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Intellectual activity of primary school pupils during non-formal education classes – research report[1]

Aktywność intelektualna uczniów szkół podstawowych podczas zajęć w formie edukacji pozaformalnej– sprawozdanie z badań

Abstract: The article presents the results of a quantitative-qualitative study and establishes regularities in the intellectual activity of elementary school students participating in extracurricular activities. The research was conducted within the framework of the program of the Ministry of Science and Higher Education entitled" University of the Young Explorer." The research was conducted in purposefully organized classes in the form of non-formal education with a developed curriculum on robot programming using *Lego Mindstorms NXT 2.0*.

The study involved a target population of 1,496 elementary school students from the Subcarpathian region, from which, after statistical calculations using *Statistica 13.3* computer program, the study population of 536 elementary school students was drawn.

The main research method was the diagnostic survey method, in which the technique was a questionnaire and the tool was a knowledge test. The survey was implemented using the Computer Assisted Personal Interview (CAPI) technique on the *Google Forms* platform. Surveys were performed in the first and last classes using a tablet.

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Based on the research, conclusions were developed in terms of the main objective of the research, which was: to determine the intellectual activity of elementary school students participating in non-formal education classes. In the conducted research, a detailed analysis of the results of the study was carried out on the basis of the taxonomy of B. German.
According to the results presented in the article, students participating in non-formal education classes on programming *Lego Mindstorms NXT 2.0* robots do not read texts carefully, have problems remembering the concept containing specialized nomenclature. Students more easily remember concepts that are related to the activity they are performing. In terms of understanding the content that was implemented in class, most students do well. In the context of the application of the acquired knowledge in practice, the data obtained indicate that, despite the knowledge they have, students have problems with the application of knowledge in practical tasks. Students definitely do not cope with tasks in which they are confronted with the search for cause-and-effect relationships.

Keywords: non-formal education, intellectual activity, primary school, pupil.

Introduction

Contemporary primary level education is more and more often supported through out-of-school institutions, such as libraries, museums, theatres, cinemas, science centres, universities. The main goal of the activities undertaken is to develop pupils' interests in learning from an early age.

At the present time, the modern school does not have enough good equipment, equipment with modern technologies to measure up to universities, foundations, companies conducting scientific activities outside the school. The capabilities of the indicated entities are definitely broader than those of schools. Nowadays, it is necessary to concert to be able to interest a student in science using various techniques and technologies. It is also hugely important to develop language skills, communication skills, learning skills, critical thinking, developing social and civic competencies including understanding different perspectives. Classes that are organized outside of school do not have to implement the core curriculum, and therefore very often focus precisely on the presented contemporary challenges faced by actors in the educational space.

This type of support for education is called non-formal education, which is defined as: *a form of learning by consciously engaging in experiences, exercises that cause intellectual and emotional activation and the formation of*

new behaviours in activities that are organised outside educational programs, which lead to the obtaining of a registered qualification (Warchoł, 2021, doctoral thesis).

The development of this type of education was strengthened in 2018-2020 by the Ministry of Science and Higher Education, which announced a program entitled *Young Explorer's University*. The initiative assumed the organisation of additional, free educational activities for primary school pupils, which were mainly intended to stimulate children's passion in the field of natural and technical sciences.

As part of this program, the University of Rzeszów received funding for classes in the form of non-formal education for the project entitled *University of Rzeszów for young explorers*. As part of this initiative, free classes were organised for primary school pupils on the construction and programming of robots using *Lego Mindstorms NXT 2.0*. The purpose of the organized activities was to stimulate and develop the intellectual activity of elementary school students by solving tasks of a mathematical and technical nature.

Intellectual activity of elementary school students

Intellectual activity is a set of mental processes that serve to process information that flows from outside to a person and flows from within. According to J. Krauzowicz, these processes serve to learn, process, create, modify knowledge about the environment and, accordingly, to learn about the behavior that accompanies them (Krauzowicz, 2011, p. 84). A similar definition is provided by T. Maruszewski, writing that cognitive processes serve to create and modify knowledge about the environment, behavior, influencing the nervous system and participating in the reception of information (Maruszewski, 2016, p. 28).

An analysis of the literature indicates that the main processes characterizing the intellectual activity of elementary school students include:

- perception,
- imagination,
- attention,
- memory,
- thinking (Strelau, 2004; Nęcka, 2005; Modrak, 2016).

Perception is the totality of processes involved in receiving stimuli from the external environment and from within the body in terms of all receptors and sense tools. It is another way of discovering, in the process of attentive and highly selective perception, the senses and meanings inherent in visible reality. In terms of intellectual activity, perception can be called

allocentric, that is, avoiding the natural tendency of the human mind to impose its own categories on reality (Strelau, 2004, p. 26).

Imagination is the ability to form creative ideas, anticipate, complete and reproduce, and the ability to present to oneself according to one's will situations, persons, objects, phenomena, etc. not seen before: fantasy, imagination (Strelau, 2004; Necka, 2005; Maruszewski, 2016).

Attention is a mechanism that is not only responsible for the selection of stimuli, but also determines the effectiveness of action under conditions requiring the performance of two or more actions at the same time (Necka, 2005, p. 62).

Memory is another component factor of cognitive processes relevant to the analysis of intellectual activity. As defined in the literature, it is a process that can consist of multiple phases or can be treated as a property of the individual. Memory is the process responsible for recording, storing and reproducing experiences (Strelau, 2004, p. 137).

„Thinking is the derivation of conclusions, coming to previously unknown conclusions, i.e. the products of thinking, imagining, perceiving, recalling, applying a mathematical algorithm to the data held" (Strelau, 2004, p. 137). Thinking is:

- deductive reasoning, which is the application of the formal rules of logic to derive conclusions from given premises,
- Inductive reasoning, which is the derivation of conclusions from observed facts,
- problem solving (Strelau, 2004; Necka, 2005; Maruszewski, 2016).

The indicated cognitive processes determine the intellectual activity of students participating in non-formal education classes.

Test procedures and methods used

As part of the project, research was carried out on the intellectual activity of pupils participating in it. The research was conducted in 2018-2020 at the University of Rzeszów.

In the conducted research, the main goal was to determine the intellectual activity of the primary school pupils participating in the non-formal education classes.

The formulated main goal of the research also included a theoretical goal, which concerned the enrichment of knowledge in the field of the relationship between cognitive processes and types of tasks adopted in accordance with B. Niemierka's taxonomy.

The taxonomy of B. Niemierka is any learning objectives described in terms of a hierarchically ordered classification scheme. The hierarchical nature of the taxonomy lies in the fact that higher categories accommodate lower categories, so the achievement of the higher goal tells us that the lower goal has also been achieved.

On the basis of the presented taxonomy, a curriculum was prepared for the implementation of classes within the framework of the *University of Rzeszow for young explorers project*. The choice of this taxonomy made it possible to organize all educational content so that it meets the requirements of the spiral model of education. An additional aspect in favor of the choice was the possibility of describing human behavior in terms of the cognitive domain determining whether the student can, understands, analyzes synthesizes, which is connected with cognitive process

Additionally, a practical goal was defined, which concerned the development of recommendations for better stimulation of the intellectual activity of primary school pupils.

The main research problem was formulated as follows: *How does the intellectual activity of elementary school students change in terms of cognitive processes in different types of tasks during classes organized in the form of non-formal education?*

The research assumed that H0 reads as follows: *Classes in the form of non-formal education implemented on the basis of the curriculum do not affect the intellectual activity of a primary school pupil.*

The target population of the survey consisted of 1,496 elementary school students from the Subcarpathian region, who were assigned identification numbers to allow comparison of student performance from the first and second surveys. A sample of 532 students, including 220 girls and 312 boys, was drawn based on simple random selection without return. The drawing of such a population of surveyed students was done automatically by the computer program Statistica 13.3. The results of the surveys were collected systematically during the first and last classes of each group of surveyed students.

Table 1 shows the full characteristics of the study group by gender, place of residence and stage of development. The data is derived from a drawn survey sample in Statistica 13.3. Drawing such a sample allows the survey to be conducted in a responsive manner.

Table 1. Characteristics of the study group.

Gender	Number	Place of residence		Stage of development	
		City/Town	Rural	Middle school age	Early adolescence
Girls	220	60	160	139	81
Boys	312	86	226	194	118
Total	532	532		532	

Simple random selection without replacement is the random selection of elements for the sample, in which each unit of the population has an equal possibility of entering the sample. This means that the probability of entering the sample is equal and greater than zero, and the selection is carried out according to an automatic plan and is based on random rules (Miszczak, Walasek, 2013, pp. 100–108).

The research strategy was to measure intellectual activity in the first and last classes. In order to test intellectual activity, the method of diagnostic survey was used, in which the technique was a questionnaire and the tool was a knowledge test. It was carried out using the Computer Assisted Personal Interview (CAPI) technique (Boguszewski and Hipsza, 2012, pp. 65-82). The test, in the form of a survey questionnaire, consisted of 20 questions, which were developed according to the assumptions of B. German's taxonomy. German on learning objectives, which includes a division into: remembered and understood messages and application of messages in typical and problem situations (Bereźnicki, 2011, pp. 120-145). For each of the above-mentioned categories, 5 closed tasks were formulated.

The first range of questions concerned only memorization of the definitions of programming concepts. The second was about understanding the concepts learned. The next two scopes were directly related to the use of the acquired knowledge and its application in practical tasks. Within this range, the first five questions were related to deductive tasks, and the next five to deduction, reduction including induction. Each of the correctly solved tasks was scored for one point, therefore the maximum number of points that a pupil could receive was 20. All the knowledge that the pupil was to obtain was determined on the basis of the developed curriculum for the prepared activities in the form of non-formal education.

In the developed program, it was assumed that the pupil will acquire knowledge and skills by learning about theoretical and practical issues, the construction of algorithms using a servo motor, touch sensor, colour sensor, ultrasonic rangefinder, NXT cube and the *Lego Mindstorms NXT*

2.0 programming environment, and that they will acquire the ability to solve algorithmic tasks on ready-made technical models constructed using the manufacturer's instructions and built on the basis of the practical skills acquired during the classes, which will allow for the fulfilment of the assumption related to the experimental nature of non-formal education classes (Kędra and Noga, 2019, pp. 13-19).

The analysis of the research results was carried out in accordance with the principle of inductive reasoning and divided into a general analysis on the basis of which H0 and four detailed areas in individual categories of knowledge and skills were verified, to define the theoretical goal and recommendations for better stimulating the intellectual activity of primary school pupils.

The analysis of the research and the conclusions taken were formulated in accordance with qualitative pedagogical research, *which deals synergistically with all the above-mentioned features, both research as such and qualitative research and pedagogical research. Qualitative pedagogical research fits into the spectrum of qualitative research in general, drawing on the experience of its practice in the humanities and social sciences, as well as a number of scientific disciplines located outside them, but always concerned with man/people and his/her world(s)* (Kubinowski, 2016, p.2016, p.10).

General analysis and interpretation of the research results

On the basis of all the pupils' answers, H0 was checked by using a statistical test of dependent variables in terms of the means of the initial test and the final test. In this respect, the calculation of statistical significance *p* was used for verification. Additionally, basic statistical analysis was performed by calculating the percentage increase, the means from the initial and final tests, standard deviation and the group coefficient of variation.

The results of the initial and final tests are presented against the background of a normal distribution in Figure 1.

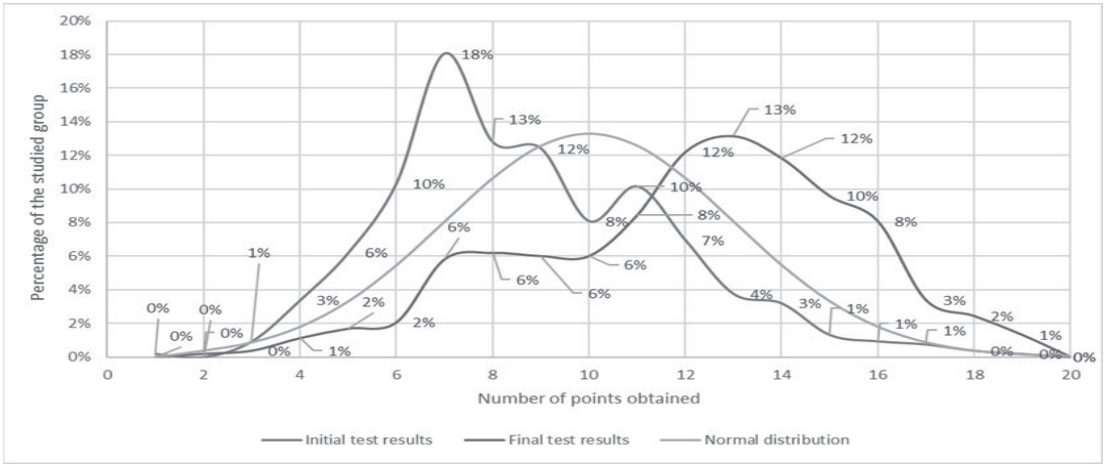

Figure 1. Distribution of pupils' results obtained in the initial and final tests.

The analysis of the presented data against the background of a normal distribution shows that the results of the pupils' initial and final tests differ from the ideal form of the normal distribution. In the case of the initial test, the pupils' results ranged from 4–16 points (the largest number of scores were in the range of 6–8 points, which accounts for almost half of the correct answers). It is worth adding that the results of the initial test represent a right-skewed distribution in relation to the normal distribution. This shows that pupils' performance in the initial test tends towards low scores. Interpreting this information, it can be concluded that students, when taking the implemented test, were unable to solve the formulated tasks and did not focus their attention on the content of the questions.

In the case of the final test, the pupils improved their results and answered more questions correctly. Additionally, it should be noted that many of the results were in the range of 10-16 points. This is confirmed by the graphical presentation of the results, in which the curve has shifted to the right, which means that after the workshops, the distribution is left-skewed, i.e. the results are concentrated at high values of points obtained. Based on the final results, it can be concluded that the students' participation in the classes stimulated their cognitive processes. It should be noted that the students remembered more, so their perception, attention and memory were stimulated the most.

The analysis carried out already at this stage of the verification confirms that during classes in the form of non-formal education pupils recorded an increase in intellectual activity.

In the case of the study group, the coefficient of variation in the initial test was 33%, which proves that the test results were characterised by typical variability, while in the case of the final test, the variation index decreased and amounted to 25%. This allows for the conclusion that the differentiation

of the results in the final test decreased and fell within the range of low variability. This means that, after the non-formal education classes, the pupils actually answered the same questions, and their knowledge and skills were at a similar level.

Based on the test results obtained from the initial test, the median was calculated as 9 points. In the case of the final test, the median was 12 points, which indicates an increase in the sum of points obtained in the final test.

On the basis of the calculated general significance value p, it is necessary to reject the H0 hypothesis that classes in the form of non-formal education implemented on the basis of the curriculum do not affect the intellectual activity of a primary school pupil, which clearly indicates that the activities carried out in the form of non-formal education in the field of programming *Lego Mindstorms NXT 2.0* influenced the intellectual activity of pupils participating in the organised classes.

It is worth adding that in the conducted research, girls obtained higher increases in intellectual activity than boys. This statement is valid because, according to developmental psychology, girls develop faster than boys. This means that their cognitive processes function better. It can also be added that in the context of place of residence, it was pupils from rural schools who obtained a higher increase in intellectual activity than pupils from municipal schools. This may result from the greater involvement of pupils from rural schools in the process of extracurricular education than their peers from municipal schools, who more often have the opportunity to take part in classes in the form of non-formal education. The analysis of the results of research on the developmental stages of pupils showed that a higher increase in intellectual activity occurred in the middle school age group and this may be due to greater involvement of pupils in this development phase than in older pupils who are at the stage of early adolescence characterised by a changing attitude to life, where a phase of ambivalence prevails, which directly affects the cognitive processes of pupils in this development period (Maruszewski, 2001, pp. 28-31).

The general analysis of the results of the research in the field of intellectual activity of students shows that during non-formal education classes, students stimulated cognitive processes, i.e.: perception, imagination, attention, memory, thinking. This is due to the fact that after the classes they correctly answered the tasks that were again set before them. It should be added that by far the classes stimulated in the students more their memory and attention, because the greatest increases in intellectual activity were noted in tasks that focused on reproducing from memory various definitions, as

well as based on the student reading the command or definition correctly. It should also be added that, unfortunately, but the classes did not significantly stimulate processes such as thinking. Such a conclusion was drawn due to the fact that students had problems wherever the correct answer had to be deduced from certain information.

Analysis and interpretation of research results in terms of memory tasks

In the first category: information and taxonomic level: remembering information, five questions marked with the numbers:

1. Explain the concept of an algorithm
2. Name what a programming language is
3. Name the component shown in the following picture
4. State how many sensor inputs the NTX cube has
5. Indicate what colors a color sensor can glow?

Questions were distinguished, which were to indicate the intellectual activity of primary school pupils in terms of remembering information, with particular emphasis on cognitive processes in the stages of development distinguished. The questions formulated were based on the processes of reproducing from the students' memory the correct definitions and concepts that were analyzed during the class. The category of these questions was also based on imaginative processes, as students had to associate the name of a given item with its correct name. Of course, it is impossible to point out here also perception, which directly links both memorization and attention.

The intellectual activity of the primary school pupils was determined by the percentage change in the results from the initial test compared to the final test, presented in Figure 2.

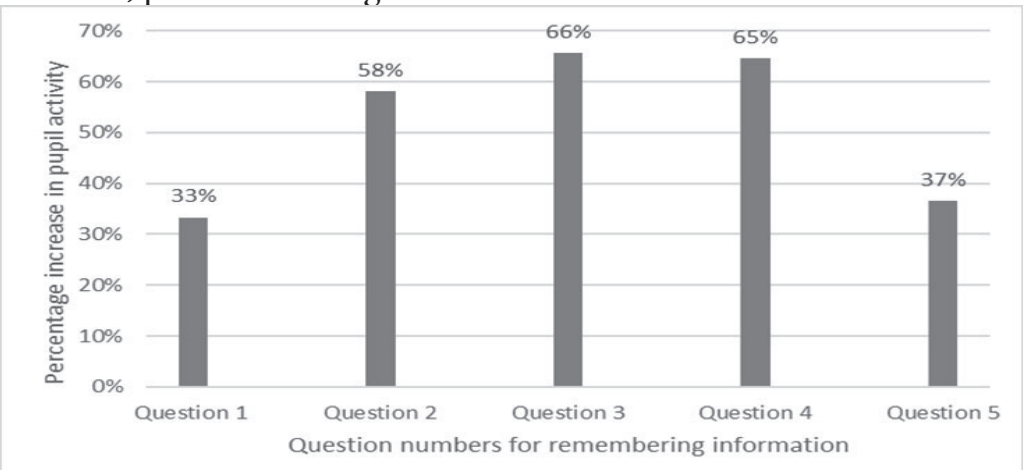

Figure 2. Graph of the set of research results on intellectual activity of primary school pupils in questions related to remembering information

The students did very well in correctly explaining the definitions of concepts, as well as in assigning names to given elements. This testifies to the very good stimulation of memory and imagination during the non-formal classes. It should also be added that during these classes the students' perception was at the right level, because they assimilated a large part of the material implemented in class.

The research conducted also took into account the gender of the pupils, and the results are presented in Figure 3. It should be noted that in almost all the questions related to memory, the girls obtained greater increases in intellectual activity. It can be assumed that such an effect is caused by the girls' careful reading of the task instruction and the proposed answer. This means that girls' attention and perception were at a higher level than boys'. This conclusion was formulated because indicating the correct answer required the pupil to read the answers in their entirety, as the final parts contained the most important information.

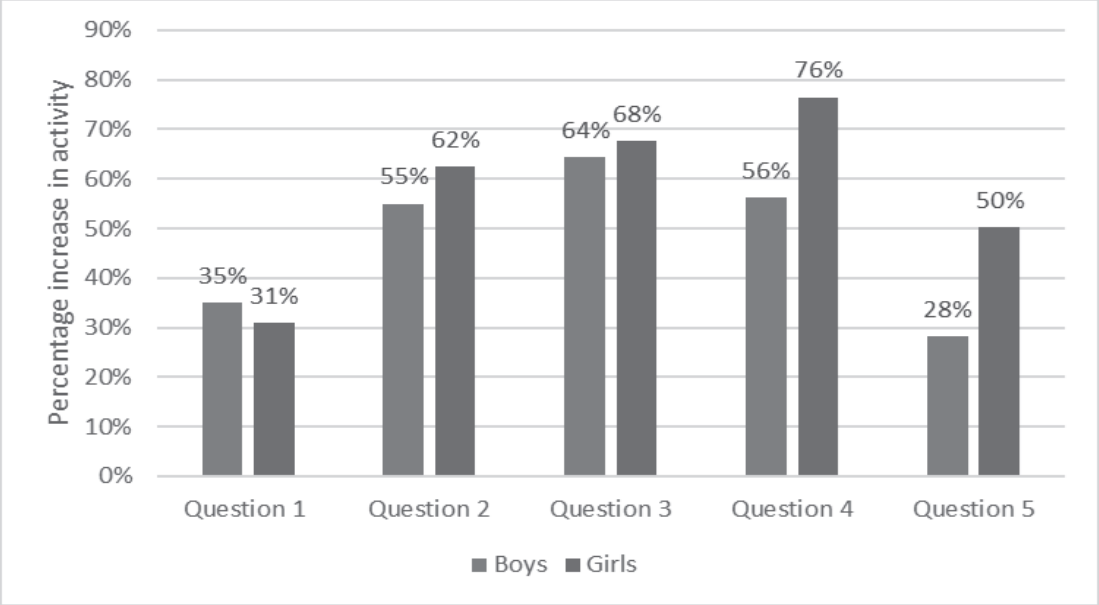

Figure 3. Intellectual activity of pupils in the field of remembering questions, broken down by gender

To sum up, boys fared much worse in this respect than girls. Such results may mean that during non-formal education activities, boys do not focus their attention, do not have sharpened perception This condition may be related to boys having a different approach to learning than girls. Boys are less likely to care about good school grades, they tend to pay more attention to relationships with their friends, while girls are more likely to want to learn well and get good grades (Rękosiewicz and Jankowski, 2014, p. 23).

The results of the research broken down by pupils' residence showed that those from rural schools tend to be much better at remembering than those from municipal schools. This may indicate that students from rural schools are more likely to rely on memorization of information, because teachers working with them rely on administering methods. Consequently, they have more developed cognitive processes, i.e.: memory and attention, than urban students, where deductive-inductive thinking is more often required. It seems that this may also be due to the fact that students coming from rural schools do not have proper technical facilities in their schools and working with new technologies motivated them more to learn, resulting in the engagement of more cognitive processes during class.

The research also investigated the results according to the stage of pupils' development. In the group of middle school age pupils, it was observed that 12-year-olds coped best with the tasks, achieving over 42% of activity in each question. Such an effect may be due to the faster development of students' cognitive processes at this age, which is confirmed by other studies. This is corroborated by other researchers, who claim that this result may be determined by the faster development of hypothetico-deductive thinking (Piotrowicz, Ziółkowska and Wojciechowska, 2014, p. 35), increased confidence in decision-making and a sense of competence (Appelt, 2005, pp. 4-5). Based on these conclusions, it can be assumed that in this age group faster cognitive development played a major role. Additionally, it was observed that 9-year-old pupils obtained a stable increase in their intellectual activity in each question, which proves the even development of pupils at this age (Rękosiewicz and Jankowski, 2014, p. 16).

In the case of pupils in the early adolescence stage, they obtained worse results than those in the middle school age. However, this is an aspect often found in the study of these two age groups, however, it should be stated that older students have problems with their emotional activity, which can have a significant impact on cognitive processes, i.e.: memory, attention, imagination and thinking. These findings are confirmed by other researchers claiming that this is a consequence of the impact of emotions on cognitive processes, which can have a negative impact on students' intellectual activity (Salovey and Sluyter, 1999, p. 34).

The presented results show that it is pupils aged 13 who achieve the best results in intellectual activity. The remaining groups recorded only a slight increase in their activity. This state of affairs may mean that 13-year-old pupils are at a stage where their cognitive processes work well with emotional processes. This is also confirmed by the results of other researchers, who

formulate the conclusion that in students aged 14-15 the phenomenon of ambivalence can be seen in their results of intellectual activity (Oleszkowicz and Senejko, 2013, pp.17-34). It can be concluded that this is due to the full entry into the stage of early adolescence, where emotional processes dominate over cognitive processes (Matczak, 2003, p.50-55).

Analysis and interpretation of research results in terms of comprehension tasks

The intellectual activity of pupils in terms of comprehension of information is the second level of B. Niemierka's taxonomy concerning the category of information. In this part of the analysis, the pupils were asked to choose the correct answer in tasks marked with numbers:

6. Distinguish which of the presented blocks will make the robot drive forward indefinitely
7. Indicate what the robot will perform first?
8. Explain what depends on the operation of the loop rearranged in the figure?
9. Explain what needs to be changed in the motor properties window to make the robot drive forward?
10. Explain, based on the figure shown, when will the robot perform its action?

The analysed range of questions was based mainly on cognitive processes such as memory, but also triggered processes related to deductive and inductive logic (Strelau, 2004, pp. 275–276), and in the case of older pupils – hypothetical-deductive reasoning (Piotrowicz, Ziółkowska and Wojciechowska, 2014, p. 35).

The results of the intellectual activity of the primary school pupils are presented in graphic form in Figure 4.

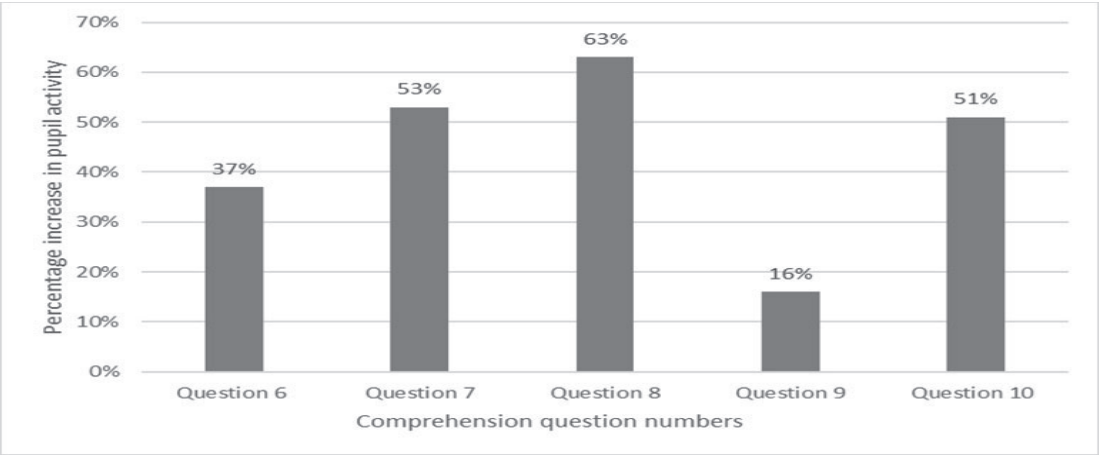

Figure 4. Graph of the set of research results on intellectual activity of primary school pupils in questions related to comprehension

It is worth stating in terms of these questions that the students did well in non-formal education classes with parallel activation of cognitive processes, i.e.: attention, perception, memory and thinking. Students connected the memorized messages with each other and were able to properly understand the questions asked. This means that their processes related to logic, deduction and induction functioned very well in programming and construction tasks.

It is confirmed by statistical calculations, because the average activity of pupils participating in non-formal education classes was 44%. This result indicates that more than one in three pupils improved his intellectual activity in terms of comprehension of information.

The research was also carried out taking into account the gender of the students, which is presented in Figure 5. From the data presented, it can be concluded that it was the girls who achieved a higher increase in intellectual activity during classes. The reasons for such an effect can be found in the faster development of their cognitive processes, primarily thinking.

This conclusion is supported by other studies, in which the main conclusion is that girls have better developed deductive logic than boys. In addition, it can also be concluded that girls are more engaged in the didactic process than boys (Cywińska, 2012, p.155).

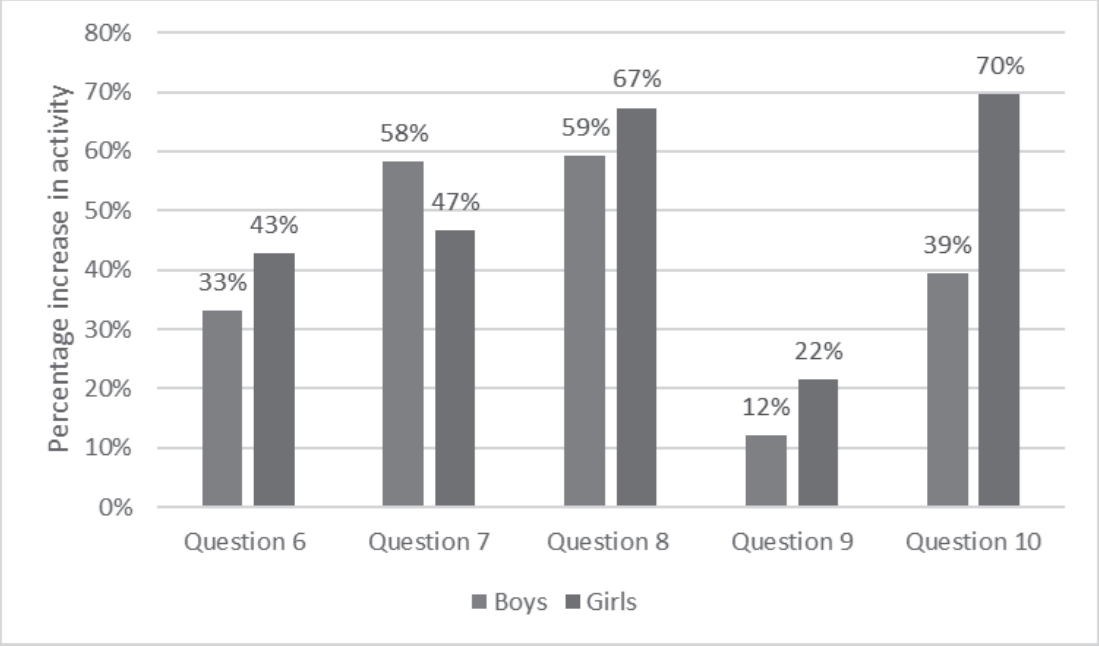

Figure 5. Intellectual activity of pupils in the field of comprehension of questions, broken down by gender

In summary, in terms of comprehension, the organised workshops had a better impact on the intellectual activity of the girls participating in them.

In the context of the pupils' place of residence, it is not possible to identify a group that achieved a higher increase in intellectual activity in this type of task. Such a conclusion was drawn due to the difference in the calculated average value of activity between pupils from urban and rural schools, which was 3%. This is also a very positive finding in terms of the development of students from rural schools, as there are no deficiencies in their cognitive development despite studying in rural schools.

It can be concluded that these were students who completed the tasks without much difficulty, which is probably due to very good cognitive functioning at this age. It is worth mentioning that this age borders on the second age group analyzed, which may mean that a large proportion of students at this age had very well developed inductive, deductive and metamemory processes, which are characteristic of the older age group This is also confirmed by A. Modrak in his research on the cognitive processes of elementary school students (Modrak, 2016, p. 17).

Pupils in the lower middle school age stage, despite underdeveloped cognitive processes, achieved a high increase in activity. Therefore, it seems correct to say that such an effect could have been influenced by modern information technologies and a properly prepared curriculum. In the case of the early stage of adolescence, it is difficult to clearly indicate at what age the pupils did best in the research. An additional factor could be the poor level of mastery of knowledge by pupils in the field of remembering and comprehending information, which is confirmed by previous research results.

Analysis and interpretation of research results in the field of tasks related to the use of information in typical situations

The next part of the analysis of the research results was related to the ability to use the acquired knowledge from the previously analysed information category in typical situations. Typical situations are tasks in which the pupil demonstrates his knowledge by solving a problem posed before him, which requires him to have basic theoretical knowledge, understand it and, consequently, the ability to apply the knowledge to a given question. At this task level, all cognitive processes in students are involved and complement each other.

Pupils intellectual activity in the use of information in typical situations was checked on the basis of questions numbered:
11. Select the appropriate flowchart for the commands shown: drive forward, turn on the light, play music.
12. Select the appropriate block diagram for the commands shown: wait, play music, drive forward.
13. Determine what the robot will do based on the picture shown.
14. Choose the appropriate flowchart from those shown below so that the robot repeats its actions in the following order: drive forward, wait for the sensor to touch, drive backward, drive sideways.
15. Choose the appropriate scheme from those shown below so that the robot travels backward if it is less than 20 cm away, otherwise it is to stand still

The questions were designed to test the ability to use previously acquired knowledge, and in particular to show the complementarity of cognitive processes. The intellectual activity of pupils in this group of questions is presented in Figure 6.

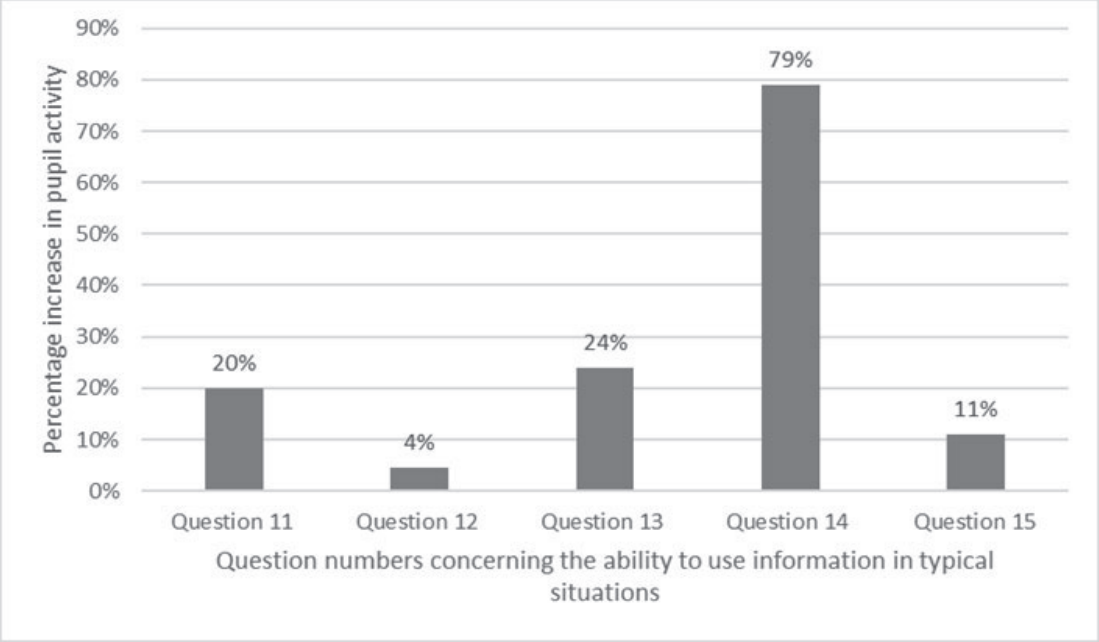

Figure 6. Graph of the set of research results on intellectual activity of primary school pupils in questions concerning the use of information in typical situations

It can be concluded from the presented results that the value of intellectual activity in this area was very low, which is confirmed by the mean value of 28% calculated on the basis of the collected measurements of the initial and final tests. It can be assumed, first of all, that the students cannot cope with such tasks, as well as that their cognitive processes are not sufficiently developed to cope with this type of task. It seems that the main

process for these tasks should be thinking, which, as the results show, does not function properly.

The results of the research, divided into the gender of the surveyed pupils, are presented in Figure 7.

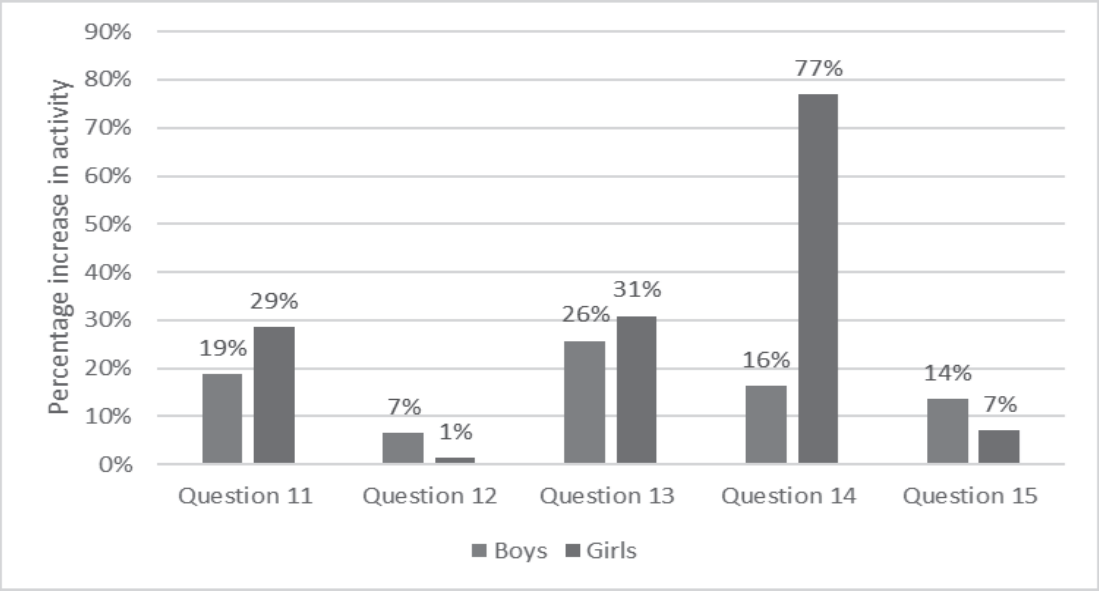

Figure 7. Intellectual activity of pupils in the field of questions on information used in typical situations, broken down by gender

The general conclusions from the presented data again indicate that it was girls who obtained a higher increase in intellectual activity in the use of information in typical situations. This confirms the previous conclusion that girls have better developed cognitive functioning than boys. They more easily and quickly connect newly formed data structures in their brains, which they use in other cognitive processes. Another reason may also be a different approach to learning than in boys, attaching importance to the educational content being pursued, resulting in better mastery and use of the content in practice. This is also confirmed by the research of B. Dyrda, who formulated similar conclusions in her research (Dyrda, 2006, pp.121-131).

In terms of the division into schools that the pupils attend, the results of the research show that it was pupils from municipal schools who achieved a higher increase in their intellectual activity. This means that they are better at applying the acquired knowledge in practice.

The division in terms of the developmental stage showed that the increase in pupils' intellectual activity increases with their age. Therefore, it should be unequivocally stated that pupils in the middle school age did not cope well with using knowledge in typical tasks, while pupils in the early stage of adolescence, aged 14-15 years, achieved an average increase of 20%.

This means that their perception, imagination, attention, memory and thinking are not as developed as those of older students. This is a logical conclusion according to all the assumptions of developmental psychology of students.

Analysis and interpretation of research results in the field of tasks related to the use of information in problematic situations

The final scope of the analysis was the use of information in problematic situations. This level is characterised by pupils using all previously acquired knowledge and skills in situations that are completely new to the learners and require them to solve a problem they have encountered on their own. This type of task is based, of course, on all cognitive processes, but mainly on deductive reasoning, i.e. applying the formal rules of logic to derive conclusions from given premises, inductive reasoning, i.e. deriving conclusions from observed facts and problem solving.

The following questions were assigned to the analysed scope:

16. Detect, based on the illustration shown, what needs to be changed in the settings shown to make the robot light sensor red.
17. What could be the cause of the robot's failure to move the sensor configuration shown?
18. Determine why the sensor does not detect colors properly?
19. Infer the removal of which block will completely change the direction of the robot?
20. Infer what you will do if you damage the traditional input of the NXT cube, and you want to upload your program?

These questions required the use of knowledge and skills, but beyond the level of typical situations.

The intellectual activity of the surveyed pupils in this area is presented in Figure 8.

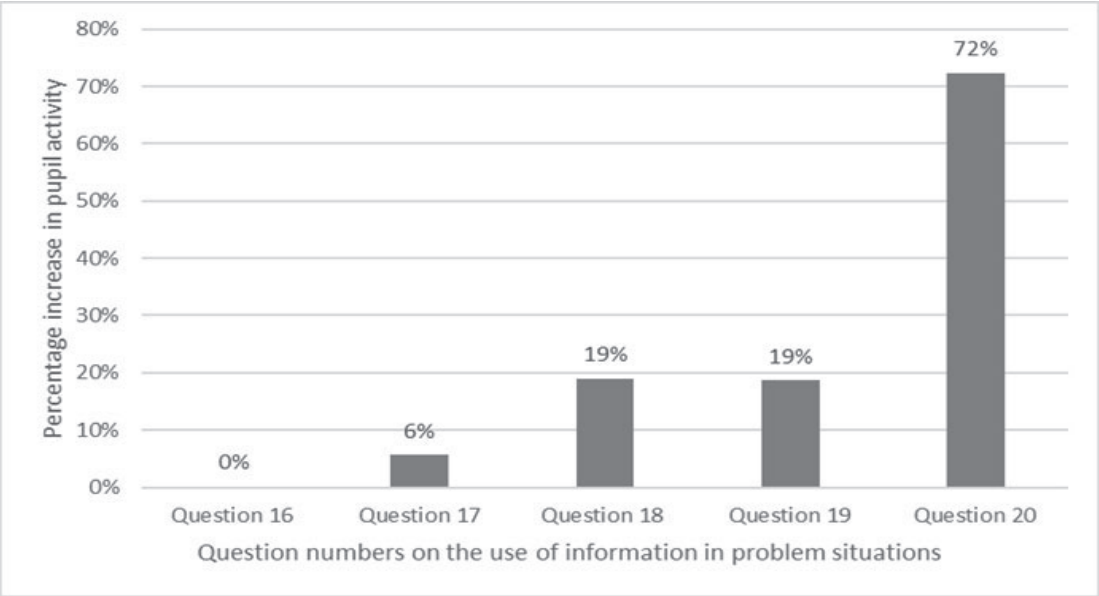

Figure 8. Graph of the set of research results on intellectual activity of primary school pupils in questions concerning the use of information in problematic situations

It can be concluded that the increase in the intellectual activity of pupils in most of the questions in this field was very low. This means that students have a problem with advanced cognitive processes, which involve deductive-inductive thinking. Pupils recorded the lowest increase in intellectual activity, amounting to 23%, which means that every fifth pupil, participating in the workshops, increased his intellectual activity in this area. This means that the student engaged more cognitive processes to solve the tasks than in the initial study.

The increase in intellectual activity of pupils broken down by gender is presented in Figure 9.

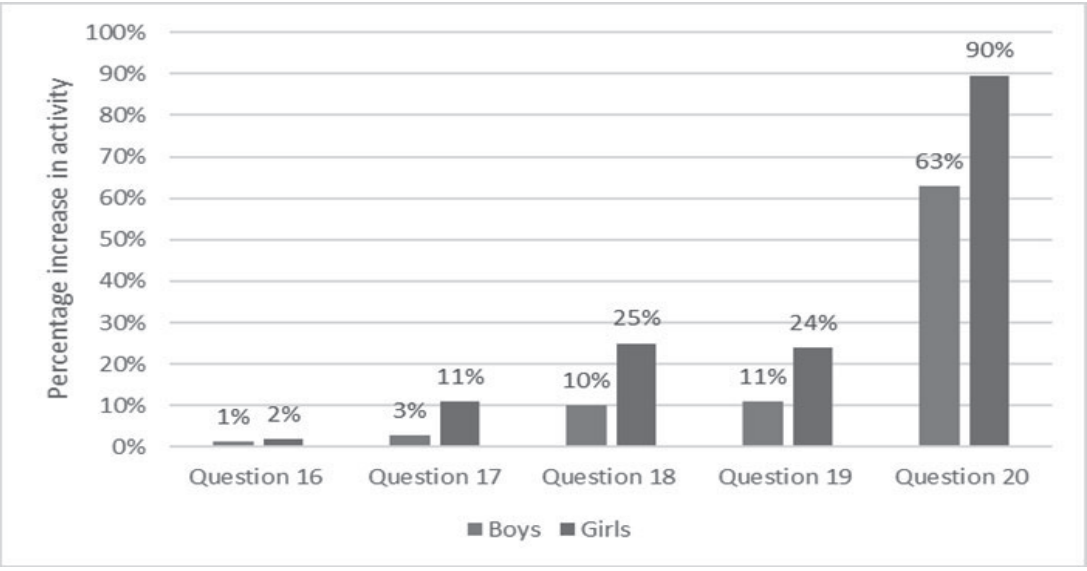

Figure 9. Intellectual activity of pupils in the field of questions on information used in problematic situations, broken down by gender of the respondents

From the presented data it can be concluded again that it was the girls who coped better with the use of information in problematic situations. There is a conclusion, which confirms previous results, that girls have better developed cognitive functioning. In the general analysis of the means obtained in this category, broken down by gender, girls reached the value of 30%, and boys 18%. This means that after the workshops, almost every third girl had improved her results from the initial test.

The results of the study by school type indicate that in problem tasks it was the students of rural schools who achieved a higher increase in intellectual activity. Therefore, it can be concluded that living in the countryside stimulates their cognitive processes to a greater extent than urban school students. By developmental stage, a very slight increase of 10% was observed in middle school students. Again, early adolescents performed better in this type of task and achieved a 33% increase in activity. This effect is undoubtedly related to better cognitive development of students in early adolescence.

Conclusions

The research conducted in the field of intellectual activity of primary school pupils shows that *non-formal education activities carried out on the basis of the curriculum affect the intellectual activity of primary school pupils.*

Such a conclusion was drawn on the basis of the results obtained from the study, which clearly indicate that regardless of the type of questions asked, students obtained an increase in their intellectual activity, which is understood as stimulation of cognitive processes. The results of the study indicate that these were mainly perception, imagination, attention and memory.

Such a conclusion was drawn because students in tasks that, required them to reproduce from memory the given information created in non-formal education classes did best. Thus, it was the indicated cognitive processes that mainly took part in interpreting messages, forming imaginations and storing messages in the students' memory.

According to the holistic theory, the other processes were also stimulated, but the students had trouble correctly connecting the messages they memorized and used in practical tasks. This means that students have difficulty in the functioning of cognitive processes at each stage of development when it is necessary to apply the acquired knowledge in practice. This indicates a disorder in the context of the students' thinking process. The main problem lies in deductive reasoning, as students are unable to draw conclusions from a preconceived set of premises. In addition, the problem also occurs in the field of observing certain phenomena and deriving

conclusions from them, because in the tasks carried out, many times students had to face the structural analysis of flowcharts, on the basis of which they were supposed to indicate the correct answer. The biggest problem occurred in terms of the problems that students encountered in solving the tasks, so they had a problem with correct deductive-inductive thinking. The detailed result in terms of the research conducted was carried out by the categories of questions asked to students.

The analysis of research in the field of remembering information showed that pupils do not usually read texts carefully, and they have problems with remembering concepts that contain specialised technical nomenclature. A related finding in the analysis of memorized information is confirmed by a study conducted with a group of students of different intellectual levels, in which regardless of intellectual level, students achieved low results in memorizing concepts and concentration (Amosa, Ladwig, Griffiths, and Gore, 2007, s. 25-29). It can be assumed that the students have problems in the correct perception of the reception of educational content, as well as in long-term memorization. This conclusion is based, for example, on the fact that students used various components repeatedly, and were unable to name them accurately. The low results in terms of solving tasks mainly related to memorization are due to the involvement of a small number of students' cognitive processes during classes. Thus, it can be concluded that the performance of activities initiates cognitive processes and their better functionally.

The analysed research results also show that it is much easier for pupils to remember terms related to an activity they perform. Such a conclusion was also taken up in a study conducted by T. Fukawa-Connelly, K. Weber, J. P Mejía-Ramos (2017, pp. 570-579). The obtained data also allow the conclusion that pupils who have had physical contact with a given subassembly or element are able to remember its properties very accurately. This indicates that classes during which, for example, complex technical structures are discussed, should be conducted in accordance with the principle of visualisation, i.e. with the use of a real model or a created miniature. This allows the student's perceptions to be engaged, to focus on the thing in question, to form their own ideas, as well as to develop a theoretical-practical model of the principle of action that enables correct thinking.

It is also worth noting that girls tend to be much better at remembering information. Their results more often stood out from those of the boys. Which is justified by their faster development and better functioning of cognitive processes. The place of residence is an equally important aspect, because pupils from rural schools were better off in terms of information

remembered in each of the questions completed. The classes seem to have had an intensive effect on the students' memory, and therefore on their perceptual processes. It can be concluded that the workshops conducted and the support provided to students from rural schools definitely has a positive impact on their cognitive processes. In terms of the developmental stage, the group of pupils in middle school age did particularly well. This is due to their stable cognitive development, which changes significantly early in adolescence. The main thing is the ability to draw conclusions during ongoing tasks, so deductive thinking, the functioning of which is beginning to stabilize.

In the case of comprehension of information, the results of the research showed that pupils are good at understanding the content of a class, but worse than they are at remembering it. Such an effect may be due to the fact that in formal education more emphasis is placed on memorising information than understanding it, e.g. by using mainly instruction methods in the educational process. This conclusion is confirmed by research on the quality of education in formal education (Praetorius and Charalambous, 2018, pp. 540-550).

Breaking down by gender the analysis of comprehension of information showed that girls did better. Such effects may be related to better girls' scores in remembering information, resulting in better comprehension of information. In the case of the division of pupils by place of residence, it is impossible to indicate a better group, because the difference in their activity is too small to be considered statistically significant. The similar result in this respect of both groups proves that each type of school is working on improving their ways of operating by focussing on the processes of practical action and independent discovery. The results of separate age groups indicate that younger pupils are better at comprehension of information than their older colleagues. Such an effect was visible in the research in the field of remembering, because middle school age pupils achieved higher intellectual activity.

The next part of the analysis concerned the use of information in typical situations. As the results show, pupils have problems applying acquired knowledge in practice. This is also a conclusion taken up in studies by M. Kunter, T. Voss (2013, pp. 99-110) and J. Scheerens (2013, pp. 1-38).

The analysis of the results shows that the girls are better at using the information obtained during interactive workshops. In addition, the conducted research shows an effect that is conditioned by the developmental psychology of children, because the better results of girls indicate their faster development and better developed cognitive processes. The research also showed shortcomings in the skills of pupils from rural schools, therefore, it

should be noted that the need to target this form of classes toward pupils from rural schools is more pronounced. Undoubtedly, it should be stated that the need to direct this form of classes to pupils from rural schools is highlighted once again. In terms of the developmental stage, it must be admitted that the results clearly indicate that the intellectual activity of pupils, and thus the development of cognitive processes, increase with age. The research results also highlight the phenomenon of pupils' ambivalence in the early adolescence phase, which manifests itself in unbalanced cognitive processes.

The final analysis concerned the ability to apply information in problematic situations and showed that pupils have problems with the proper use of acquired knowledge in problem tasks. It is difficult for them to carry out tasks that fit into the curriculum in terms of content, but due to the fact that such examples were not performed in the classroom, they are impossible to perform. Similar conclusions are drawn from their research by L. Groß-Mlynek, M. Graf, T. Harring, K. Gabriel-Busse, T. Feldhoff (2022, p.5), indicating that students are unable to apply knowledge in tasks that are deductive-indicative in nature. It should be especially emphasised that pupils do not have properly developed computational thinking responsible for the correct processing of algorithms. Perhaps it is in this aspect that the poor results of pupils in this field lie.

The results in this aspect also show that girls have much better developed cognitive processes than boys and obtain higher increases in intellectual activity. It is worth emphasising that in this area pupils from rural schools achieve higher increases in activity, which becomes an important conclusion in the context of the development of non-formal education. In the area of the developmental stage, middle school age pupils have poorly developed inductive and deductive thinking, as a result of which they recorded very poor intellectual activity. Their colleagues who were in the early stage of adolescence did much better in this respect, which seems to be justified, because they benefit from full development of hypothetical-deductive reasoning.

The main recommendation in terms of better stimulating pupils' intellectual activity is to increase the number of tasks that require the application of the acquired knowledge in practice. Particular attention should be paid to the process of solving problem tasks, because pupils have a lot of difficulties with them and make a large number of mistakes when solving them.

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