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Implementation of the «Learning Through Research» principle at Ukrainian secondary schools: Experience and prospects

Implementación del principio de «Aprendizaje a través de la investigación» en las escuelas secundarias de Ucrania: experiencia y perspectivas

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Contents

ABSTRACT:

The current achievements of pedagogy on the problem of implementing the "learning through research" principle in Ukraine have been analyzed and existing deficiencies have been identified. Innovation system of implementation of the "learning through research" principle has been proposed. Its main idea is to combine three interrelated and interdependent approaches: familiarization of students with methods of scientific cognition; organization of educational process on the basis of research-exploring activity; involvement of students in research activities.
Keywords: methods of scientific cognition, content of education, natural sciences

RESUMEN:

Se han analizado los logros actuales de la pedagogía sobre el problema de la implementación del principio de "aprendizaje a través de la investigación" en Ucrania y se han identificado las deficiencias existentes. Se ha propuesto un sistema de innovación de implementación del principio de "aprendizaje a través de la investigación". Su idea principal es combinar tres enfoques interrelacionados e interdependientes: la familiarización de los estudiantes con los métodos de la cognición científica; organización del proceso educativo sobre la base de la actividad de investigación-exploración; Participación de los alumnos en actividades de investigación.
Palabras clave: métodos de cognición científica, contenidos de la educación, ciencias naturales.

1. Introduction

One of the main tasks of Ukraine's modern educational policy is to ensure the quality of education adequate to the pace of the development of society and the transformation of the natural environment. The crucial principles of education involve: the fundamental training of the graduate student, aimed at providing his mobility and ability to adapt in a dynamic social and working environment; possession of personal qualities to be competitive; motivation for further improvement of personality.

The Concept of New Ukrainian School emphasizes: the intrinsic value of knowledge is rethought in such a way that a modern person has to adapt quickly to changing circumstances, to gain knowledge independently, to be competent to work with information, that is, using modern technologies, to find the necessary information for the accomplishment of a set task, to analyze, generalize, compare, make reasoned conclusions and make decisions on their base (New Ukrainian School. Conceptual Approaches of the Middle School Reformation. Ministry of Education and Science of Ukraine, 2016). Thus, life puts forward a public request for the formation of a thinking and creative personality who will be ready, unlike a person-performer, to think independently, generate ideas, make ambitious non-standard decisions and argue them. Significant potential for the development of such students' abilities is connected with research activities, specifically in the conditions of growing dynamism of society, possibility to reach new levels of nature cognition. The initiative of young people gains particular importance, as well as their desire to find out novelty and the ability to explore actively the complexity of the changing world, and create new original strategies of activity. The key principle of educational activity becomes its scientific character and predictability, the establishment of stable interaction between the content of education and scientific research.

1. Despite the achievements in the field of natural sciences education, there can be seen a passivity of students during the learning of educational material, reducing of their cognitive activity and independence in school practice, which leads to a decrease in the quality of education, their inability to gain knowledge independently. Program for International Student Assessment (PISA) surveys also confirm the insufficient level of Ukrainian students' ability to perform a lot of types of research-based tasks (Program for International Student Assessment [PISA], 2018). At the same time, natural sciences subjects have a great potential for the formation of students' research skills. The analysis of psychological and pedagogical literature as well as school practice allowed revealing a contradiction between the growing need of the society in the formation of a creative personality and the absence of proper educational environment. The necessity to resolve this contradiction led to the choice of the theme of our study.

2. Methodology

2.1. Goal of the Study

To highlight the state of implementation of the "learning through research" principle in the practice of the modern Ukrainian general secondary school, to find out the main ideas of existing experience, to develop and scientifically substantiate the perspective ways of the implementation of this principle in the process of natural sciences learning.

2.2. Research Tasks

1. To highlight the state of development of the problem at the level of pedagogical activity and personal achievements of students and single out progressive ideas of experience.

2. To develop innovation system for the implementation of the "learning through research" principle and examine it experimentally in the process of studying the school course "Biology".

2.3. Research Methods

Theoretical: comparative analysis to find out different views on the problem, determine the study directions; modeling to develop a system for the implementation of the "learning through research" principle; systematization and generalization to formulate conclusions and recommendations for the improvement of the process of students' research skills formation.

*Empirical:*generalization of pedagogical experience, observation, interviews, questionnaires to determine the state of implementation of the problem in the practice of school training.

Experimental: pedagogical experimentthat has provided an examination of the effectiveness of the proposed innovation system; statistical methods for quantitative and qualitative analysis and determination of the reliability of the research results.

2.4. Research Methodology

Experimental research has been carried out on the basis of Ternopil general secondary schools №9, 24, 26, Terebovlia general secondary school №1 (Ternopil region) and M. Kravchuk Lutsk

Gymnasium №21. Summative experiment involved 528 students and 212 teachers of natural sciences subjects. It was conducted in 2012. Its aim was to substantiate the expediency of working out of the innovation methodology of the "learning through research" principle. Formative experiment lasted for 5 years (2013-2018) in 6-10 grades. 404 students participated in it.

Effectiveness of the proposed system was checked during the formative experiment. The students of experimental groups, grades six to ten inclusive, were trained in accordance with the methodology we proposed, and students in the control groups were trained according to the traditional methodology. The first diagnostic survey was carried out in the control (C) and experimental (E) groups before the beginning of the experimental work. Its aim was to determine the level of students' research skills formation before the introducing of experimental system. The second diagnostic survey was carried out after its introducing with the aim of determining the effectiveness of students' research skills formation.

The level of formation of each skill (initial, average, sufficient, high) for each student was determined on the basis of the analysis of tasks performance.

Formula: R = Xaverage was used for the determination of the numerical value of the indicator of the average group level of the formation of skills. The coefficient of growth in the formation of skills (k) was determined by the formula: k = R10grade / R6grade, where R10grade is the average group index of the formation of the research skills in the tenth grade, R6grade is the average group index of the formation of the research skills in the sixth grade. The validity of the difference in the rates between the individual groups was evaluated using the Student's *t*-test. According to the monitoring of the proposed tasks performance, the operating component was evaluated as an integral result of the formation of a complex skill. The analysis of the links between the components of research skills was conducted using correlation analysis.

3. Results

3.1. "Learning through research" principle implementation in the theory of natural sciences teaching in Ukraine

The problem of organizing of students' research activities was developed by the Ukrainian scientists according to the following main directions: use of various means of cognitive, including educational and research activities management (B. Korotiaiev 1989, V. Moliako 1983, V. Palamarchuk 2000, H. Yahenska 2011, and others); substantiation of didactic conditions of the development of students' research abilities and formation of their research skills (V. Buriak, 2010; A. Solohub, 2011; A. Stepanyuk, 2012, and others); formation of future teachers' research competence in the process of their professional training (V. Hrubinko & A. Stepanyuk, 2016; N. Mishchuk, 2011; A. Stepanyuk & N. Moskaliuk, 2010; O. Ptashenchuk, 2017; N. Shyian, 2011; O. Yaroshenko & Yu. Skyba, 2015, and others); training of teachers for the formation of students' research skills (H. Zhyrska, 2015; N. Petrova, 2010, and others).

Study of dissertations, scientific articles and methodological guidance of modern Ukrainian teachers and lecturers regarding biological education have shown that they expose only some issues of the use of students' learning and research work with the aim of formation of natural sciences knowledge, general learning and research skills, increasing interest in studying. Majority of works concerning organization of the research activity are devoted to the work with senior students. The problem of forming students' research skills in the process of Biology learning at the middle school has been comprehensively disclosed in the scientific works of H. Yahenska (2011). She singled out the types of basic, tactical and strategic research skills, developed and substantiated the methodological system of formation of research skills of the students of the basic school in the process of teaching biology. This system is based on the structural-functional model of research skills, provides realization of direct and inverse links between its components and the subject-subject interaction of participants of the educational process at lessons and during extracurricular work.

The analysis of pedagogical literature allowed us to interpret research skills as a complex hierarchical system that includes the following types: basic, tactical and strategic. We consider the research competence of students as a characteristic of a person capable of search-and-transformation activity in the educational process; ability to gain new knowledge and skills that contribute to self-development; one of the independent, compulsory and universal components of general educational and subject competences of students; a system of knowledge, skills and values which are necessary for the implementation of research activities; a complex of personal

qualities that determine the ability and readiness to carry out effective educational-research and scientific-research activities. Activity approach to the gaining of biological (natural sciences) education gives a possibility to develop subject competences and to form the research competence of students through the following research techniques (observation, research and analysis of natural phenomena and processes, laboratory and field experimentation, simulation and full-scale modeling at all levels of the organization of nature (from the molecule, through cells, to the organism, the population, ecosystems and biosphere), create subject competences and form research competences of students.

3.2. "Learning through research" principle implementation in the practice of natural sciences teaching in Ukraine

The results of summative experiment proved that the familiarization of students with the methods of scientific cognition is now becoming an urgent problem in connection with the important social tasks faced by a general secondary school: to develop intellectual potential of the society and each individual. This is based on National Standard for basic and complete secondary education of students, in which "Methods of scientific cognition" constitute one of the content cross-cutting lines of education (The State Middle and General Secondary Education Standard. Ministry of Education and Science of Ukraine, 2011). At the same time, knowledge about the methods of scientific cognition is a part of the additional unit within the structure of the educational subject "Biology", "Chemistry", "Physics". For example, in the "Biology" syllabus for students of 6-9th grades of general secondary schools special attention is drawn to the fact that "teaching of Biology at the middle school is aimed at the implementation of the following tasks: *acquisition of knowledge* about the role of biological science in the formation of a modern scientific picture of wildlife; methods of cognition of wildlife; *mastering the skills* of application of biological knowledge for the explanation of the processes and phenomena of wildlife; conducting of simple biological researches; work with various sources of information" (Biology Syllabus for General Secondary Educational Establishments, Grades 6-9. Ministry of Education and Science of Ukraine, 2017). It is also stated in the syllabus that cognitive activity plays the leading role in teaching Biology. It is aimed at mastering the methods of scientific cognition and is realized through laboratory research, practical and laboratory works, research training workshop and projects. The purpose of *laboratory research* is to develop students' ability to observe, describe, single out the essential features of biological objects, draw biological objects, form the skills of using a microscope, solve cognitive tasks, and make conclusions. *Research training workshop* involves the formation of personal experience of research activity in the process of solving cognitive tasks. So, students of the 6th have to name the methods of studying organisms (observation, description, comparison, experiment), and in the 9th grade they have to characterize the methods of biological research (descriptive, experimental, modeling) (Biology Syllabus for General Secondary Educational Establishments, Grades 6-9. Ministry of Education and Science of Ukraine, 2017).

The analysis of school textbooks has shown that they provide only definitions of the listed methods of scientific cognition and examples of their use. The descriptive type of presentation of the material prevails in all textbooks. Problematic questions for actualization knowledge are offered before the presentation of the material only in some of them. However, they are not always designed to motivate the student to find answers. The reproductive type of tasks prevails. It is important to form the students' of 6-8th grades ability to compare, analyze and generalize for. But there are only 6-7 % of exercises which involve comparison in the textbooks for the 7th grade. The proportion of such exercises is increasing in the textbooks for the 8th grade. Some of them provide a comparison plan, as well as the tasks on creating comparative tables, which is very important, in our opinion. There is no special information on the methods of scientific cognition and their structure in the textbooks. There are only tasks that require the use of separate methods or their elements. However, they are placed unsystematically and represent a small share of the total number of tasks. In our opinion, such an approach does not contribute to the holistic disclosure of the essence of the methods of scientific cognition, in general, and to the application of the research method, in particular.

For the confirmation of our conclusion, we conducted a summative experiment aimed at understanding the teachers' opinions concerning applicability and possibility of implementing the principle "learning through research" and identifying the level of formation of school leavers' research skills.

All surveyed teachers (100 %) answering the questionnaires mentioned that they use research

tasks in the process of teaching. 88 respondents (83.02 %) use actively such tasks at the lessons, 144 respondents (67.92 %) use them during extracurricular work and 40 respondents (18.87 %) use such tasks during out-of-school work. The overwhelming majority of respondents (92.45 %) aim to create logical skills of students at the lessons – the ability to compare, analyze and generalize. Answering the question "Do you set a special goal of forming students' research skills at the lessons?" 84 teachers (39.62 %) answered "No". This indicates a lack of attention to the formation of an important component of the learning competence of a contemporary student.

At the same time, 43.40 % (92 teachers) focus on forming the students' ability to plan and conduct elementary experiments. The vast majority of teachers (86.79 %) organize students' independent observation having previously discussed the plan of monitoring for the formation of the ability to observe. Minority of the teachers give the tasks that require observation without prior discussion of the monitoring plan. Only a quarter of teachers believe that they form the ability to observe through organizing teacher's activities observation. Despite the fact that the process of natural sciences learning undoubtedly involves conducting at least elementary experiments, 8.49 % of respondents noted that they did not use the experiment in the process of training. Among the reasons was the lack of time for the experiment at the lesson or the lack of equipment. Only one teacher (the length of teaching experience is 4 years) considers that the main reason is that he does not have sufficient methodological training to organize the experiment properly.

The results of the survey showed that teachers use the experiment at different stages of the lesson. Experiments are most often conducted during laboratory classes and while studying new material. 59.43 % of the respondents use an experiment to revise background knowledge and motivate learning activities. This method is rarely used when checking home assignments. Only 3 teachers used an experiment during the thematic attestation. A lot of teachers (67.92 %) also noted that sometimes they conduct experiments at non-standard lessons, often at the stage of motivation of learning activities.

179 teachers (84.43 %) remarked that conclusions based on the results of the experiment are usually formulated jointly by the teacher and students. However, 16 teachers (7.55 %) formulate conclusions based on the results of the conducted experiments themselves. The majority of teachers (75 %) combine individual and group forms of work when conducting laboratory work. The main difficulties in conducting laboratory work as well as in organizing of research activities are related to the lack of necessary equipment and / or methodological training in this particular sphere.

Thus, the results of the questionnaire and interviews proved that teachers mostly use traditional approaches to presenting course content. Teachers do not have profound knowledge of the methodology of forming students' research skills, underestimate the importance of this activity, and therefore this process has a spontaneous character and is based, in general, on the intuitive perceptions of teachers. They experience considerable difficulties in organizing students' research activity, planning its succession, selecting objects, means and methods of research, etc. The result is an insufficient level of school leavers' research skills. According to the results of the diagnostic survey, the low level of the formation of the cognitive and operational components of the students' research skills was revealed. Only 2.27 % of students demonstrated high level of formation of the ability to put forward hypotheses, the ability to solve logical tasks with a graphical representation of data was shown by 8.33 % of students, and 9.84 % of students were able to solve elementary tasks on modeling of natural processes. The vast majority of students showed the initial and average level of these abilities formation. The tasks involving planning of the experiment and integrated analysis of the research were particularly challenging for students.

It was found out that a significant share of the respondents (40.15 %) could not name the methods of cognition. 43.18 % answered partially incorrectly or incompletely. And only 16.66 % showed an adequate level of knowledge. 36.37 % of students were not able to explain the difference between a hypothesis and a theory. The answers of 34.84 % of students were partially incorrect or incomplete. 28.79 % of students answered this question completely. 428 out of 528 students (81.06 %) did not understand the necessity of introducing a control variant (control group) during the experiments. 88 students (16.66 %) had some notion of a control group and only 12 students (2.27 %) were able to substantiate the necessity of a control group in the experiment.

Having analyzed existing accomplishments of the pedagogy in Ukraine on the problem of introducing the "learning through research" principle, we came to the conclusion that it should be applied systematically. It involves the combination of three interrelated and interdependent approaches: familiarization of students with methods of scientific cognition as a type of knowledge

and as a way of activity; organization of educational process on the basis of research-exploring activity; involvement of students in research activities in extracurricular and out-of-school work.

3.3. Characteristics of the innovative system of the implementation of the "learning through research" principle

The analysis of literature as well as training practice has shown that there is a need for such a model of education that will ensure the implementation of the "learning through research" principle through the formation of research skills, the organization of educational, cognitive and research activities of students. We will characterize our proposed innovative system of the implementation of the "learning through research" principle in the educational process, which involves three interconnected subsystems: 1. Formation of the students' research skills as a hierarchical system, which involves the familiarizing of students with methods of scientific cognition; 2. Organization of educational process on the basis of research-exploring activity; 3. Involvement of students in research activities in extracurricular and out-of-school work. It is an open self-regulating system, which involves special familiarizing of students with methods of scientific cognition, including a research component in the educational activities of subjects of education as a permanent organic component. Its specificity is in the peculiarities of the subject, object and methodology of natural scientific cognition.

The following principles form the basis of the modeling of innovative system:

1. It is recognized that incorporating of general methods of scientific cognition into the content of education is necessary for the realization of the goals of teaching: the formation of a system of knowledge on the fundamentals of science and the scientific outlook, preparation of students for filling gaps in their knowledge, the implementation of didactic principles of science and consciousness. One of the tasks of the training process, as well as means of "humanization" of knowledge is considered to be students' acquaintance with the methods of scientific cognition and formation of appropriate skills. Therefore, it is important to report on methods of scientific cognition in the content of the course material as a type of knowledge and as a way of activity.

2. In the real process of cognition the used methods are interconnected. For example, analysis and synthesis closely intersect with most scientific methods. Elementary-theoretical analysis involves abstraction from the non-essential, which is, in its turn, carried out on the basis of analysis and synthesis. Analysis and synthesis are connected with the experiment, induction, and deduction, moving from abstract to concrete and many other methods of scientific cognition. Different scientific methods are components of modeling: observation, measurement, experiment, analysis and synthesis, abstraction, extrapolation, etc. Experiment as the most complicated method of empirical cognition involves the use, besides the mentioned methods, of observation, comparison, measurement (elementary empirical methods) and many theoretical methods of research. Besides the mentioned methods, experiment as the most complicated method of empirical cognition involves also the use of the following methods: comparison, and other empirical and theoretical methods of research.

3. There are no "clean", isolated methods of scientific cognition: they all are interconnected and penetrate into each other. Each method can be used as an independent one or be a part of a more complex method, and in this case it appears as a technique. In their specific scientific use, methods not only mechanically supplement each other, but interact dialectically; they are interacting elements of a certain unity, with branched transitions inside it. None of the methods, when isolated or without connection with others can give complete results in the study of multi-faceted phenomena and processes of the objective world. This is explained by the fact that the cognitive abilities of each method are limited and depend on their epistemological nature. There is certain subordination of the methods of scientific cognition, which manifests itself in their dependence on one dominant method. Domination means a kind of "adapted" subordination of isolated methods, that is, their adaptation to the most effective study of those aspects of objects that act as a subject of a particular discipline (Moroz, I. (ed.), et al., 2006, pp. 120-121).

4. Both general and special methods of cognition are highlighted in the process of learning natural sciences. It is advisable to make students acquainted with a group of methods of scientific cognition at the introductory lesson, before studying of separate courses, or at the interdisciplinary lesson.

There are three ways of the familiarizing of students with methods of scientific cognition.

The first way is spontaneous: the students master methods in the process of learning. However,

many years of experience in education have shown that while studying the course content, it is impossible to form either students' holistic idea of the methods of scientific cognition, or their ability to use them without difficulties.

The second way is a systematic organization of the acts of creative cognition which are rationally combined with acts of reproductive cognition (B. Korotiaiev, 1989, p. 71). This way is considered to be the most fruitful and effective. It involves teaching students the cognitive procedures (explanation, description) and actions and operations that are part of their composition.

The third way is a special teaching of students the methods of scientific cognition, which varies depending on the type of knowledge that is being studied (V. Palamarchuk, 2000; A. Stepanyuk, 2012).

Our system anticipates a logical combination of all these ways. In this case, acquaintance of students with the methods of scientific cognition involves reporting them the following information about each method: 1) the definition of the method; 2) purpose and possibilities of use; 3) the essence of the method; 4) structure of the method as a way of activity; 5) the relationship with other methods of scientific cognition; 6) use of the method for the cognition of nature (historical aspect).

It is impossible to include information on the methods of scientific cognition to the content of education without identifying a special system of didactic means, which include: selection and distribution of necessary and accessible information on methods of scientific cognition in the content of school education; a range of special tasks. Information about each method should be presented in the following order: prior to the studying the material – a brief overview of the methods of science; then – informing in the process of studying of the material and; in the end, generalizing practical lessons.

It is recommended to deliver the information on the methods of scientific cognition: 1) before studying the new material; here, the teacher tells the students about the scientific method as an element of this material, explains the purpose of its use; 2) during the studying of new material (the teacher also disclose the content of the scientific method and the purpose of its use in scientific and educational cognition); 3) after studying the new material; here, the teacher gives students the task for independent work and immediately reports on the method to be used. The most appropriate time to inform senior students of the methods of scientific cognition is at the lesson after studying the new material, just before the explanation of the task for independent work. The techniques used for this are as follows: 1) teacher's explanation and demonstration of the application of the method for the perception and comprehension of this information by students; 2) use of knowledge about the method by the students in reproductive and creative activity under the direct supervision of the teacher; 3) application of the scientific method by students in independent work which is imaginative and of reproductive nature.

The process of formation of students' skills to use methods during their learning involves the following stages: cumulation (accumulation of practical experience), comprehension of the essence and structure of the method; identification of its model and rules of use; practical application.

Research activity is a hierarchical, pedagogically managed system of interaction of subjects, aimed at cognition of nature, and as a result of which there is subjective new knowledge or its new quality and students' mastery of research skills. Research competences are capable of self-development: the research experience through reflection stimulates motivation to reach a higher research level. New experience of activities stimulates further improvement of research skills.

Types of research skills at different hierarchical levels are as follows: *basic* (compare, analyze and correct statements, classify, establish causation-consequential relation, determine the connection between the structure and functions, prove and argue, technical skills); *tactical* (select, analyze, present scientific information, put forward hypotheses and argue them, work with graphic organizer, use and build models, conduct laboratory research according to the given plan, outline the direction of the experiment, determine the object and subject of research, perform statistical processing of the results; to form a conclusion based on the results of the experiment); *strategic* (to carry out a holistic analysis of the research according to its description, to plan research, to conduct a theoretical and experimental study) (H. Yahenska, 2011, pp. 34-35).

Formation of research skills takes place in accordance with their structure. First of all, a motivational component is formed by searching for interesting forms, techniques, and original learning tools. Cognitive and operational components of research skills are formed during the systematic and motivated fulfillment of research activity. The processes of reflection are activated. If a student takes this activity as necessary, the formation of the motivational component goes to a

higher level, and a stable internal motivation is formed. This, in its turn, stimulates the expansion of research activities, during which the cognitive and operational components rise to a higher level. The research activity is developing as collaboration between teachers and students during the study of objects of nature, solving of theoretical problems. In this case, mechanisms of mutual positive induction between the subjects of research are formed (H. Yahenska, 2011, p. 68).

The *first subsystem* of the proposed innovation system of the implementation of "learning through research" principle involves the activity of a teacher in familiarization of the students with the methods of scientific cognition according to the following stages:

I – *motivational.* A holistic imagination of the methods of scientific cognition and their significance in the process of cognition and during the learning of natural sciences disciplines is formed. It is supposed to do the tasks aimed at the formation of a cognitive interest in research activities through familiarization with the history of discoveries in the natural sciences, the development of instrumental and analytical methods of cognition of nature, etc.

II – *information-procedural*. It involves two components: successive specification and generalization of knowledge about general and specific scientific methods of scientific cognition in the process of studying academic disciplines; formation of operational research skills (analyze, observe, compare, systematize, perform statistical processing of digital data, generalize, etc.). Methods of scientific cognition are studied as a kind of knowledge and as a way of activity.

III – *organizational-activity*. A research type of learning through the integration (simultaneous realization) of learning and research activities is introduced at this stage. A special system of tasks is used for the formation of tactical and strategic research skills. Research elements are included in various forms of training (lessons, excursions, and field practices) and extracurricular work (preparation of reports, work in problem groups, scientific circles, scientific societies, etc.) with the presentation of the results of scientific research in the form of publications, speeches at scientific conferences and seminars.

IV – *reflexive-correctional*. It involves students' awareness of training activities, their reflection and correction.

V – *result-evaluative* stage combines two ways: self-assessment of the level of possession of research skills by students and the assessment of teachers and the scientific community.

All the mentioned stages are interrelated and interdependent. For example, IV and V stages are singled out rather conditionally, since the corresponding activities of students are present at all stages.

The second subsystem involves the implementation of research technology of learning. An effective means of its implementation is considered to be the organization of students' activity on the research principles of gaining knowledge, acquiring the subject competences and their implementation through research approaches in the organization and conducting of educational and cognitive activities. For this purpose, in the existing syllabuses of school courses of the natural sciences cycle, it is recommended to carry out laboratory studies, workshops, projects, etc. Besides, we believe that research technology should be implemented in textbooks by structuring the course content. Teachers and students should be proposed a scenario for organizing research activities in the study process. Training should be organized under the motto "Explore, learn, care" and the following ideas should be taken into account: the crucial importance for verification and correction of the perceptual image is to include practical activity, communication and scientific research into the processes of perception. Usually the three levels of perception are distinguished: 1) sensory – sensitive capture of an object, its penetration in the field of perception; 2) perceptual – understanding of the object, assigning it to a certain class of objects; 3) operative – practical operations with an object. These ideas combined with the research approach have been taken as the basis for creating of the sections of the textbook "Natural Sciences", most of which have the following structure: 1. Actualization of students' life experience and motivation of educational activities by means of asking a problem question. 2. Research activity (thinking or practical). 3. Getting useful tips from mythical heroes. 4. Comparison of the results of one's own activity with existing analogues. 5. Self-analysis and self-assessment. 6. Practical use of the obtained knowledge (A. Stepanyuk, T. Hladiuk & I. Kucherov, 2012, p. 161).

The third subsystem involves the use of both traditional forms of research work (preparation of scientific reports and participation in scientific seminars, conferences, organization of research activities within the class work; participation in the work of clubs, work in teams of scientific laboratories; preparation and publication of scientific works, etc.) as well as innovative work (work at the Academy of Young Scientists, competition "Young Researcher", optional classes of research

direction, summer school of research, junior tournaments, school scientific society, Internet Olympiads, etc.).

Traditional forms of students' activities, as the experience shows, are quite effective, but they have a number of disadvantages: there are differences between the content of education and research; the organization of training is dominant, and research activity is subordinated to educational activity, is carried out additionally and requires separate organizational, material and time resources; research work is assessed as a separate type of activity and is not sufficiently taken into account in assessing the level of students' outcomes and relates mainly to those who have expressed interest in this type of activity and have a pretension to a research career (V. Hrubinko & A. Stepanyuk, 2016, pp. 228-229). Consequently, to avoid them, our proposed system of the implementation of the "learning through research" principle involves the introduction of the following pedagogical conditions in the educational process: the research of topical scientific problems in the priority areas of science and technology development; intensification of research in scientific schools and research centers and laboratories, as well as ensuring their high quality and increasing the number of competitive scientific products; expansion and strengthening of information and technological bases of scientific activity of students with the purpose of optimization of their education and satisfaction of their interests and abilities; strengthening the scientific ties between educational and research institutions.

3.4. Discussion

The results of the first diagnostic survey proved that at the beginning of the study of the biology course, most students of both control and experimental groups had an initial and an average level of research skills. The majority of students showed an initial level of such basic skills as ability to classify and establish the connection between the structure and functions of biological objects. There was only a small share of students with high level of the ability to analyze statements and correct mistakes and establish causation-consequential relations. No students with high level of tactical and strategic research skills were identified. More than 90 % of students are characterized by an initial level of strategic research skills.

The results of the second diagnostic survey indicated that the indices of research skills of the experimental group are significantly higher than those of the control group. A comparative analysis of the results of the two diagnostic surveys allowed to find out the dynamics of the levels of the students' formed research skills. The number of students whose basic and tactical research skills are at a high level has sharply increased. Correspondently, there have become nearly 7 % of such students in the control group and nearly 25 % in the experimental group. It has been found out that there is a tendency for the level of research skills to grow during the educational process when comparing the level of the formed research skills at the beginning and at the end of the experiment. This tendency is noted for all the hierarchical levels in both the control and the experimental groups. However, the intensity of growth is different: the growth rate is higher in the experimental group and especially it refers to tactical and strategic skills. The growth rate of skills formation in the experimental and the control groups for basic skills is 1.76 and 1.36 correspondently, for tactical skills it is 3.8 and 1.57, and for strategic skills it constitutes 8.5 and 2.0. Differences in the growth are statistically significant for all levels of research skills (for basic $p < 0.05$, for tactical and strategic $p < 0.01$). Close direct correlation has been identified between the indices of research skills formation of different hierarchical levels (for basic and tactical $r = 0.64$; basic and strategic $r = 0.51$; tactical and strategic $r = 0.68$). This indicates the close correlation of research skills of different hierarchical levels: without the formation of basic skills, it is impossible to form tactical skills, which, in turn, become the basis for the formation of research skills of the strategic level.

4. Conclusions

A new solution to the scientific problem of implementation of the "learning through research" principle into the practice of a general secondary school has been proposed. It led us to the following conclusions:

1. The theoretical analysis of the problem of the study has shown that it is topical but not sufficiently developed at the following levels of formation of the content of education: academic subject, academic content, pedagogical activity. The results of conducted summative experiment show that the quality of implementation of this principle in schools of Ukraine is insufficient. However, educational institutions have strong traditions and great potential opportunities and

perspectives for organizing the educational process on the basis of research-exploring activity. The work on formation of students' research skills is carried out at schools. However, the main focus is on the formation of elementary practical skills. Teachers do not have enough necessary equipment and literature for the proper level of organization of such activities. The great majority of teachers would like to increase their own level of research skills and, thus, they require appropriate scientific and methodological support for this.

2. The results of the conducted study showed that it is possible to raise the effectiveness of the implementation of the "learning through research" principle in case the proposed innovation system is used, which means a comprehensive solution of the problem through the application of a systematic approach to the interpretation of the essence of research skills and, correspondently, familiarizing of students with the methods of scientific cognition, organizing the educational process on the basis of research-exploring activity, involvement of students in research activities in extracurricular and out-of-school work.

The study does not cover all aspects of the problem. The prospects for further study consist in the development of learning and teaching support materials of the proposed innovation system, which will contribute to the increasing of effectiveness of the formation of the research skills and mastery of program material, interest in learning of course content, activating and optimizing of the educational process, improving the efficiency of teachers' and students' work.

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