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# THE INTEGRATION OF ALGORITHMIC THINKING INTO PRESCHOOL EDUCATION

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## Abstract

Algorithmic thinking involves the ability to think so that the problem to be solved is interpreted as a series of simple and small tasks that lead to a solution. An algorithm is a set of simple instructions that lead to the solution of a task. Instructions should be specified in a way that anyone can solve this problem. Algorithmic thinking skills are not just related to computer science and programming. These skills are used in all areas of activity, when solving problems. First of all, the problem must be understood, while it is necessary to assess how it can be solved, choose the best strategies, break the problem into smaller sub-problems and solve them step by step. In this way, algorithmic thinking can be used and taught in early and preschool education, every time children encounter a new problem or situation. The role of educators is to guide children to understand, assess and recognize the problem themselves and to help them in taking steps to solving the problem whether they are right or not. Children can easily learn about the concept of algorithms using examples from their everyday life. For example, at an early age, children may describe algorithms that include steps to dress or brush their teeth, while older children may use algorithmic steps to conduct an experiment. By learning algorithmic thinking skills, children can more easily interpret data and develop thinking strategies to understand and solve problems at a very early age.

The ongoing Erasmus+ project “Algolittle- Algorithmic Thinking Skills through Play-Based Learning for Future’s Code Literates” involved 46 educators in the Workshop for the Integration of Algorithmic Thinking Skills into Preschool Education for stimulating algorithmic thinking of the children in their care in everyday situations. The participants were introduced to algorithmic thinking skills through play-based activities. Discussions followed about algorithms, algorithmic thinking skills and integration activities. After the workshop a qualitative analysis of the educators’ opinions about integration of algorithmic thinking skills into preschool practice was carried out.

Keywords: algorithmic thinking, problem solving, preschool education.

## 1 INTRODUCTION

The starting point of the National Curriculum for Early and Preschool Education is in "understanding the child's learning as a result of his active and involving participation in various activities". Children learn through play and, through direct experience of a variety of learning resources, apply research and other activities. Children need to be computer - literate in order to be able to participate fully in today's society, either as users or creators of digital technology [18]. Thus, the need to provide children with access to computer science education from an early age has been already recognized [2], [3], [17]. Modern education is based on research, information exchange, teamwork and the connection of different knowledge in which different knowledge and skills are applied. This approach encourages critical thinking, problem solving, creativity in approach and communication among students and drawing conclusions. These skills and competencies are acquired and practiced from the first days of the child's encounter with the environment [14].

The concept of Algorithmic thinking has been present since the 1950s and 1960s, referring specifically to the use of an ordered and precise sequence of steps to solve problems and (when appropriate) a computer to automate that process [24]. The term derives from the concept of an algorithm, which refers to solving a problem by developing a set of steps taken in a sequence in order to achieve the desired outcome [12], [19], [21]. According to Wong and Jiang [23], algorithmic thinking is considered as “an integral component of computational thinking, which means formulating a solution in the form of algorithm or a series of steps”.

Algorithmic thinking can be used for any problem - solving process, either through coding or in real life situations [7], [15]. “Algorithmic thinking is the ability to think in terms of sequences and rules as a way

of solving problems or understanding situations” [5], therefore it requires certain skills as well. Algorithmic thinking skills in early childhood education include abilities to learn and do things according to the rules or models, meaning that children are able to understand, use, apply, and develop simple algorithms. Children are also able to analyze and correct the sequence of actions in order to achieve results, transfer familiar action methods to new situations and clearly describe their activities to others. An accurate description of the activity is possible mainly at the age of 4 and older, when children are able to verbalize their actions. Algorithmic thinking skills that can be taught in preschool also include breaking the problem into smaller parts, determining a procedure according to sequential steps, trying to find the most effective solution, developing logical thinking, legality, pre-numerical skills, and various other socio-emotional skills [22]. Problem - solving competency means engaging students in solving a problem using different strategies, approaching it from multiple perspectives and with diverse modalities. Its processes include: exploring and understanding; representing and formulating; planning and executing, and monitoring and reflecting [16]. There is a general misconception that algorithms are used only to solve mathematical problems, and are not applicable in other disciplines [24]. Kindergarten children are most easily introduced to algorithms first using examples from their daily lives. For example, at a younger age, the steps of washing hands or teeth may be prominent, while in preschool children it could be applied in successive steps during certain experiments. However, according to Shelton [20], the development of algorithmic thinking in young children does not necessarily require the use of computers, but can be achieved by “unplugged” methods, which are not an alternative to computer use, but are used as an auxiliary activity in understanding and solving problems. Understanding algorithms as a set of concrete and precise steps provides a basis for understanding how an algorithm is developed, which can later be more easily applied when learning programming [4].

Play is a very important activity for children in preschool education. Learning takes place in different ways during play, but there are different activities based on play and initiated by adults and free play of children through which children also learn. Important holistic issues in game pedagogy are freedom, choice, participation, and inclusion. Play and learning in context are strongly related. Playful learning or the use of a learning game is different from free play initiated and controlled by children as players, although some algorithmic thinking skills may be included in this type [4], [20]. Students of Early and Preschool education should learn to use play as a “source, context, and medium for children’s learning and development” [8]. When educators integrate algorithmic thinking skills into teaching through play-based learning, they should consider the holistic perspective of the child’s development and avoid “instrumentalization and regulation of play” [9].

Modern technological society, rapid progress of ICT and new learning strategies have become challenges in the education of new generations. This is a complex task for teachers who are expected to successfully teach these future generations. Teachers and educators need to be up- to-date with the 21st century competencies and skills and with the ability to select appropriate activities and digital tools for their students [11]. Very little research has been conducted **on** the development of algorithmic thinking skills in preschool children [10]. An example of such research was conducted by Voronina et al. [22], the results of which indicated that preschool children who were taught algorithmic thinking skills showed a much higher level of development of planning activities compared to the control group of children. Moreover, in these children increased self-regulation, self-control and self-evaluation of their actions were observed. They learned to use algorithmic thinking skills in various forms of their activities. Moreover, they mastered teamwork skills, collaborated effectively in pairs and groups in order to achieve desired results and were able to independently ask questions and reflect on their actions in the process of algorithmic activity.

The Erasmus+ Algolittle project was launched with the aim of increasing the competencies and acquiring knowledge and skills of undergraduate students of early and preschool education related to the use of algorithmic thinking skills through play - based learning, The main goal of the project is to prepare a course program and teaching materials to teach preschool teaching undergraduates how to reflect on the algorithmic thinking skills in all areas of preschool education, as an innovative approach. This project started on September 1, 2020, and will be running until August 31, 2021. The project coordinator is Izmir Democracy University from Turkey. The partners in the project include The Faculty of Teacher Education, University of Rijeka (Croatia), Polytechnic Institute of Viseu (Portugal), The Faculty of Education of the University of Maribor (Slovenia), The School of Robotics (Italy) and Educloud enterprise (Turkey). The most important activities of the project include the higher education curriculum for the course "Algorithmic Thinking Skills in Early Childhood" to be conducted in all partners’ countries in the academic year 2021/22. “The instructional design will be designed for preschool teaching undergraduates to support younger children to apply algorithmic thinking into all

learning areas and daily life tasks, so the design will be reflected in the teaching of integrated subject areas" [1].

One of the first partners' activities in the project was the organization and implementation of the workshop for preschool teachers from the practice in order to analyze and discuss how to integrate algorithmic thinking into all subject areas addressed in preschool education. Two workshops were held in Croatia, after which a qualitative research was conducted through focus groups.

## 2 METHODOLOGY

The aim of the research was to examine the preschool teachers' opinions **about** the term *algorithmic thinking* as well as possibility of applying algorithmic thinking steps in preschool education. Qualitative research was conducted through four focus groups with a total of 46 preschool teachers, educators in the Workshop for the Integration of Algorithmic Thinking Skills into Preschool Education in order to stimulate algorithmic thinking skills of children in their care in everyday situations. The focus groups have been carried out online after the workshops in two sessions on different dates. The first and the second focus group were organized online on 11<sup>th</sup> February 2021 and encompassed 17 educators from the kindergarten "More" in Rijeka, while the third and the fourth focus groups were organized online on 2<sup>nd</sup> March, 2021 and involved 29 educators from 7 different kindergartens from the Primorje-Gorski Kotar county and the Istrian county in Croatia. The implementation of the focus groups took place predominantly as a targeted conversation with pre-structured topics and subtopics on the application of algorithmic thinking skills and ways of following the steps of algorithmic thinking for reaching goals in the teaching process. Preschool teachers expressed their attitudes and opinions through a conversation, describing their experience in the application of skills and steps of algorithmic thinking in their work with children. The implementation of each focus group was recorded. Based on the obtained transcripts, the results were analyzed by systematizing the participants' answers to a particular question.

## 3 RESULTS

For the purpose of this paper the topic *The concept and application of algorithmic thinking skills in working with children* was analyzed through structured questions:

- What does algorithmic thinking present to you?
- Which skills of algorithmic thinking do you think could be taught at a preschool age?
- In which way would you apply the algorithmic thinking skills in working with children?
- How can we integrate algorithmic thinking skills in preschool education through play?

The group agrees that they have been using this kind of teaching and that they already apply certain algorithmic thinking skills in working with children but did not understand this in the way it was presented to them during the workshop. The participants gave concrete examples and ideas for integrating algorithmic thinking skills in different learning domains. It was noted that they suggested many activities for each learning domain in a short time regarding their own experiences. The examples mainly included the activities serving the development of linear algorithmic thinking skills. The participants quote: *"We use steps in executing tasks in everyday routine activities"*, *"The activities in the centres are carried out according to afore - planned steps, especially in tidying up the materials and toys"*, *"The examples of the usage of steps on a daily basis can be noticed in preparing cutlery and eating space"*, *"Respecting steps is noticeable in the routine of preparing children for going outside"*.

The educators stressed the importance of integrating algorithmic thinking skills in early childhood education through play - based learning, which was basically the main goal of the workshop. The participants emphasise that they use *"games with simple algorithms, simple experiments, dance choreography, board games, gamification, trial and error, storytelling, changing roles, labyrinth-solving exercises and specific situations that children encounter in everyday life..."* Interaction and awareness were established as a result of the examples, experiences, and discussions on how to integrate algorithmic thinking skills into early childhood education.

By systematizing the answers to the question: *“How can we integrate algorithmic thinking skills in preschool education through play?”*, the group was unanimous on the importance of play and the power of pretending while learning a concept. It was observed that the teaching of algorithmic thinking through games was suitable for young children. It was concluded that for many planned activities it is possible to integrate algorithmic thinking skills in preschool education with play-based learning. Examples of individual play activities were selected according to the statements of the participants: *“Coding games, for example Bee-Bot”, “Sport and music games, as examples dance steps with music related to the set choreography”, “Science games, with seeding as an example”, “Mathematics games, for example creating a puzzle according to the colour and number of cubes”, “Symbolic games, as an example theatre in kindergarten”, “Board games, for example rolling the dice with instructions on activities that have to be performed”, “Building games, with construction of a wooden bridge as an example”.*

The group concluded that the efforts they had invested in designing activities on the workshop will result in children showing interest in more frequent implementation of algorithmic thinking skills but also in their own interest in the context of innovation of the teaching process.

The second topic, *Algorithmic thinking steps to achieve the goal in the teaching process*, was analyzed through the questions:

- How can we apply algorithmic thinking in order to encourage children to follow in the paths/ sequences/steps to achieving the goal?
- How can we teach children to follow in pre-planned steps to achieve a goal?
- How to teach children to create a plan to solve a problem?
- How can we teach children to assess whether their plans and steps lead to a solution or not?

The participants’ reflections were provided by means how to offer several examples of activities that can be used to solve a problem through a series of steps or by repeating certain steps until a goal is reached. The group was unanimous that the main focus strategy is to create a teaching process including guidance in order to teach children follow in the steps to achieve a goal. Some participants quote: *“Asking questions using visuals to make children think about the solution ways”, “Discussing via choosing different solution ways”, “Repetition and play”, “Observing the results and process steps”.*

Therefore the proposed techniques are the following: asking questions, letting children talk about it, observation, drawing attention to a situation, discussing, trial & error, play...

The most agreed upon technique was play-based activities, i.e. letting children to create their own steps, to determine the rules of the games, and to follow in the steps themselves. Since many daily activities are natural examples of algorithms, teachers also suggested including children in daily life situations, giving examples and models related to everyday life and thereby letting them experience these activities in the form of an algorithm.

By systematizing the answers to the question *“How to teach children to create a plan to solve a problem?”* the group agreed that the most applicable techniques are various games, simulations and storytelling.

The polarization of attitudes was most apparent in the answers to the question: How can we teach children to follow in pre-planned steps to achieve a goal? The preschool teachers’ answers varied in this respect and included play-based activities such as *“giving examples, using materials, images, photos, pictures, art, videos, modelling, simulating daily activities, presenting, positive feedback to motivate them, reflect on what happened...”*. Another group of teachers proposed different concepts that do not include activities but ask questions and let children brainstorm. In regard to the question on how to teach children to evaluate the process steps the preschool teachers proposed that children should have been allowed to talk about what they did after they **had** tried to reach a destination or solve a problem. One participant said: *“This form of preparation is extremely good regarding the direction of the curricular reform we are undergoing”.*

All in all, the preschool teachers declared that creating simulation activities, different stories, manipulating the learning environment and presenting various parameters would lead children to think out of the box and look for different solutions.

The group also emphasized the improvement of personal competency of teaching in the implementation of the algorithmic thinking. Here are the highlighted answers: “*The ideas we have created can also be used in our subsequent work, as forms to be revised*”, “*I can devise activities by organizing play-based learning on computers*”, “*Such planned activities can contribute to the thematic-integrated teaching*”, “*I find the workshop beneficial*”, “*I am willing to receive news about the new workshops as well as participate in them*”.

The systematization of the answers lead to the conclusion that the preschool teachers had already conducted a multitude of applications of algorithmic thinking in their activities but were not aware of the fact that these applications could also serve for developing algorithmic thinking skills. Play-based learning was emphasized as the most appropriate method. It was realized that for a child’s holistic learning and development, an interdisciplinary perspective is just as important as examining algorithmic thinking and combining it with games.

## 4 CONCLUSION

There is not enough research related to the application and development of algorithmic thinking skills in the field of early and preschool education. Integrating algorithmic thinking into preschool education can increase educators’ knowledge and skills and improve their practice. Furthermore, such a method can contribute to the development of creativity and logical thinking in children, so that they will be able to transfer what they have learned to new situations. The Algolittle project will try, with modern teaching methods and strategies, to implement an algorithmic way of thinking, problem-solving skills, logic and creativity in the daily practice of future preschool teachers.

All preschool teachers involved in the focus groups point out that the workshop gave them a new perspective on developing various skills in children. They support the inclusion of the algorithmic thinking in the education of students, future preschool teachers. They feel that students will be highly motivated to learn about teaching based on games and problems. The results obtained through the focus groups will be used to improve some existing course curriculums of Early and Preschool Education study at the Faculty of Teacher Education in Rijeka, oriented to training students for integrated activities aimed at developing children's abilities, but also to develop a curriculum for the course "Algorithmic Thinking Skills in Early Childhood", which is one of the goals of the Algolittle project.

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