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Strategies of solving tasks while using the multimedia computer program by 7-year-old students[1]

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Abstract:

Both in the classroom as well as on the computer screen pupils can apply similar strategies of dealing with tasks (with difficult situation). For this reason multimedia programs for learning mathematics treated are as educational alternative manner of the forming amongst children abilities of solving problems. Domain of computer programs is better adapting the level of difficulty of tasks to individual possibilities of each of users. It seems that contemporary multimedia programs are effective (Kaczmarek, 2003; Watoła, 2006; Raszka, 2008). However from conducted research which are taking into account behavior of pupils while using the computer is pointing out to the uncertainty in this belief. It turns out that abilities acquired while using the multimedia program of children aren't transferring for solving problems in tasks of the paper-pencil type (Kengfeng, 2008).

1. Introduction

Solving tasks is an only way to mastering accounting abilities. At first children add and subtract by using objects. They are putting objects near in order to add and are moving away in order to subtract. As a result of the generalization operations of counting they are able to count on substitute objects. Instead of using one sort of items (e.g. bean) they are starting to use other such as matches or fingers. Eventually, children have gathered sufficient experience to carry out operations in the mind without the need of using the items.

Solving tasks causes the twofold discovery. On the one hand allows you to determine the answer to a question. On the other use a known algorithm (sequence of the operations) in the new situation tasks. As a result children learn to solve the increasingly difficult tasks and are developing the ability of counting. Mathematical abilities of pupils are developing in this way. Along with this skills are developing strategies of solving tasks by students – Jeromy Bruner calls them action plan (1967, p. 87-88).

Situations in which child is solving the tasks determine the context of application rules. Bruner (1978, p. 676-677) considers these exercises for most important as they contribute internalization of discovered rules. Remember rules pupils can apply in new situations (for example from counting on beans to counting the icons on the screen on the monitor). The condition of such transfer is the existence of a certain degree of similarity between the terms of the task. In the absence of or insufficient similarity child solving the task, even though it knows the algorithm may not link it to the current situation (eg. between counting on beans and counting on

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the abacus). You have to remember that we do not know whether children naturally treat objects on the screen as objects to count (as on an abacus). Meanwhile, the multiplicity of exercises in moving function of counting and numeracy can increase efficiency in solving problems of this type. Such an assumption also take most of the authors of multimedia programs takes such an assumption.

The level of difficulty of solved tasks is a rate of the mathematical knowledge and ability of pupils. With a high level of math skills decides the amount of logical experiences (they have a direct impact to the formation of the system of the knowledge and abilities) and level of the emotional development, especially the level of emotional resistance, self-assessment and motivation to intellectual exertion (Gruszczyk-Kolczyńska, 2015, p. 18-24).

The number of tasks that pupils must solve in order to achieve a satisfactory result at the first class is huge. Forming the skills of solving tasks is continually putting pupils in the task situation. Each situation requires the intellectual effort of the students. The task situation becomes a difficult when the level of the skills of pupils is much lower than required. In psychology we know that difficult situations are generating the highest level of negative emotions. Gruszczyk-Kolczyńska (2015, p. 210-213) writes that if the level of negative emotions does not exceed certain border in the child, it remains a factor encouraging the mind to the activity – is holding the human body on the high activity level, ready to action – this is extremely important phenomenon in the learning process. If the situation will be difficult and too much burden the child's mind, level of the border will be crossed, and if children experience will be dominated by defeat – it will not be able to cope with the emotions and begin to search of another way to cope with difficult situation (for example he will look for an opportunity to escape). This type of behaviours are natural defences reactions.

In the class the teacher constantly creates task situations. He must take care that children will solve the problem by themselves. He cannot allow them to copy the answer from the friend, whether solved it by method of trial and error. He is guided by a belief, that solving tasks (including mental effort) is an individual process.

The role of teacher is putting children in situation of such tasks to fit the sphere of the nearest development (Vygotsky, 2002, p. 88), as well as care of the appropriate level of pupils motivation. He is trying to encourage pupils to be willing to concentrate on tasks and make the effort of finding solution (Gruszczyk-Kolczyńska, 2015, p. 138-141). Unceasing putting pupils in difficult situations requires from the teacher a proper selection of tasks, appropriate motivating instruments and the control from the teacher, whether pupils use appropriate methods of solving tasks (e.g. whether are copying the solution from the friend).

Similar action must serve an educational multimedia program designed to learn mathematics. Taking the role of the teacher it must have properly designed tasks in order to encourage pupils to take the intellectual effort. Moreover educational programmes must include an appropriate system of awarding for well solved tasks and suggest the other way of reaching solution if students are taking attempts to set the result for example by the method on of trial and error.

Modern multimedia programs fulfilling mentioned above aspects remind the person of the teacher, with this fundamental difference, which once prepared (designed) are supposed to match the capabilities of each user. The programs must be ready to provide such a level of difficulty of tasks so that they are in a sphere of nearest development of a child. This applies to both, the level of difficulty of tasks, and the way of awarding to pupils. The program must be adjusted to reward the effort that is taken by every user.

It seems that modern educational programs allow individualizing the learning process. This is an extremely important issue considering that solving tasks is an individual act (children must carry out the solution independently). Thanks to the adaptability of the difficulty level of tasks to individual possibilities of pupils the multimedia programs seem to be precise and effective in the math education (such a request was deduced on the basis of interviews with parents in the study).

However the question arises whether multimedia programs are effective? If their mechanisms of precise adapting the difficulty level of tasks to the possibility of pupils and reward mechanisms for taking the effort, as well as the blocking wrong behaviours of students are effective for acquisition news and math skills of pupils who benefit from these programs. This question is as essential, because findings of current Polish researches (Kaczmarek, 2003; Watoła, 2006; Raszka, 2008) conflict with American findings (Kengfeng, 2008) which clearly shows that learning math at the computer (using software and mathematical games) is only supporting and only increase the motivation to learn math.

Based on available studies it was concluded that to determine the real effectiveness of the multimedia programmes it is necessary to analyse the behaviour of pupils while using computer programs. Such research, built and formulated in this way, was missing so far in Polish studies. To determine this information was carried out a pedagogic experiment, which use the most known and most commonly program in the early-school education to learn math “Klik uczy liczyć” (Kłosińska & Włoch, 2002). This program is designed for children from 5 to 9 of year of age.

2. Conducted research

The main problem of the research was to determine how children learn mathematics using computer multimedia programs. During the study was intended to examine how students use the computer program for learning and determine the effects of this process.

25 seven year old and one 8 year were taking part in the research. This group was divided in two: control group counting 13 pupils (6 boys and 7 girls) and experimental group counting 12 pupils (6 boys and 6 girls). At the beginning of research was carried out a test of the knowledge and mathematical abilities individually with each of examined pupils in the separate room. After conducting the first test of the knowledge and mathematical abilities (pre-test) pedagogic experiment was commenced in the form of individual meetings with every pupil and the program "Klik uczy liczyć". Research was carried out in the back part of the class, behind the other students. On the first meeting with the computer, after conducting a test, the pupil for the first time runs the program "Klik uczy liczyć" (it was a condition for the selection of the test group). The pupil was asked for restart the computer (and then researcher independently ran a recording program which record the child work – under the pretext of the necessary application for the operation of educational program), and next pupils could use the computer. This part was the test of computer skills and also represented the first meeting of the series of 10, on which pupil could use the program on "Klik uczy liczyć". Another meetings differed in only the fact that the computer was already been turned on (running was also the recording program). The CD with educational programmes was already in a case of the computer, and the adult asked only for starting it. From that moment the child alone performed the instructions of the program. An important aspect of this research was the fact that the pupil wasn't aware that his activities are being registered.

At the end of experimental meetings with the educational program was carried out the second test of the knowledge and mathematical abilities (post-test). In post-test was used the same tool what in the pre-test with the difference that pupils had to solve much more tasks (it resulted from the progress in learning). For this reason two meetings were arranged. Each of them went under the same conditions.

It will be present know the reason which was taken to adopt the surveyed students in the experimental group and control group. This division, together with a choice of experiment methods allowed consequently determining:

1. State of knowledge and skills of students entering experiment (phase of pre-test).
2. State of the knowledge and skills of students after 5 months of the experiment (phase of post-test).
3. On the basis of the difference in the state of mathematical knowledge and skills of students before the experiment (pre-test) and after (post-test) you can determine the nature of the changes that have occurred in the students who benefited from the educational computer program (experimental group) and students who have not benefited from this program (students from the control group).
4. On the basis of differences in the growth of the knowledge and skills of pupils from the experimental and control groups (point 3) it is possible to determine the effectiveness of a computer program. It was assumed that if the students in the experimental group achieve a higher score than students in the control group (that is, students who did not use a computer program used in the study) will provide a high effectiveness of educational computer program. It will be otherwise, when students in the control group will prove to have a lower or similar results as the pupils from the experimental group.

Because it is difficult to separate the impact of school education from the influence of the multimedia program we assume that the test takers will be students of the same class, attending the same educational activities (including after class activities) and taught by the same teacher and implementing the same curriculum. It was to minimize the number of variables intermediary.

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Used during the research tool to determine the knowledge and mathematical skills has been developed according to the program used in the study "Klik learns to count." The authors of this program designed 17 levels of difficulty. For each level of difficulty prepared in the test 4 tasks and in accordance with the principle of gradation of the difficulty they passed the test on the card. Students were solving tasks until they become too difficult for them. Designed the toll contain tasks that exceeded the capabilities of students with the test class (class 1). In this way the border solved tasks determined the level of knowledge and skills of students. This tool was used in pre-test and post-test.

3. Results

Before you will be presented with the way of behaviour of the pupils in front of the computer screen it is important to explain the mechanism of adapting the level of difficulty of tasks to the ability of pupils in the program "Klik uczy liczyć".

Authors of the program divided the tasks in seventeen steps scale ensuring that users don't feel the marked difference in the change of the level of difficulty. I will briefly present specificity of the levels of difficulty of tasks. The first level of difficulty concerned counting objects, the next three levels (from 2 to 4) included action for adding and subtraction within 20. Three next levels (from 5 to 7) relate to the tasks which does not exceed the number 100. Levels 8, 9 and 10 authors donated to applying tasks of multiplying and divisions. Next three levels concerned adding and subtracting within the limits of 1000. Next three levels concerned the addition and subtractions within 1000. The last (to 17th) relate to multiplication and division to 1000.

Pupils using the program "Klik uczy liczyć" at first received the simplest tasks to solve, then more and more difficult. Users didn't change the level of difficulty of solved tasks by their own (such an option was available in the primary window menu of the program) the program without reporting to the user automatically moved the level of difficulty of tasks against one step higher if the pupil solved 20 tasks correctly. Program decreased the level of difficulty of tasks (by one), when the pupil repeatedly gave the wrong answer.

This studies focus on analysis of the behaviour of pupils using the multimedia program "Klik uczy liczyć". To determine the behaviour of users it was necessary to "be" between the user using the educational program and the computer screen – that is task situation. For that purpose was used a recording program working in the background of educational programmes. The program using the camera saved how child behaves in front of the screen, which buttons of the keyboard he is using and what is happening on the computer screen (look: illustration 1). Collected in this way footage (48 hours) allowed to analyse behaviours of pupils under the different angles.

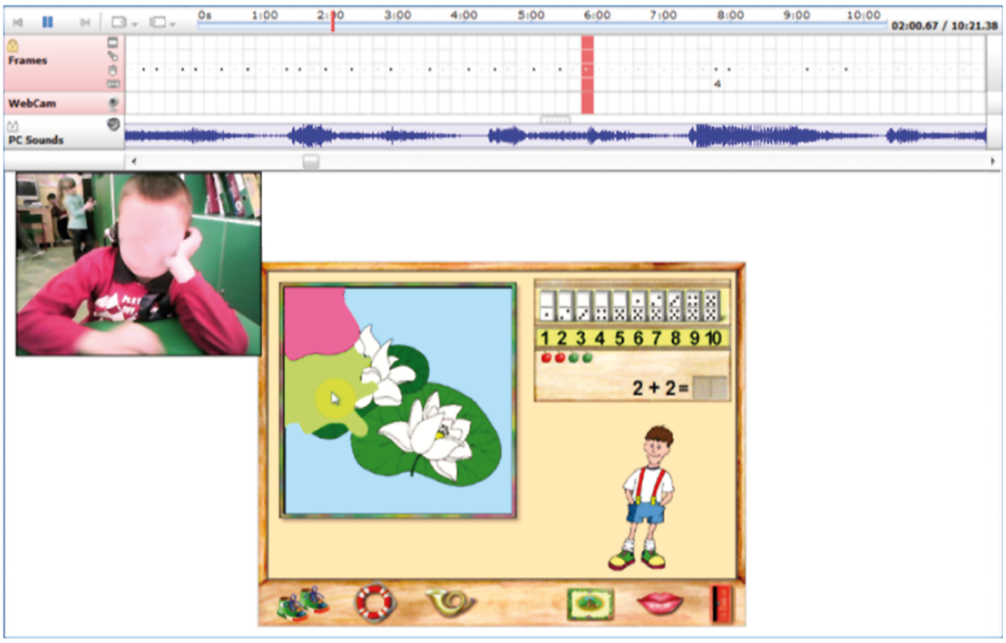
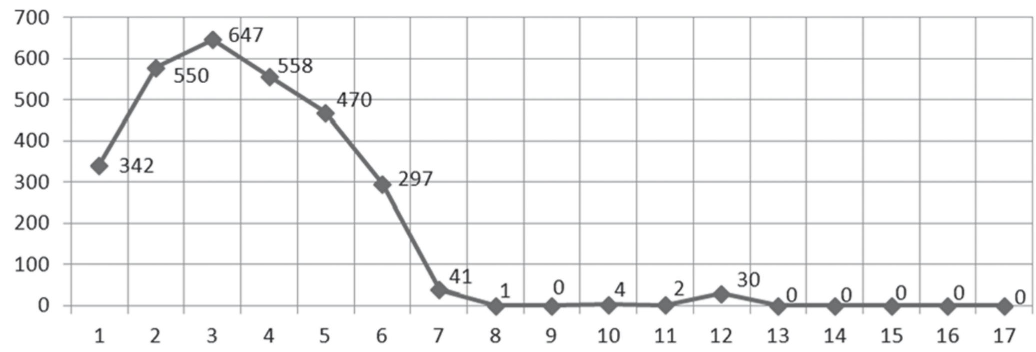


Illustration 1. Model frame from the recording program (the face of the pupil was blurred)

Gathered material showed current level of each of the 12 pupils of the experimental group. The level of mathematical abilities of all pupils using the educational program was described on graph 1. It was established on the basis of counted all tasks solved by students in the program (on the basis of analysis of the collected recordings). The tasks have been adapted to the level of corresponding level of difficulties.

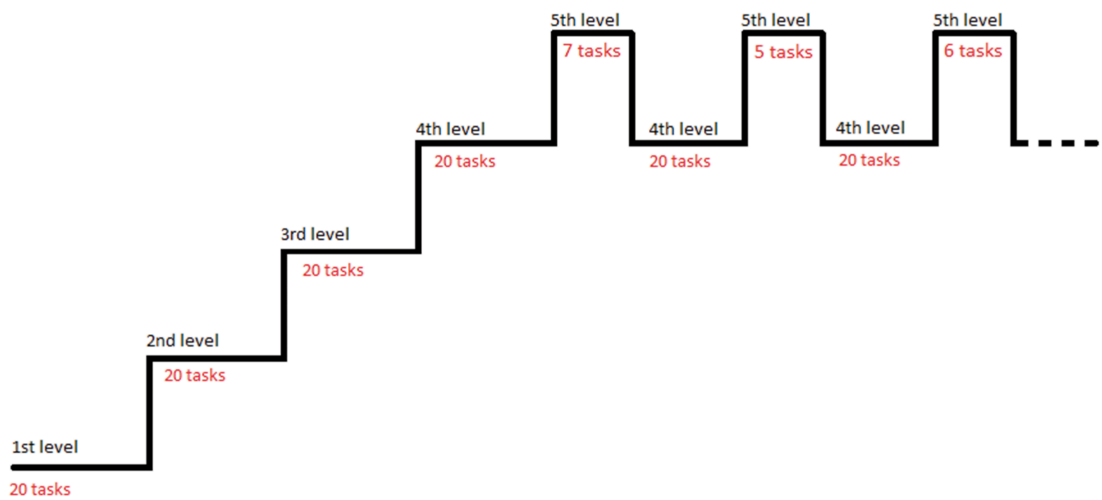


Graph 1. Comparing the number of performed tasks on each of levels (1-17) by all pupils from the experimental group.

On graph 1. you can see, that examined pupils (from the experimental group) well coped with tasks relating to addition and subtraction in frames of the first ten – 3rd level. The solved tasks were similar to the ones which recently pupils learned in the classroom. More difficult tasks – above 4th level has caused that the level of difficulty was more and more difficult for the pupils – it is current level of solved tasks in the classroom.

Later discussed will be how the pupils solved the tasks through educational computer programs. The behaviour of each of examined pupils showed that each of them wanted to solve tasks of the program. Since the majority of examined pupils carried those out them in similar way therefore will be presented characteristic differences between strategies taken by pupils. I should be added, that strategies mainly depended on differences in mathematical abilities and motivation to learn.

Pupils solving 20 tasks correctly on the first level of difficulty (simplest – concerning counting of objects) received tasks for one level more difficult – concerning: additions within the limits of 10. It should be noted that the program didn't inform users about increasing or decreasing the level of difficulty of tasks. When the pupil solved 20 another tasks correctly the program again increased the level of difficulty of tasks. The program worked in such way till the moment when pupils came across the level of difficulty of tasks which exceeded their mathematical abilities. In this way pupils stopped on the different levels of difficulty of tasks. The level of difficulty of tasks, which pupils weren't able to solve was the limit of the possibilities of individual users. It was outlined on graph 2. The presented mechanism provides the way into which the program adapted the level of difficulty of tasks to the possibility of pupils.



Graph 2. Example of the way of solving tasks in the program "Klik uczy liczyć", by the pupil which correctly solved task on the first, second, third and fourth level of difficulty, however tasks on the fifth level were too difficult.

Tasks with which pupils didn't have problems were good situations in terms of the emotions because it doesn't require great intellectual effort. Tasks that crossed the border of possibilities of pupils represent some sort of threat which could be seen in the behaviour of children (e.g. resignations from using the program). Task situations on the border of the possibility of pupils generated by the program were difficult situations for pupils. Because users weren't able to meet independently the tasks they sought other ways to determine the answer. These behaviours were named strategies, which was dominated by certain behaviour, for example: escape, using the option of the "lifebelt", setting the result by the trial and error approach, or counting available objects instead of making an attempt to set the result in the memory. These strategies will be presented a below.

The reason for the appearance of the strategy of solving tasks different from the strategy which was prepared by authors of the program (i.e. counting in mind) was insufficient differentiation of levels of difficulty of tasks in the program and a way of encouraging pupils to take the intellectual effort. It is necessary to add, that pupil solving a task didn't know (didn't receive such information), which award they will receive after solving the specific task. The result was disappointment and the resignation from making further attempts to solve tasks.

One of the forms of assistance from the program was giving to the user the possibility of counting the objects. They were available on the four first levels of difficulty. In every task on these levels of difficulty pupils had objects counting (e.g. fixed small wheels). Seven-year-old pupils having designed in this way instead of calculate a simple action (e.g. 1 +2, 4-3) gave up from counting in memory, for counting objects visible on-screen. Pupils behaved in this way even though at the test of the knowledge and mathematical abilities which were taken before pupils started using the computer, they were able to perform tasks more difficult.

Objects for counting in the program were available only to the fourth level of difficulty of the tasks. The more difficult tasks (above the fifth level of difficulty), concerning counting over third ten, has caused that objects for counting "has disappeared". The pupil using earlier objects for counting had to solve these tasks in other way. As indicated the analysis of recordings showed, that pupils with high mathematical abilities solved tasks in the memory; pupils which counted on objects used fingers, or buttons of the keyboard as proxy objects. But as first test of the knowledge and mathematical skills pointed out that the majority of pupils of the first class (even pupils who have used objects) had no difficulty in solving more difficult tasks in which was no longer available objects for counting and they passed on counting in memory. On this basis, it can be concluded, that simple tasks (up to the fourth level of difficulty) were a waste of time, because pupils had already higher skills and do not need specifics objects to solve the task (see: Jelinek, 2013a).

When objects for counting were missing, and the level of difficulty of tasks increase (above the fifth level of difficulty) pupils from first-class have more and more often applied the trial and error approach for solving a problem. It consisted on entering randomly numbers without paying attention to the sense (actual value of the result with regard to task), or even a repetition (repeatedly entering the same value). Authors predicted this type of behaviour and designed the lock of the program which was supposed to stop the possibility of writing the answer, if the user previously typed quickly a few incorrect answers. Pupils who pointed out that after you type all digits (0-9) on the screen did not appear result, tried to establish the cause and slowed down the pace of entering the result. This turned out to be a sufficient way to break the lock of the program. From that moment pupils still have used the trial and error approach, slowing only a pace of entering the results.

Using trial and error approaches without thought and only to get around the blockade of the program prove about avoiding effort during solving tasks in the program, into awards received in the simplest way.

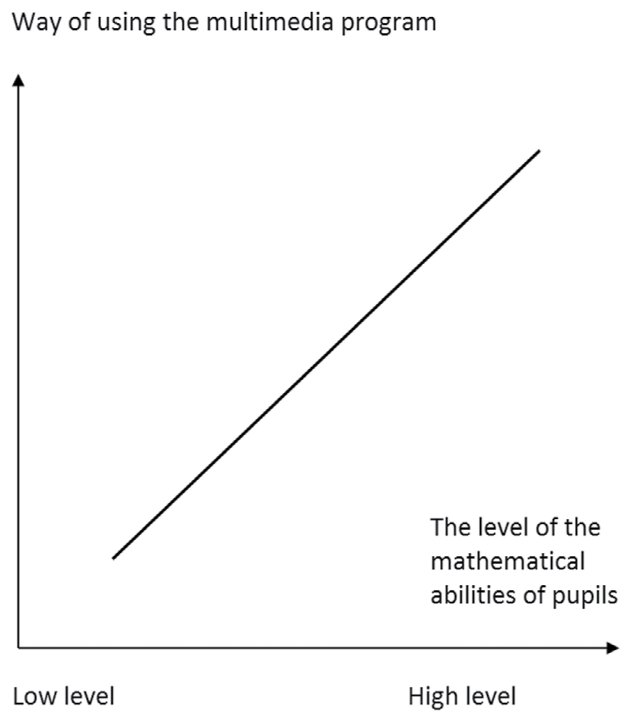
Pupils who didn't make an attempt to solve too difficult task and had no patience for setting the result by slow entering the solutions (wanting to pass the blockade of the program) use a strategy, in which has dominated escape. It concerned the resignation of even the minimum effort. Pupils gave up solving the tasks (especially those associated with counting), and left for seeking the easier task (e.g. a preferred task was collating rubbish into appropriate containers). The other type of escapes concerned pupils who wanted to experience the award for these tasks, which could not solve at the level of their possibilities. Pupils left the task, opened a window of the main menu of the program, moved the slider of the level of difficulty of tasks to the lowest level, and then returned to the unfinished task and carried them out until the end in the easier way (e.g. by counting objects present in the tasks). In this way they received the same award for smaller intellectual effort. It is necessary to add information that despite the lower or higher level of difficulty users received the same award for the same performed task. This behaviour was determined with strategy, in which using lifebelt is dominating.

Authors of the program realizing that some tasks may be too difficult for users prepared the option of the "lifebelt". Its role was to provide ready solution without the need to perform any intellectual activities. It is worth to point here that in the program instructions this function hasn't been clarified. This can attest to the fact that authors were aware that too early to know this option could be abused. It was so. Pupils who searched for hidden attractions in the program discovered the option of the "lifebelt" and being pleased with an award they continued use of this choice. The consequence of too frequent using the lifebelt, was lowering the level of difficulty of tasks even by two levels. This way those pupils who discovered the function of the "lifebelt" were pleased with his double happiness. The behaviour of this type was determined with name of the strategy, in which dominate the usage of the lifebelt.

4. Conclusions and discussion

There is a perception that weak pupils should solve more tasks in order to make up missing (relative to peers) mathematical skills. Care of the quality of educational situations in which pupils will be able to solve tasks is an essential part of math education. One of the ideas to enhance the quality of math education is implementing multimedia programs which are individualizing the level of difficulty of the task and control the work of users.

The results from the research show that pupils who are weaker in mathematics are quickly giving up solving the tasks in situation in which the educational programmes are putting them. Pupils are taking other than intended by authors of the program behaviour about how to use the program – own strategies. Escape from solution, use the trial and error approach, or excessively are using the option of the "lifebelt". It was established that the reason is incompatibility of the level of difficulty of tasks and the way of motivating pupils for taking intellectual effort. It can be conclude that the skills acquire by the – in a way not predicted by authors of the program (own strategies) – also can attest to the educational effectiveness of the program. However as results of research on the basis of a comparison of the results of two tests of the knowledge and the math skills of pupils who have benefited from the program (experimental group) and those who didn't use the program (control group of 13 people) shows that there is no difference in terms of knowledge and skills between examined pupils. This indicates that using the program (in a manner that is consistent, or inconsistent with the authors of the program) and solving on average 250 tasks in the mathematical program by pupils (so many



Graph 3. The level of the knowledge and skills of the pupil in mathematics to the way of using the program for the learn mathematics. Own study

tasks on average solved pupils using the program "Klik uczy liczyć" in the course of the research) does not significantly affect the mathematical skills verified using a paper-pencil test.

Similar conclusions introduced Kengfeng Ke (2008). He has been encouraging children to use available on Internet educational programs and mathematical games and he stated that they only increase the willingness to the learn mathematics, but not the impact on using these skills apart from the program in paper-pencil tasks.

On the basis of studies carried out two relations were established: the more children know and can do in mathematics, the longer they are using the program in the way, into which authors of the program predicted it, acquiring thanks to that mathematical experience. And vice versa: the fewer children know and can do in mathematics, the sooner they pass on their own strategies seeking awards in the program and treating using the computer, as the opportunity to play. For these pupils using the computer is an educational waste of time. These conclusions are contrary to the current opinion, that educational multimedia programs were effective.

The reason for the low efficiency of the education program are certainly factual errors which made the authors of the program (Jelinek, 2013b) but the defective seems also these mechanisms of the program that make the educational multimedia program acts as a teacher. They are: (a) mechanism of adapting the level of difficulty of tasks to individual possibilities of pupils, (b) a system of incentive to intellectual exertion, and (c) the blockade of the program. The study confirmed the findings of Czesław Kupisiewicz, who was writing about the learning of the children using the computer as a teaching machine notes that this process cannot be held without the teacher's control (Kupisiewicz, 1975, p. 46).

It is also important to compare the existing Polish research results from the above described. Analysis of the research method used revealed how current Polish research didn't consider the crucial element of the learning process – preserve pupils when using the educational program. The authors using the experimental method focus on the comparison of the results of two tests (of pretest and posttest). Setting this makes a difference in terms of knowledge and mathematical abilities. They were however able to – on the basis of such collected information – is to separate the impact of the school education (in the class) from the learning on the computer (Jelinek, 2013b). Taking into account the way of behaving while using the computer allowed to favour pupils which solved tasks alone (according to the strategy of authors of the program), and which carried out applying the own strategy (e.g. with trial and error approach whether using the option of the "lifebelt"). Thanks to this treatment was able to determine the effectiveness educational of multimedia programs.

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