PECULIAR FORMS OF CLASSES AT PRESCHOOLS – THE USE OF A CALCULATOR IN TEACHING MATHEMATICS

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Abstract

When children undertake action aimed at exploring the world of mathematics they make use of the three types of representation: enactive representation, iconic representation, symbolic representation. If any of the above is skipped, it results in abandonment of construction of mathematical concepts which are no longer given personal meaning. In teaching one should depart from the ‘mythic’ statement that preschool children have not got the ability to discover the meaning of mathematical concepts unaided. The elements that benefit the development of conceptual mathematical knowledge in children include is among others: use of appropriate tools. A calculator is one of the instruments that dominated the world of electronics.

This article examines the ‘mythic’ area of mathematics, namely the use of a calculator in teaching arithmetic’s or its use in solving other mathematical problems. The theoretical section describes issues that gave the foundation for development of an action plan of the work with children. In effect, the pictures and conclusions are a record of the children’s mathematical thinking and modes of exploring the possibilities offered by a calculator. The final section of the article contains conclusions with proposals of teaching methods based on the use of a calculator.

Keywords: mathematics, preschools, calculator, the language of mathematics.

1 INTRODUCTION

In literature mathematics is seen as a branch of science with a vast and diverse subject area related to numbers, shapes and spatial relations. It is a dynamic science that undergoes modifications, it is constantly enriched with new developments and improved research methods. Those who experienced and fully understood it exalt its beauty and abstraction. Appropriate transfer of knowledge will be an unforgettable experience for children.

The experience resembles our feelings when we come across a nice poem that appeals to our heart, which we read or hear somewhere. We learn the sensitivity to this sort of experience from other people. Nobody is born a Virgil or Mickiewicz or a Ramanujan or Banach. [27].

In spite of a great deal of research and conclusions, teaching mathematics is still largely formalised. The consequence is that children can only use a set of practised and fixed algorithms and every instance of departure from a pattern induces determination [11].

Unaided discovery of mathematical relations is a prelude to understanding mathematical concepts [7] [15]. Children as young as three will search tirelessly for a solution to a puzzle or a mathematical problem with their hand glued to a sheet of paper, looking for an exit from a labyrinth. They gladly create sets made up of similar things, they add or subtract some of the elements. They are unyielding in asking questions and await more mathematical problems – in solving them they find joy and motivation to continue working.

At this stage of teaching mathematics, preschool teachers usually start with painting a scenario in which the child undertakes a search and investigation of mathematical relations, and only when the anticipated outcome is achieved, do teachers introduce the symbol or the name. This model of understanding mathematical concepts is based on three types of representation:

- enactive representation – discovery through experience and gestures, model-based action which allows discovery of relations present in the reality;
- iconic representation – use of images that represent information in such a way that interpretation and clarification are not required, it is an appeal to the imagination,
symbolic representation – use of drawings, symbolic records or graphic symbols that need to be explained to be understood [1].

When children undertake action aimed at exploring the world of mathematics they make use of all the three types of representation. If any of the above is skipped, it results in abandonment of construction of mathematical concepts which are no longer given personal meaning.

In teaching one should depart from the ‘mythic’ statement that preschool children have not got the ability to discover the meaning of mathematical concepts unaided. Many teachers believe that children should be first shown the course of action to create a ‘base’ of mathematical concepts required for problem solving [12].

Failure to accept child’s independence in building knowledge leads to reconstruction of learned patterns, termination of activity in investigating and creating mathematical concepts. The outcome is a low level of mathematical competencies.

Therefore, a different teaching method is advocated so as to make the child start thinking and acting, only if the child feels the need to do it, at the enactive and iconic levels, for the child to be intellectually active and able to see the sense of our educational purpose in its action. The name or symbol itself should appear only when the child knows and understands its meaning. Only then is the child ready to comprehend and remember the new concept or symbol – and use it. [3].

The elements that benefit the development of conceptual mathematical knowledge in children include:

- problems proposed by a teacher that stimulate the development of mathematical or instrumental knowledge;
- teacher’s intervention that can transform the action of students to knowledge, through introduction of accurate mathematical terminology, which helps children interpret mathematical objects and relations present in the language of mathematics [17];
- creating conditions that favour the use of Wittgenstein’s language-games.

Wittgenstein’s concept of language-games refers to forms and situations in which new meanings are formed, old meanings are becoming clearer and take on new aspects [5].

- stimulating child’s action through the use of appropriate tools.

In this day and age children have access to a great deal of electronic tools with which they can explore mathematical issues and learn mathematical symbols. A calculator is one of the instruments that dominated the world of electronics; it is available as a standalone device and has been incorporated in other devices such as watches, computers, cell phones, etc. Despite its widespread presence, there is a persistent myth that the use of calculators leads to thoughtless calculations, and its usefulness in teaching is only apparent.

Contemporary teachers hold debates and try to turn calculators into friends, not enemies, of the teaching process [3]. In this regard Bernhard Kutzler introduced the notions of visualization and trivialization, seeing the calculator as a tool that represents graphic elements of the language of mathematics and an instrument of elimination of calculation errors. Visualization refers to illustration of an object, fact or process. The result is an anticipated mathematical symbol. Trivialization is based on the calculation potential of a calculator and generating results, which facilitates the perception of relations [16]. In other words, one can see the sense of mathematics in arithmetic’s [26].

2 METHODOLOGY

The analysis of the role of a calculator in the learning process of preschool children, included in this presentation, is based on the following detailed research problems:

- P1: How skilled are children aged 5-6 in using a calculator?
- P2: How do children who use a calculator for mathematical operations combine mathematical and instrumental knowledge?

The following hypotheses have been formulated for the problems:

- H1: Not all preschool children can skilfully use a calculator. One needs to be familiar with the functions of specific buttons to be able to use this tool in mathematical operations.
• H2: Children who use a calculator to solve a mathematical problem create patterns of its use.

The research was conducted at “Nutka” private preschool in Siedlce in a group of children aged 5-6. The study was based on a diagnostic survey questionnaire, observation and non-standardised covert interview.

The study was based in 2014 and 2015 year.

3 RESULTS

The research initiated with the children being introduced into the subject based on their current knowledge. The person who initiated the dialogue was an ARITHMETICIAN, she welcomed the children, introduced herself and encouraged the children to discuss her profession and what she does. In the following step, the ARITHMETICIAN told the children about the place she comes from:

_Dear children, I live on a small island surrounded by oceans. Our country is beautiful, it is full of flowers and trees. The people are always smiling and they have a passion for mathematics. Every citizen, no matter how old they are, uses a mysterious tool that helps us overcome difficulties in calculations. I am wondering if you know what this device is called?

I will quickly add and subtract and the result will be exact._

The children guessed that the device in question was a calculator.

**Experiment 1**

The children were supposed to find out by trial and error which button activated the calculator, by pushing different buttons.

**Results**

One of the children immediately replied that it was the ON button. The other children either followed the clue provided by their friend or tried to activate the device unaided to make its existence meaningful.

**Experiment 2**

The children were supposed to find out by trial and error which button deactivates the calculator, by pushing different buttons.

**Results**

Two of the children knew which button they should use to switch off the calculator. They said that their toys have the same button. They did not say OFF, but pointed at the button.

**Experiment 3**

The children were supposed to find the 1 button on the keypad, push the button and describe the symbols that appeared on the screen. Then they were supposed to push the C button and describe what they see on the screen.

**Results**

The replies were the following:

– “Ah, there isn’t one there’s zero”
– “One disappeared, there’s nothing”
– “C – clears” etc.

**Experiment 4**

The children could push any number button they wanted and then press C.

**Results**

The children easily found their way around symbols, they explored the secrets of the calculator buttons.
Experiment 5

The children were supposed to find 1 on the keypad, look at the digit on the calculator screen and reproduce the graphic symbol by using sticks. Accordingly, they were asked to do the same for the other digits: 2, 3, ..., 9, 0.

Results

When reproducing 1 most of the children referred to their mathematical knowledge rather than look at the calculator screen.

![Figure 1.](image1)

As a result of a dialogue with the researcher, whose aim was to direct the children’s attention to adequate visualization of the symbol displayed on the screen, 1 assumed its real shape.

![Figure 2.](image2)

The children found it easier to reproduce the following digits: 2 and 3.

![Figure 3.](image3)  ![Figure 4.](image4)

The digit that caused the greatest trouble was 4. In some cases the children reproduced the digit their own way by using everyday experience. One child was unable to arrange the sticks in such a way as
to make the symbol look like the one on the calculator screen. Help was offered by a girl sitting at a neighbouring table who said that four looked like an upside-down chair and she turned a chair upside down. The metaphor stimulated mathematical thinking in the troubled child.

Figure 5.

The familiarity with a calculator and combination of mathematical knowledge with instrumental knowledge was observable once the children completed step 5.

Figure 6.

The children noticed that there was no need to arrange the sticks from scratch – with the addition of one stick 5 could be transformed into 6. That was the start of generalization of rules: how to make the other digits in a fast and efficient way. Some children built their digits from scratch while others subtracted or added sticks from / to the existing symbols.

Figure 7.

Experiment 6

The researcher arranged a situation in which thinking processes are naturally induced in children. The children were asked to press 3 one time, then again and then one more time... until there was no more space left on the calculator screen. To end the experiment the researcher asked the children: How many threes can fit onto the screen?
Results

The children counted the threes on the screen and noticed that the number was not the same for all calculators. They concluded that this was relative to the size of the calculator. They gave the following explanations: Ania has a large calculator and mine is small. Kasia said: I have a red calculator and hers is white, that’s why.

Experiment 7

The researcher continued the thread of the preceding experiment: What happens when you have no space left on the screen and press 3 one more time?

Results

The children were encouraged to further explore the “mysterious instrument”, they pressed 3 as many times as possible. Some of the subjects were not satisfied and tried with other numbers as well.

Experiment 8

The task was based on the strategy: ‘Try and draw conclusions’. The researcher held a calculator and said:

− Wow, a 10 appeared on the screen of my calculator. How did I do it?
− What should I do to see a 11 on my calculator screen?
− What should I do to see a 12 on my calculator screen?, etc.

Results

The experiment offered another opportunity to explore the language of mathematics. The investigations and reached conclusions significantly improved the children’s knowledge about calculators, which translated to their perception of certain relations and formulation of correct conclusions:

If you press 1 and 0, they’ll make a 10.
When we pressed 3 there were 3333. For 11, we press 1 and 1. Etc.

The end of the first meeting with the ARITHMETICIAN.

The children switched off the calculators and listened to continuation of the story of the ARITHMETICIAN.

I am happy that you have had a chance to learn about our mysterious device, and to see how well you use it. And now listen to the next part of my story:

Indeed, the people in our country are very happy, but we are worried because our country has neither a name, nor an emblem or a flag. We could not think of anything good, which is why we came here to ask for your help.

I will place a sheet of grey paper on the floor and write down your proposals for a name of our country. We will choose the most interesting option, one that appeals to everybody.

Results

The children based their proposals on their experience with the calculator. Eventually, they chose ‘Kalko’. 
4 DISCUSSION

The aim of the research presented in this article was to answer the question on the role of a four-function calculator in teaching the language of mathematics to preschool children. The main research problem was divided into two detailed problems for which hypotheses were formed. The classes allowed verification of the hypotheses. During the classes one could observe the children’s intellectual and physical activity and the children were engaged in a constructive dialogue.

The accumulated data allowed for confirmation of the first hypothesis which reads as follows:

**H1:** Not all preschool children can skilfully use a calculator. One needs to be familiar with the functions of specific buttons to be able to use this tool in mathematical operations.

At the start of the research the children familiarised themselves with the fundamental functions of a calculator. They identified relations, learnt mathematical symbols whose traditional form is slightly different. They helped each other and explained in their own language the instructions and which button to press. They talked about mathematics, they coded Polish to the language of mathematics and the other way round, they decoded mathematical symbols to the spoken language. The same is presented by the results of the observation and the debate with the children conducted as a part of each experiment.

Marek Pisarski pointed to the need to give children opportunities to experiment with numbers and their forms by means of a calculator. He held a meeting with children during which some of them used a calculator for the first time in their life. The classes started from verification of children’s knowledge about numbers which they knew and which they encountered. The debate around numbers was an occasion to solve different problems and come up with new ones. At the second stage, the children were given calculators and they could press any buttons they wanted, but they had to look at the screen and describe what they saw. To conclude the exercise, there was a summary of the ‘imprinted’ knowledge – the children, with closed eyes, answered the questions about numbers. The answers sometimes surpassed the expectations of the researcher. The answers were satisfactory and made the author advocate incorporating calculators into the teaching process [22].

The findings of Halina Matułka were similar. She decided to depart from predetermined assumptions and personally explore the virtues of a pocket calculator. Her study involved children aged 5-10 – before they proceeded to solving mathematical problems, they first learnt about the functions of particular buttons of a pocket calculator. The first experiment that involved a calculator, which she found to be the most effective, was ‘Shopping’ – the children could buy, pay and give change. In the following step, she introduced other teaching aids: a sheet of paper and a pencil, a tape measure, a dice; the calculator was used to verify the accuracy of one’s own calculations. At the end, she concluded:

*Working with a calculator is different than working without it. It does not necessarily entail becoming used to intellectual helplessness. However, teachers must be alert. Working with a calculator has many advantages – we work quicker and pupils show more interest and involvement. But there are difficulties, especially at the beginning – you have to arrange the lesson in a different way, create conditions for calculating in one’s head and verifying the results with a calculator, and stick to the rules. It is hard to say if there are more advantages or disadvantages [18].*

Errors that arise from the use of a calculator in the teaching process were described by Agnieszka Herma. She referred to a graphing calculator but one can apply the results to a younger age group that uses regular four-function calculators. In her estimation, the errors associated with working with calculators include:

- inadequate time of application of the tool;
- misinterpretation of generated messages [4].

Among the causes of the errors she listed:

- inadequate time of application of the tool;
- misinterpretation of generated messages;
- deficits in mathematical knowledge;
- limited skills in operating the device;
- deficits in knowledge about technical limitations of the calculator;
The research proves the second hypothesis:

H2: Children who use a calculator to solve a mathematical problem create patterns of its use, which helps them combine mathematical and instrumental knowledge.

Based on the results of the study, one can conclude that the majority of respondents could combine mathematical and instrumental knowledge. They knew the graphic representations of particular numbers and could find them on the calculator keypad. With the numbers on the screen, they were able to reproduce the digits on the table by using sticks.

Similarly, the authors of *Poradnik dla nauczycieli klasa 4* rightly presented a calculator as a device that gives students a chance to experiment, find rules, formulate hypotheses and verify and improve them [2].

Excellent methods of stimulating children to explore calculators and find out more about their functions, the functions of specific buttons, the potential to create original algorithms, were described by Krzysztof Mostowski. [19]. The Open University Group (1982) and the Mathematical Association (1985) and the authors of Primary Initiatives in Mathematics Education (a project realized in 1985-1989) conducted classes addressed to children and observed the patterns according to which they solved mathematical problems. The researchers found that not only adults can use calculators – children too are able to efficiently combine their mathematical knowledge with the potential offered by a calculator. The process is not devoid of thought, as confirmed by the fact that the children could use learned algorithms in everyday situations. The researchers advocated incorporating calculators into the teaching programmes applied in elementary schools, even at the earliest stage of education [23].

5 CONCLUSIONS

Authors of publications on teaching mathematics emphasise that mathematical knowledge, intuition and mathematical dexterity are shaped through action supported with systematic formalisation. Ryszard J. Pawlak calls this process ‘formalisation in action’, and stresses that it is not about passive contemplation of mathematical records, but active work on improving one’s understanding of mathematical concepts [21].

A calculator can serve as an instrument that will make it easier for children to assimilate the language of mathematics. For this reason, it seems essential to:

- make preschool teachers aware of the possibilities in teaching mathematical terminology offered by calculators;
- prepare preschool teachers to reasonable and valid use of calculators during classes (development of lesson plans, worksheets and other teaching materials);
- spread the presence of calculators among children, not only for their everyday needs (playing shopping, bank or post office) also for exploring the world of mathematics;
- teach thinking through analogies;
- encourage children to speak up about their quests, observations and discoveries;
- teach interpreting results;
- develop skills in asking questions that create problem situations;
- adapt children to decision making;
- organize classes that enable children to experiment with a calculator in hand;
- practise skills in action planning.

The results of research concerned with the use of calculators lead to the following conclusion: working with calculators helps in teaching arithmetics and stimulates abstract thinking and positive emotions. These factors dispel children’s fear of mathematics and make them adopt a proper attitude to the subject, which, in turn, is a start of trusting in oneself. [13] [8]. Single-handedly, without any fears, they use their knowledge and develop strategies of calculating and solving mathematical problems. They are capable of translating official mathematical knowledge for the needs of everyday life.
REFERENCES


