APPLICATIONS THAT HELP DEVELOP ALGORITHMIC THINKING

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ABSTRACT

Planning and managing one's own world is extremely important for every individual. We can learn how to do so as early as kindergarten (Match two cards, Tic-tac-toe, Domino, Jigsaw puzzle). There is a large number of games that symbolize real world and imitate real choices and activities with algorithmization elements. In kindergarten, the development of algorithmic literacy and digital technology can be effectively connected (visualization of objects and actions).

KEYWORDS

Algorithmization, Digital Technology, Pivot, Cards, QR Code

1. INTRODUCTION

Computational/algorithmic thinking can be developed in children in kindergarten. Game-based activities and tasks are used to develop children's computational/algorithmic thinking in a natural way. Every day pupils encounter activities in which they can see certain regularity, repetition and sequence of individual steps, e.g. brushing their teeth, making a drink, baking a cake, their daily routine (from getting up in the morning to going to bed in the evening), etc. Children need to realize that every activity has a specific progression – the sequence of individual steps (one always knows which step follows which). If a child omits any of the steps, or changes the sequence of the steps, they need to expect an incorrect result. The same can be said about various programs or machines which we encounter in everyday life. If the commands are incorrect, the program cannot be executed or contains errors.

There is a large number of definitions of computational and algorithmic thinking. Each new technology brings about new opinions. However, the most often used and quoted definition is the one by Jeanette Wing, who defines computational thinking as *“a way of solving problems, designing systems and understanding human behavior through basic concepts of computer science”* (Wing, 2010). This is a timeless idea which refers to the similarity of real and computer worlds.

Having observed the development of algorithmic thinking in the Slovak and English preschool environments, Ivan Kalaš defines algorithmic thinking and algorithmic literacy as *“a set of skills which enable an individual to control their behavior and make something happen in a desired way in a changing environment where there are other participants”* (Kalaš, 2011).

2. DIGITALIZATION OF EDUCATION

Digital technology can be used in preschool instruction. By effectively connecting technology, methodology, idea and didactic content, the teacher can develop their pupils' computational and algorithmic thinking in an enjoyable and natural way. What does the term digital technology, or information and communication technology mean? Kalaš and Moravčík (2012) introduce an interesting definition, stating that it is *“a wide set of instruments, processes and knowledge used to process and communicate information. In education, these are computational and communicational instruments, processes and information resources which support instruction, the education process and other learning activities in different ways”*.

Nowadays, when a teacher wants to be a good teacher, they need to be an expert not only in didactics and pedagogy but also in digital technology – they need to have digital competencies and be digitally literate.

The Framework Educational Program (2018) defines digital literacy as “*a set of digital competencies which an individual needs to be able to use digital technology for work, learning, in their leisure time and for taking part in social life in a safe, confident, critical and creative manner*”.

Digital literacy goes hand in hand with digital competencies. They are clearly defined both in the strategic document titled “The Digital Competence Framework for Citizens” (2017) and on the “The Development of Digital Literacy” website (2018).

- A. Information and data literacy
 - Browsing through, searching for and filtering of data, information and digital content
 - Evaluation of data, information and digital content
 - Data, information and digital content management
- B. Communication and cooperation
 - Interaction through digital technology
 - Sharing through digital technology
 - Development of participating citizenship through digital technology
 - Cooperation through digital technology
 - Netiquette
 - Digital identity management
- C. Creation of digital content
 - Creation of digital content
 - Integration and modification of digital content
 - Copyright and license
 - Programming
- D. Safety
 - Device protection
 - Personal data and privacy protection
 - Health and well-being protection
 - Environmental protection
- E. Problem-solving
 - Identifying needs and technological response
 - Creative use of digital technology
 - Identifying competency gaps
 - Technical problem solving
- F. Technological competencies
 - Computer hardware and software
 - Other digital technology
 - Computer systems and networks

Apart from the teacher being digitally literate, digital literacy further encompasses “*skills and the inner need to master digital technology in order to achieve educational goals related to the subject they teach; knowledge, skills and understanding of how to help their pupils develop and then assess their digital literacy*” (Kalaš, Moravčík, 2012).

3. DIGITAL TECHNOLOGY IN PRESCHOOL EDUCATION

How will a teacher know if a particular digital tool is suitable for kindergarten instruction? What criteria should they follow? What should they pay attention to? What is and what is not important?

The teacher’s personality and competencies (didactic and digital) always comes first. The teacher’s competencies can be summarized in the following three points (Kalaš et al., 2013):

1. A kindergarten teacher must be digitally literate.
2. A kindergarten teacher must know which didactic methods will help children learn through digital technology and aid their development.

3. A kindergarten teacher must be able to determine whether a particular digital technology is suitable for children.

There are several criteria for determining whether or not digital technology should be incorporated into the kindergarten environment. However, the most established classification is the one based on the developmental appropriateness. Resulting from the DATEC project (The Developmentally Appropriate Technology in Early Childhood), this classification contains nine criteria for determining the appropriateness of digital technology (Siraj-Blatchford and Siraj-Blatchford, 2006; Siraj-Blatchford and Whitebread, 2003):

1. A digital tool should be educational.
All applications, programs, software and technology which a teacher intends to use in kindergarten must have clearly defined educational goals.
2. A digital tool should encourage cooperation.
Not only individual activities, but also activities aimed at cooperation are extremely important in the kindergarten environment. A shared experience and the ability to share and a common interest play an important part in the cognitive development of a child.
3. A digital tool should support integration.
Digital technology should be a part of games and education, along with other methods – project activity, didactic games, etc. Digital technology is a tool for children; it is used for a certain purpose, not all the time, and certainly not as a reward!
4. A digital tool should support games.
Games and imitation are main activities in preschool education. They help develop children's creativity and representative and symbolic behavior (role playing). To children, toys, objects and digital technology are symbols through which they discover and explore not only the world around them but also environments which would otherwise not be available to them.
5. A digital tool should leave initiative to children.
According to the general rule, digital technology should allow children to control the learning process (however, sometimes this rule should be broken and programmed learning should be used instead – the development of written speech, pre-mathematic skills, etc.)
6. A digital tool should be intuitive.
Programs should be simple and easy-to-understand – the application performs each clearly defined task as a single operation.
7. A digital tool should be free of vulgarity and stereotypes.
A tool, which does not meet this criterion, should not be used in an educational institution.
8. A digital tool should improve children's awareness of health and safety.
Children need to realize that it is extremely important to change activities – after using digital technology, children should go for a run. Three-year-old children should not spend more than 10-20 minutes working with digital technology. This time increases with age.
9. A digital tool should encourage children to cooperate with their parents.
When parents, children and teachers cooperate in order to achieve common goals, the level of children's academic skills increases. Children have a more positive attitude toward learning and behave better.

4. APPLICATIONS FOR PRESCHOOL EDUCATION

First of all, one needs to know how to develop children's computational and algorithmic thinking. Even though the used technology makes the learning process easier, it is the methodology that is important. On the following pages, we will present the applications and activities that could be used to help develop computational and algorithmic thinking in preschool children.

4.1 Pivot

The application Pivot Animator is a simple program which makes a figure on the screen move. The figures are made of ellipses and lines. Apart from human figures, there are also other instruments or animals. Moreover, one can design their own figure. How do we make a figure move? We need to split each

movement. We can make the figure move using the joints which are represented by red dots. By changing the position of the joints (and recording the change), we create an animation. The more we can break the figure down, the smoother and more real the movement is going to be.

4.1.1 Activity 1

There is nothing easier than to put the movement of the children and the “Pivot” together. Physical activity is one of the key activities in kindergarten – simple gymnastics, morning warm-ups and all kinds of outdoor activities. Arm exercising is an automatic activity to which we pay no attention. We are not even aware of the movement of the arms – that we repeatedly raise and then lower them. However, if we want to make the Pivot exercise with children, we need to know how to realize this movement. When exercising their arms, children raise their hands and then slowly lower them. In order to make the Pivot perform the exercise, these movements need to be set, with each movement representing a new phase. By doing so, one will create an animation of the Pivot exercising its arms (see Figure 1).

Figure 1. Pivot Application – Exercise

4.1.2 Activity 2

Another interesting activity could be creating an animation which captures the changing position of the sun in the sky during the day. Children in kindergarten learn about seasons, months of the year, the changing of night and day (darkness and light). Again, movement phasing can be applied to a real situation with which children are familiar (see Figure 2).

Figure 2. Pivot Application – The changing position of the sun in the sky

4.2 Cards

The application Cards is a simple program which the teacher can use to create activities which help children improve their problem-solving skills. The application does not contain a given task or activity. Instead, it enables the teacher to create their own activities (problems) which they then can have the children solve. There are various options. Children can solve the problem either by moving cards with text or pictures on them to a predetermined place. The program determines whether the solution is correct or incorrect. Such tasks can be based, for instance, on describing algorithms using pictures or words, with stress being put on determining the correct sequence. In the program, the teacher can create the following types of activities – sort in the correct order, match, add, categorize.

4.2.1 Activity 1

The first activity is sorting pictures in the correct order. Children can be motivated by pointing out similarities between the activity and their own experience – situations when the correct order of steps is important, e.g. first I will wash my feet, then put on my socks, then my shoes and only then can I go outside. Other daily routine activities can also be used (getting up in the morning, brushing one's teeth, going to kindergarten, lunch, evening shower, going to bed). In the Cards application, the teacher prepares cards with pictures of everyday activities (baking a cake, crossing the street, making tea, a growing plant, order of numbers, seasons, months of the year, etc.), with the children's task being to sort the pictures in the correct order (see Figure 3).

Figure 3. Cards application – Seasons

4.2.2 Activity 2

Another activity in the Cards environment is matching. The children's task is to match pictures, e.g. finding pictures which share similarities, pairs or pictures of the same size. It is entirely up to the teacher which version of the game they choose. In the Cards application, the teacher prepares a group of cards with animals and their homes on them. Children's task is to find the correct pairs. The teacher could also have children match robots which only differ in little details (which would be a more difficult activity) (see Figure 4).

Figure 4. Cards application – Animals looking for their home

4.2.3 Activity 3

Another activity created in the Cards environment is addition. Such activities are aimed at finding patterns and creating combinations. The basic activity is the creation of a necklace. The necklace consists of color beads (red, yellow and blue), which alternate in a pattern, e.g. three red, two blue, one yellow, etc. However, some beads fell out of the necklace and the children’s task is to add the correct beads in their correct positions (see Figure 5).

Figure 5. Cards application – Adding beads

4.2.4 Activity 4

The last activity created in the Cards program is a task aimed at categorization. The basic task would be sorting cards with geometric shapes in different sizes, colors or types. The task could be modified in different ways – create groups with only red shapes, square shapes, round shapes, etc. Having children create groups of shapes based on their size and having them sort them from the smallest to the largest would be a more difficult task (see Figure 6).

Figure 6. Cards application – Sorting shapes

4.3 QR Codes

QR codes, or 2D codes, contain all kinds of encoded information. Generally, a QR code can include approximately 7,000 digits which equals to nearly 4,300 characters. A QR code can contain an URL address, regular text, GPS coordinates, emails and texts, PDF documents, voice recordings, etc. In order to be able to read a QR code, one needs to own a smartphone, tablet or iPad with a special application. What is even more interesting is that the teacher can create their own QR code and use it to make instruction of any subject more intriguing. Moreover, there are websites which enable the user to print out the generated QR code or project its content to the entire classroom. There are also tools which enable users to choose the color of the QR code or a picture which represents the content encoded in the QR code.

4.3.1 Activity 1

One of the activities is to encode the numbers 1 to 6 in a QR code. For each number the teacher can create a unique QR code (in a different color and design). The teacher can use either an interactive whiteboard or a projector to display the generated QR codes to the entire classroom, or they can print them out and hand them out to children. Children use a mobile device (a smartphone or a tablet) to read the codes, with their task being to recognize the number (see Figure 7).

Figure 7. QR codes – Determining numbers

4.3.2 Activity 2

Another activity could be encoding online didactic games aimed at developing key competencies such as determining colors and geometric shapes in a QR code. Again, it depends on the form and organization of instruction how the QR code will be displayed – display the QR code to the entire classroom or print them out and hand them to children in smaller groups (pairs or groups of three) (see Figure 8).

Figure 8. QR codes – Online task

5. CONCLUSION

Children should leave kindergarten having mastered the main key competencies which they will follow up on and further develop at other levels of education. In their study, Siraj-Blatchford and Siraj-Blatchford (in Kalaš, 2011) mention four key learning areas, pondering how they could be developed through digital technology:

- Communication and collaboration
This area is developed through collaborative problem-solving, drawing, recording a video, constructing, working with image applications, software experimenting, etc.
- Creativity
A well-designed program environment which requires interaction on the children's part. It enables a child to try various activities (and when they do not succeed, it allows to them to try

something else). It is extremely important to develop children's creativity; to make them try new activities; to ask them "What if..." questions.

- Socio-dramatic play
Using appropriate applications and tablets to play travel agency, post office, office, malls, etc.
- Developing the learning ability
Technology can help children think about their thinking processes, i.e. help them develop metacognitive operations.

The goal of the paper was to present different ways to help develop algorithmic thinking, logical thinking and the problem-solving ability in preschool children. We presented different applications and particular activities which could help not only current but also future teachers integrate algorithmic thinking into everyday activities.

REFERENCES

- Carretero, S., Vuorikari, R., Punie, Y., 2017. *The Digital Competence Framework for Citizens*. European Union, Luxembourg.
- Kalaš, I., 2011. *Spoznávame potenciál digitálných technológií v predprimárnom vzdelávaní*. Ústav informácií a prognóz školství, Bratislava.
- Kalaš, I., Moravčík, M., 2012. *Digitálne technologie v materskej škole 1. Práca s obrázkami, Práca s textom*. Metodicko-pedagogické centrum, Bratislava.
- Kalaš, I., et al., 2013. *Digitálne technologie v materskej škole 5. Didaktická práca s digitálnymi technológiami. Spoločne na internete*. Metodicko-pedagogické centrum, Bratislava.
- MŠMT, 2018. *Framework Education Program for Basic Education*. Qtd. 27. 10. 2018, available at: <http://www.msmt.cz/file/45304/>.
- MŠMT, 2018. *Podpora rozvoje digitální gramotnosti*. 2018. Qtd. 27. 10. 2018, available at: <http://pages.pedf.cuni.cz/digitalni-gramotnost/vymezeni-digitalni-gramotnosti/>
- Siraj-Blatchford, I., Siraj-Blatchford, J., 2006. *A Guide to Developing the ICT Curriculum for Early Childhood Education*. Trebtham Books, UK.
- Siraj-Blatchford, J. - Whitebread, D., 2003. *Supporting Information and Communication Technology in the Early Years. Supporting Early Learning*. Open University Press, Maidenhead, UK.
- Wing, J., 2010. *Computational Thinking: What and Why?*. Qtd. 27. 10. 2018, available at, www.cs.cmu.edu/~CompThink/papers/TheLinkWing.pdf