THE ALGORITHM OF SCIENTIFIC CONCEPTS FORMATION IN THE JUNIOR PUPILS IN THE LEARNING PROCESS

Oksana Loiuk, Tetyana Gritchenko
Pavlo Tychyna Uman State Pedagogical University
Uman, Ukraine
lov1207@ukr.net
gtya212@ukr.net

Abstract. *The article reveals the urgency of the problem of scientific concepts formation in junior pupils. The algorithm for the scientific concepts formation in junior pupils has been based on the synthesis of M. Maslova's concept of thinking integrity; Y. Ponomariov's research on the inner action plan; Yu. Kulyutkin and G. Sukhobskaya's position on transition from the operational components of visual-thinking to the content components of the conceptual, research psychologists (O. Kulchytska, O. Luk, O. Molyako, etc.) about the creative process structure; P. Halperin and N. Talyzina's research results concerning mental actions and concepts formation.*

The conclusions about the algorithm effectiveness for the scientific concepts formation in junior Pupils in the process of studying the disciplines "I am in the world" and "Natural science" have been presented.

Key words: *junior pupils, scientific concepts, visual-figurative thinking, conceptual thinking, problem question, hypothesis, meaningful generalization, mental activity formation, self-control, self-esteem.*

Problem formulation. The information and communication technologies intensive development, the powerful globalization processes influence, the active introduction of new scientific inventions into the society life, the reform processes taking place in education, determine the scientists' special attention to study the problem of a coherent, creative person development. As never before, the progressiveness of any society is determined by the personality development level. This factor is the main lever of further progress and is provided by education. Relevance of the above is reflected in the Law of Ukraine "On Education", the Concept of the New Ukrainian School, the State Standard of Primary General Education. The normative documents state that the education purpose is the child's comprehensive development, his talents, competencies and cross-cutting skills in accordance with age and individual psycho-physiological characteristics and needs, values formation, autonomy, creativity and curiosity development.

Psychological and pedagogical researches show that personality development is based on theoretical knowledge and scientific concepts.

In the learning theory, there are known areas which concentrate and enrich scientists' progressive formation experience of the scientific concepts in junior pupils. These are: P. Halperin and T. Talizina's theory of mental actions phased formation; M. Shardakova's theory of concepts formation by revealing the ratio of verbal-conceptual, figurative and practically-effective thinking activity; V. Davydov and D. Elkonin's theory of meaningful generalization; L. Zankova's theory of pupils' training on the raised difficulty complex; I. Yakimanska's theory of developing education; V. Palamarchuk and O. Savchenko's concept of general educational skills and abilities formation and development. The concepts that are formed in primary school pupils are an indicator of their knowledge quality and evidence of their intellectual development.

However, scholars[1],[2],[3],[4] also proved that junior pupils often learn the concept definition without understanding its essence. They operate the terms without realizing the existing essential features, experiencing difficulties in their classification and systematization.

---

[1]Байбара Т. М. Методика навчання природознавства в початкових класах: навчальний посібник. 1998.334 с.

[2] Біда О. А. Природознавство і сільськогосподарська праця : Методика викладання : навч. посібник [для студентів пед. ф-тів вищих навч. закладів та класоводів]. 2000. 400 с.

That is why the search for new organizational and content components of educational activity, in which the thinking development of junior pupils will be more effective, and optimization of the concepts process formation is essential for a modern school.

The article aim is to present the results of the theoretical substantiation and the practical application of the algorithm of scientific concepts formation in junior pupils in the learning process.

Presenting main material. *Knowledge* (by scientists O. Brushlinsky, G. Kostiuk) is the system of concepts and judgments, which can become the pupils' property only through appropriate mental actions[5,6].

D. Elkonin understands *concepts* as a set of definitions, the set of many significant relations in the subject [7]. To form the concept it is necessary to identify all sides of an object or phenomenon. Since they are not given directly, they must be detected in the process of dealing with objects. Consequently, the process of a concept formation directly depends on the formation of actions with objects that open their essential properties. In the above-mentioned case, actions with objects are methods of human brain work[8]. Under the *scientific concepts* we understand the psychic neoplasm which is the result of the learning process, the process of subjective knowledge independent discovery[9]. Therefore, we believe that the problem of scientific and theoretical concepts formation in the primary school educational process is extremely important.

Analysis of psychological and pedagogical sources has showed that in science the significant theoretical and methodological base has been created. The leading positions on the problem of scientific concepts formation among pupils have been stated.

Based on these studies, we have attempted to develop our own algorithm for the scientific concepts formation among junior pupils. As a basis we have taken:

1. P. Halperin and N. Talyzina's research results concerning the mental actions and concepts formation.

Researchers believe that the main source of the concepts formation is the human activity on the basis of sensations, further – perceptions, representations, and, on this basis, – the concepts. N. Talyzina offers to begin to form the actions concept with objects that are aimed at identifying the characteristics important for the researcher of these objects[10]. P. Halperin identified the action as the central activity element. He offered the concept of mental activities phased formation. According to the scientist, mental actions are the result of the transformation of external actions into internal, into the plan of sensations, perceptions, ideas, concepts[11]. N. Talyzina and P. Halperin consider the actions transition from the external plan in the internal specifically human form of obtaining new knowledge. A well-known approach to the concepts formation is possible provided that it is based on concrete visual material or sensations and perceptions.

2. M. Maslova's concept on the thinking integrity.

According to the researcher, holistic thinking involves the use of both visual and figurative types of thinking.

The right hemisphere of the 7-8 year old child brain matures much earlier than the left one, and then child thinks in images and seeks to practice. The psychological mechanism of visual-figurative thinking during the perception of a certain phenomenon is the chain of auditory, visual and other images. They are combined by temporal-spatial associative relationships, which are called

---

[3]Костюк Г. С. Навчально-виховний процес і психічний розвиток особистості. 1989. 612 с.

[4]Методика навчання освітньої галузі «Природознавство»: курс лекцій / Укладач Т.Я. Грітченко. 2016. 163 с.

[5]Брушлинский А. В. Психология мышления и проблемное обучение. 1983. 96 с.

[6]Костюк Г. С. Навчально-виховний процес і психічний розвиток особистості. Київ, 1989. 612 с.

[7]Эльконин Д. Б. Избранные психологические труды. 1989. С. 257.

[8]Эльконин Д. Б. Избранные психологические труды. 1989. 560 с.

[9]Новейший психолого-педагогический словарь. 2010. 928 с.

[10]Талызина Н. Ф. Формирование познавательной деятельности младших школьников : кн. для учителя. 1988. 175 с.

[11]Гальперин П. Я. Основные результаты исследований по проблеме «формирование умственных действий и понятий». 1965. 51 с.

the moving object of the subject. A moving image is the basis of the mental processes of preschoolers and junior pupils. However, the junior pupils are observing add-ons on the basis of associative chains. Children, operating on specific subjects, gradually master logical operations of comparison, analysis, synthesis, classification, abstraction, concretization, and generalization. Therefore, in conceptual thinking, attention is drawn to the internal, essential objects and phenomena properties and the relation between them[12].

The holistic thinking development should begin at the junior school age, since visual-figurative thinking with the obligatory conceptual elements use is its characteristic.

3. Yu. Kulyutkin and G. Sukhobskaya's statement on the transition of the visual-figurative thinking operational components into the conceptual thinking content components. The transition from the operation of concrete things relations to the operation of abstract relationships the scientists call the main condition for the creative thinking development. This process takes place just at the beginning of the child's school education[13].

Of course, at first it is easier for pupils to solve any task, if they see a particular subject they can analyze the concrete facts and make a general conclusion rather than the opposite. If, however, it is necessary to form abstract concepts, it is necessary to move from the offered definition, the standard by a stepwise analysis of the whole in order to discover its genetically original, substantial relation as the basis of this whole internal unity.

4. The research of psychologists (O. Kulchytska, O. Luk, O. Molyako, etc.) on the structure of the creative process.

It is well-known that all human knowledge is the process of setting and solving certain problems. In order to reveal the essence of uncertainty thinking starts involving in the work. It analyzes the problem situation and transforms it into an understandable task in the form of verbal formulation. This allows at least a minimum prediction of future results. The solution of the contradiction between the known and the desired occurs through the brain's analytical and synthetic activity[14].

Junior pupils tend to focus on the final result, not on the process of achieving it, because they are not aware of it and cannot verbalize.

5. V. Davydov and D. Elkonin's development theory.

According to the scientists, the content of educational activities is theoretical (scientific) knowledge. The assimilation of such knowledge is associated with the formation of abstractions, generalizations, which, in turn, are the basis of productive thinking. Educational activity differs from others by one peculiarity: its result is the acquisition of new abilities (new ways of acting with scientific concepts – the process of obtaining knowledge). In the process of joint activities of the teacher with pupils or between pupils there is a transition from external activity forms to internal activity forms. The result of this process is the psychic neoplasm – knowledge[15],[16].

Thus, one of the highest values of educational activity is search activity. It is aimed at the student's independent discovery of ways and means of solving life problems.

6. *Y. Ponomariov's statement on the internal action plan.*

According to the scientist, the development means of the internal action plan is the solution of theoretical problem tasks. Thanks to the functioning of the action plan, the success of the received knowledge formalization is ensured, and mechanical learning is excluded[17]. Concepts are expressed in words. The word makes it possible to create the right image mentally in accordance with the task.

Summarizing theoretical aspects of the problem of scientific concepts formation we have supplemented our algorithm of the studied phenomenon with a practical component. We have

---

[12]Маслова Н. В. Золотой ключик для учителя: основы ноосферной педагогики. 2009. С. 9-14.
[13]Кулюткин Ю. Н., Сухобская Г. С. Развитие творческого мышления школьников. 1967. С. 20-26.
[14]Кульчицкая Е. И., Моляко В. А. Сирень одаренности в саду творчества. 2008. С. 38-46.
[15]Эльконин Д. Б. Избранные психологические труды. 1989. С 245.
[16]Психическое развитие младших школьников: экспериментальное психологическое исследование / под ред. В. В. Давыдова ; Науч.-исслед. ин-т общей и педагогической психологии Акад. пед. наук СССР. 1990. С. 24.
[17]Пономарев Я. А. Психология творчества и педагогика. 1976. 280 с.

developed, selected from the scientific and methodological literature (O. Antoshchak, T. Brailko, V. Barava, V. Zots, L. Derevyanko, I. Dychkovska, E. Zaika, I. Kalmykova, G. Ivanitsa, G. Nedozirna, O. Pometun, L. Pyrozhenko, N. Sydorenko, V. Telyachuk, A. Lesina, L. Tolkachova, M. Chepil) and systematized special games, tasks and exercises[18].

In accordance with our developed algorithm for the concepts formation in junior pupils it takes place in three stages: motivational-orientational, developmental-operational, and reflective-creative. Let's present a detailed description of each of them.

I stage– motivational-orientational. Its goal is to focus pupils on the problem, to raise interest in the topic under discussion; stimulate cognitive needs, motives; to learn to determine the guiding action principle.

The main stage tasks:

1) to direct pupils to perform cognitive and problem-solving tasks;

2) to form a motivational basis for action;

3) to encourage pupils to cognitive and problematic questions;

4) to intensify their imagination, fantasy in order to create an image of the final activity result;

5) to learn to independently determine the activity purpose, turning it into a personally significant (first, under the teacher guidance, then – on their own);

6) to determine the guiding principle for action;

7) to develop skills of independent information search.

Teacher's actions: creates problematic situations; formulates the problem, the task; creates guidelines for recognizing links between component parts of an object; defines goals, activity tasks, plans activities; defines the tasks content, forms, and activity methods; provides the necessary information; controls and regulates students' actions.

Pupils' actions: focus on the problem situation and its in-depth analysis; necessary knowledge actualization, verbal task formulation; the problem awareness, for the decision of which it is necessary to define the purpose and develop an action plan; self-assessment of their capabilities in solving a specific task; self-control, making corrections in their own educational and cognitive activity.

Exercises:"Assumptions", "Confusion", "Quibble", "Yes – no", "Prolong the sentence", "Complaint box", "Angles", "Five words – three words", "Microphone".

***I stage result*:** the children learn to identify the problem, the goals, to plan their activities, to update the experience acquired earlier.

II stage – developmental-operational. The stage purpose is to ensure pupils' awareness and verbalization of obtaining new knowledge process as a result of cognitive and creative activity.

***The main stage tasks*:**

1) to promote active use of previously accumulated experience by pupils, further development of mental operations in the process of performing problem tasks; the development of conceptual thinking visual-figurative elements, creative imagination;

2) to create conditions for the development of the psychological creativity mechanism, to ensure the transition to real action;

3) to teach to formulate theoretical positions, to comprehend the mastered way of action for the purpose of its further application in non-standard conditions.

The second stage involves the following structural components: ideas nomination and fixing; hypotheses statement, their content analysis; hypothesis testing; decision choice, meaningful generalization, new knowledge consolidation; control, self-control. Let's consider each of these components in more detail.

1. Ideas nomination and fixing.

Teacher's actions: encourages pupils to put forward ideas, guesses, and their verbal design; fixes pupils' thoughts on a board in the scheme or a model form.

---

[18]Лоюк О. В. Теорія і практика розвитку творчого мислення учнів у навчально-виховному процесі початкової школи. 2016. С. 207-216.

Pupils' actions: put forward their ideas for solving the problem.

Methods of cognitive-creative activity: heuristic conversation; associative relations establishment; search for analogies.

Exercises:"Brainstorming", "Creative Drawing", "Restoration", "Invent Wish", "Imagine...", "Synectics method", "Associations Catalog".

2. Hypotheses statement, their content analysis

Teacher's actions: thinks about the alternation of individual and collective work, which makes it possible to create an atmosphere of commonwealth, mutual understanding, dialogue in finding the truth; it ensures that the pupils do not ignore each others' thoughts, maintains the commonwealth atmosphere.

Pupils' actions: each pupil expresses his point of view, his own problem vision, offers hypotheses for the contradictions solution.

Methods of cognitive-creative activity: hypothesis construction according to the headline, the topic key words; work in pairs and in small groups, which are formed at the children's will, where the mutual experience enrichment takes place, the points of view comparison with the thoughts of others (dialogue as a different language); receiving visualization (creating a future result image).

Exercises:"The Wizard", "Searches of connecting links", "Make a sentence", "What will happen next", "Fantasize", "Fantastic hypotheses", "Construction of consequences system", "Choose the position".

3. Testing the hypothesis (solving the problem with heuristic methods and techniques)

Teacher's actions: involves the entire team to work (in small groups, in pairs); carries out the optimum choice of educational activity methods; provides support in case of difficulties; positively evaluates every pupil's success; poses additional questions, compares different opinions, suggests to substantiate them; demonstrates a reasoning example to pupils.

Pupils' actions: together with a teacher and other children, analyze the situation on the basis of knowledge and experience; perform substantive and mental actions; conceptualize, compare new information with their own knowledge; learn a teacher's mental activity pattern; actions are accompanied by a language directed at another child or teacher.

Methods of cognitive-creative activity: modeling and schematization; establishment of cause-effect relationships, diverse subject analysis; change the main subject purpose and use it in an unusual role; finding objects of new properties; solving the problem in several ways; methods "increase – decrease", "division – association", "revival – petrifaction"; methods to compose fairy tales ("fairy tales", "fairy tale outdoors", "what's next").

Exercises:"Fantastic situations", "Objects classification", "List of possible causes", "Combinator", "Yes – no", "Deny my opinion", "Unusual things use", "Combine the fairy tale".

4. Decision choice, meaningful generalization, new knowledge consolidation

Teacher's actions: creates an atmosphere of mutual assistance through interaction; stimulates pupils to express themselves; shows the possible ways of constructing logical sentences that reflect the relationships found; detailed proof plan, its logical scheme.

Pupils' actions: argue their own point of view and substantiate the findings; perform tasks according to the model and gradually transfer to non-executed tasks; apply a new action method; actions are accompanied with the different language.

Methods of cognitive-creative activity: generalization; rules and concepts formulation; a recognized features description using definitions and narration; creating choice situations; an incentive to find alternative solutions; choral reading aloud definitions, rules with a gradual transition to individual reading; practical application of the learned action mode in order to verify its effectiveness; discussions.

Exercises:"PRESS Method", "Decision Tree", "Common Search", "Continuous Thinking Scale", "Definition Formulation", "Alternate Way Search", "Compare", "Compare Doers Actions".

5. Control, self-control

Teacher's actions: controls, diagnoses the state of action mode (or concept) assimilation; attracts students to control the activities course (control, self-control, intercontrol, work in groups), demonstrating the reasoning algorithm.

Pupils' actions: carry out their activity control: comment on the actions algorithm based on theoretical knowledge with each step justification; work in a small group or in a dialogue (one pupil reproduces the material, and the other controls); proceed to reproduce the acting way in the external speech about themselves to internal speech.

Methods of cognitive-creative activity: formulation of recommendations, algorithms; visual representation of the performed action (drawing, scheme, etc.); operations definition that make up the action.

Exercises:"Retell, relying on...", "Voice", "Retelling", "Transmit opinion in other words", "What was, what will be", "Action Algorithm", "Reduce".

II stage result: comprehension of the received action method, the ability to apply it in various situations.

III stage – reflective-creative. The purpose is to stimulate the need for independent creative activity on the basis of knowledge, skills; impressions obtained at previous study stages.

The main stage tasks:

1) to teach pupils to evaluate their own level of understanding and learning new knowledge by resorting to past experience;

2) to cause a positive emotional experience from the work that contributes to increasing self-esteem;

3) to encourage children to verbalize the experiences that accompanied the creativity process;

4) to teach pupils to define goals and design future activities, mentally reproducing the sequence of all subsequent actions and operations;

5) to encourage pupils to apply the acquired knowledge in the new environment;

6) to promote the children's desire to fulfill their creative tasks independently.

Teacher's actions: evaluates only the process of pupils' activity; initiates and intensifies the pupils' reflection about individual and joint activities; creates conditions for the emergence of independent children's creative activity; directs pupils' independent search to resolve difficult situations.

Pupils' actions: purposefully carry out self-control and self-evaluation, determining: the mastering degree of ideas, knowledge, actions ways, values; the possibility of their use for the new knowledge acquisition; compare results with the tasks, analyze the difficulties causes; analyze their own mental activities and feelings; realize the situation to achieve the goal; evaluate their ability to share knowledge with others; establish connections between the well-known and those that still need to be learned; express new ideas and thoughts.

Methods of cognitive-creative activity: a question on the pupil's awareness of the new knowledge value gained; creative tasks performance; the problem simplification; analogies vision; individual independent tasks; return to key words, true and false allegations; the answer to the question from the stage I.

Exercises:"Good – Bad", "Top of Success", "Time Machine", "Unfinished Suggestions", "ABC Soup", "Impressions Circle".

III stage result: formed ability to evaluate acquired experience, potential opportunities, use the acquired values in the independent creative activity.

Thus, the theoretical substantiation of the algorithm for the scientific concepts formation in junior pupils, a detailed stages description and their effectiveness, gives all grounds to argue that its application will contribute to the formation of pupils' ability to independently solve medium and high severity problems, obtaining a new way in solving them.

In order to test and validate our developed algorithm, an experimental study has been conducted on the basis of Uman secondary school #3. The experiment has involved 102 primary school pupils. There have been 2 experimental classes with a total number of 52 pupils who have studied according to our offered algorithm and 2 control classes with a total number of 50 pupils

who have studied according to the traditional system. Four primary school teachers (class guides of experimental and control classes) have been involved in the experiment.

Experimental work has included the following steps:

I. Instantiate section of the existing level of pupils' scientific concepts formation in experimental and control classes.

II. Conducting classes from the courses "I am in the world" and "Natural Science" with the application of the developed algorithm, which contribute to the purposeful process of scientific concepts formation based on experimental classes.

III. Control section – measurement of pupils' scientific concepts formation levels in experimental and control classes and their comparative analysis.

The study results of the instantiate and forming stages are presented in Table 1.

Table 1

Dynamics of changes in levels of scientific concepts formation in pupils of control and experimental classes before and after the forming experiment

Levels \ Pupils	**Experimental classes (52 pupils)**				**Dynamics**		**Control classes (50 pupils)**				**Dynamics**	
	Knowledge statement		Final knowledge cut				Knowledge statement		Final knowledge cut			
	n	%	N	%	n	%	n	%	n	%	n	%
High	4	7,7	11	21,2	+7	+13,5	5	10	7	14	+2	+4
Medium	18	34,6	28	53,8	+10	+19,2	16	32	20	40	+4	+8
Low	30	57,7	13	25	-17	-32,7	29	58	23	46	-6	-12

Diagnosis of scientific concepts formation levels in junior pupils has been carried out with the help of special questionnaires, pedagogical observation, and educational products evaluation.

These tables indicate an increase in the number of pupils in experimental classes with a high (13.5%) and an average (19.2%) level of scientific concepts formation and a decrease in respondents with a low level (32.7%).

Conclusions and perspectives of further scientific research. Thus, according to the comparative analysis results, we can state that the most significant differences in the levels of scientific concepts formation in junior pupils occur in experimental classes. That confirms the effectiveness of our developed algorithm. Pupils' activity on the stages defined by the algorithm repeats cycles of children's thinking from 6 to 10 years: from the visual-effective, through the visual-figurative to the conceptual. This algorithm can be used during educational activities, individual lessons, during a certain topic study. Using the technique of organizing a lesson or educational event by analogy with it, the teacher will achieve significant results in the scientific concepts formation in primary school pupils.

However, the conclusions and results obtained do not pretend to be the final solution to the problem of scientific concepts formation in junior pupils. Further scientific research may be aimed at studying the problem of updating the educational activities content in primary school.

References:

1. Байбара Т. М. Методика навчання природознавства в початкових класах: навчальний посібник. К. : Веселка, 1998. 334 с.
2. Біда О. А. Природознавство і сільськогосподарська праця : Методика викладання : навч. посібник [для студентів пед. ф-тів вищих навч. закладів та класоводів]. Київ; Ірпінь : ВТФ «Перун», 2000. 400 с.
3. Брушлинский А. В. Психология мышления и проблемное обучение. Москва, 1983. 96 с.
4. Вікова психологія / За ред. Г. С. Костюка. К. :Навчальна література, 2006. 414 с
5. Гальперин П. Я. Основные результаты исследований по проблеме «формирование умственных действий и понятий». Москва, 1965. 51 с.
6. Эльконин Д. Б. Избранные психологические труды. Москва, 1989. 560 с.
7. Костюк Г. С. Навчально-виховний процес і психічний розвиток особистості. Київ, 1989. 612 с.
8. Кулюткин Ю. Н., Сухобская Г. С. Развитие творческого мышления школьников. Ленинград, 1967. 38 с.
9. Кульчицкая Е. И., Моляко В. А. Сирень одаренности в саду творчества. Житомир, 2008. 316 с.
10. Лоюк О. В. Теорія і практика розвитку творчого мислення учнів у навчально-виховному процесі початкової школи. Умань, 2016. 216 с.
11. Маслова Н. В. Золотой ключик для учителя: основы ноосферной педагогики. Москва, Севастополь , 2009. 126 с.
12. Методика навчання освітньої галузі «Природознавство»: курс лекцій / Укладач Т.Я. Грітченко. Умань : ВПЦ «Візаві», 2016. 163 с.
13. Новейший психолого-педагогический словарь. Минск, 2010. 928 с.
14. Пономарев Я. А. Психология творчества и педагогика. Москва, 1976. 280 с.
15. Психическое развитие младших школьников: экспериментальное психологическое исследование / под ред. В. В. Давыдова ; Науч.-исслед. ин-т общей и педагогической психологии Акад. пед. наук СССР. М. : Педагогика, 1990. 160 с.
16. Талызина Н. Ф. Формирование познавательной деятельности младших школьников : кн. для учителя. Москва, 1988. 175 с.
17. Hao N. et al. Enhancing verbal creativity via brief interventions during an incubation interval // Creativity Research Journal. 2014. Vol. 26, № 1. P. 30–38. DOI i: 10.1080/10400419.2014.873658.
18. Luthans F., Youssef C.M., Avolio B.J. Psychological Capital: Developing the Human Competitive Edge. New York : Oxford University Press, 2007.
19. Muller E., Seligson M. Civic Culture and Democracy: The Question of Casual Relationships // American Political Science Review. – 1994. – Vol. 88. – N 3. – P. 635–652.