting for the children. When it is the first contact, with the concepts of direction, it is a difficult unit, a difficult skill sometimes, but with practice they understand exactly how it goes to direct a robot somewhere, but in general they are interested and they always watch it, as many times as I have happened to see it.

T7: I think that they liked them, they wanted to participate and they weren’t afraid to try.

I: Ok; In your opinion, what were the main difficulties that the children encountered during the activities? And also, was it, let's say, easy to use the cards with arrows?

T6: Well, depending on the activity, it might have been difficult for them if it was too complex, but it helps a lot to put arrows because it helps them see a little bit in detail and step by step a direction, so that definitely helps with the arrows and that was what helped them the most in completing it correctly. Otherwise, yes, if it is too complex with many turns or changes of direction, it might have been a little more demanding and complicated for some children, but yes, we also adapt it to the level of each one.

T7: Yes, that is true. In my class, I have a lot of younger children and children with difficulties and I didn't use a lot of the cards. I saw that the younger ones prefer to select a route that is straight and avoid turning.

I: And when do you usually use them on the cards?

T6: The cards with the arrows, you place an arrow in each box of the grid, depending on which direction the bee should follow.

T7: in my class, I prefer to use them after completing the route and use them on the grid to show the direction followed. It is used more for reflection than programming.

I: Ok, how did the children with special needs respond to the computational thinking activities?

T6: That depends on the level of each child. If it is to the extent that a child's understanding is required to be able to cope, then it's simplified. Mainly of course, we gave them simplified routes to follow and they were able to cope. We didn't try very complicated ones, but the simplified ones were fine too, there were some children who perhaps needed more help, even which button they needed to press, let's say.

T7: Yes, I agree.

I: Okay. Which computational thinking activities did the students enjoy the most in your opinion and what do you think makes them attractive?

T6: I'm not here every day but from the ones I remember seeing they were nice ones where we gave direction with our own bodies. We had arrows and I remember, we had to follow a certain path in order to get somewhere, so they would say, I'm going there, I'm going to turn there or whatever they liked. Moreover, they also really liked the Bee-Bot that gave him direction with the arrows.

T7: I think the Bee-Bot, but also all activities that they have to create something or move with their bodies.

I: What do you think makes these activities attractive?

T6: The fact that it's not often part of the school curriculum is what makes it something more special, they don't have time to get bored of it. The fact that it has to do with technology is something that is everywhere these days and is very attractive, whether they like it or not. Whether it's that we press buttons that the bee has and it makes noise, it has lights and it makes it quite attractive, I think. It has a nice appearance already. The fact that we can combine it with many themes, that is, if we have a suitable grid, whether we're talking about spring or winter, we can include it if we want.

T7: You are right. But also, we try to make them interesting, when children are asked to help snowman from melting, to free snowflake from prison, to help Bee-Bot not to sink, they are motivated to help the heroes, the task has meaning for the children and they enjoy it more if it becomes part of their fantasy play.

I: And upon completion of the program, have you noticed any difference in the students' skills?

T6: They have definitely gained experience with it, which was obvious, the next times it was used. They were more ready and with more knowledge about what we do. And how they will use the robot, the concepts of right and left are things some people may not have fully understood yet, but they definitely have a sense of orientation that if they point somewhere they will know that I am now pointing in that direction. Yes, they have definitely helped.

T7: Yes, they are more confident and now they want to try more routes that are difficult. They gradually are more capable in expressing themselves and do tasks that they need to work for several days for examples make their own story.

I: Okay, thank you very much.

Non-exclusive licence to reproduce the thesis and make the thesis public

I, Chrysoula Kapsali Moschovaki,
(author´s name)

1. grant the University of Tartu a free permit (non-exclusive licence) to

   reproduce, for the purpose of preservation, including for adding to the digital archives of the University of Tartu until the expiry of the term of copyright, my thesis

   IMPLEMENTING COMPUTATIONAL THINKING ACTIVITIES IN A GREEK KINDERGARTEN ,
   (title of thesis)

   supervised by Leo Siiman ;
   (supervisor´s name)

2. grant the University of Tartu a permit to make the thesis specified in point 1 available to the public via the web environment of the University of Tartu, including via the digital archives, under the Creative Commons licence CC BY NC ND 4.0, which allows, by giving appropriate credit to the author, to reproduce, distribute the work and communicate it to the public, and prohibits the creation of derivative works and any commercial use of the work until the expiry of the term of copyright;

3. am aware of the fact that the author retains the rights specified in points 1 and 2;

4. confirm that granting the non-exclusive licence does not infringe other persons' intellectual property rights or rights arising from the personal data protection legislation.

Chrysoula Kapsali Moschovaki
29/05/2025