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METHODOLOGY FOR ORGANIZING STUDENTS' SCIENTIFIC RESEARCH WORK IN GRADE 6 WITHIN THE INTEGRATED COURSE "EXPLORING NATURE"

Abstract

The article substantiates a methodology for organizing scientific research work of Grade 6 students in the integrated course "Exploring Nature" and presents the results of its experimental testing. The essence, stages and forms of students' research work are clarified, and basic, tactical, and strategic research skills are characterized. The methodology comprises four components (motivational-target, content, procedural, resultative) and five pedagogical conditions (situation of success, educational environment, pedagogical support, professional orientation, motivational environment). The experiment was conducted in 2023–2024 in two Grade 6 classes (experimental group – 13 students, control group – 14 students); 26 teachers were surveyed beforehand. In the experimental group, the mean level of research skills rose from 2.02 to 2.36 points on a four-level scale, and the share of the initial level fell from 30.5% to 16.7%, whereas in the control group the indicators remained practically unchanged. Positive dynamics of the motivational-target component was recorded in the experimental group. Methodological recommendations for teachers are proposed.

Keywords: students' research work, integrated course "Exploring Nature", research skills, methodology, motivation, pedagogical experiment.

Introduction

Problem statement. Modernizing the content of education requires a shift from reproducing knowledge to acquiring it independently, processing information critically and applying it in new situations. One means of such a shift is students' scientific research work, which combines cognition, creativity, and the socialization of a schoolchild as a researcher [1; 2]. The integrated course "Exploring Nature" for Grades 5–6 of the New Ukrainian School offers particular opportunities for its implementation, as it serves as a propaedeutic basis for studying biology, chemistry, physics, geography and astronomy [3]. At the same time, practice reveals a contradiction: despite a considerable body of scientific work and an adequate material base, teachers do not fully use the potential of integrated courses for developing research skills, and research work is often reduced to the teacher demonstrating experiments, whereas involving every student in independent activity is more effective.

Analysis of recent research and publications. The theoretical foundations of students' research activity were developed by L. Baikova, V. Vorobyova, L. Hrebenkina, I. Zymnia, N. Kushnarenko, L. Levchenko, A. Ludchenko, H. Prymak, M. Romanova, Yu. Turanov, V. Uruskyi, V. Sheiko and O. Shcherbakov [4]. Methodological aspects of organizing research work in biology and ecology are examined in the works of Yu. Skyba and M. Skyba [5], N. Hrytsai [6] and H. Pantelei [2]; the development of schoolchildren's research skills in the natural sciences is summarized in the monograph by H. Yahenska and A. Stepaniuk [7]; extracurricular research activity is covered in publications by M. Kryva [8], O. Braslavska [9] and O. Vozniuk [10]. However, the scientific and methodological literature lacks an experimentally tested methodology designed specifically for the integrated course "Exploring Nature" in Grade 6.

The article aims to substantiate a methodology for organizing students' scientific research work in the integrated course "Exploring Nature" in Grade 6 and to verify its effectiveness experimentally.

Research methods: analysis of psychological, pedagogical, and methodological literature; observation of the educational process; surveys of teachers and students; a pedagogical experiment (ascertaining, exploratory, and formative stages); methods of mathematical statistics.

Main Body

The Essence of Students' Scientific Research Work and Research Skills

Scientific activity is intellectual creative activity aimed at obtaining new knowledge and (or) finding ways to apply it [11]. In terms of content, it is characterized by a goal, tasks, object, subject, conditions, stages, means, and result. By students' scientific research work, we mean a conscious, multifunctional, creative activity of a student aimed at obtaining a scientific result and carried out in line with the stages of scientific inquiry. Its significance is twofold: in the resultative aspect, it yields new (at least subjectively) knowledge; in the procedural aspect, it develops research competence and research skills [1].

Students' research work passes through the following stages: setting a research task; putting forward a hypothesis and defining the goal; planning; implementing the plan; analyzing and evaluating the results and drawing generalizations. Within the general cycle of scientific activity, they can be combined into three phases: the design phase (from identifying a contradiction to formulating the goal and criteria), the technological phase (direct testing of the hypothesis), and the reflective phase (evaluation and self-evaluation of results) [12]. The guided development of this activity proceeds gradually – from the reproductive stage (olympiads, competitions, reviews) through the empirical-practical stage (excursions, collecting specimens) and the research-experimental stage to the productive-activity stage, at which students independently perform research tasks, build models and defend their own projects. The outcome of such work may take a reference-based, descriptive, project, experimental or research form [4; 13].

Research skills are interpreted as a system of intellectual and practical knowledge, skills and habits necessary for carrying out a study or its individual parts independently [2]. Given the hierarchical nature of these skills, we distinguished three groups: **basic** (comparing; analyzing and correcting statements; classifying; establishing cause-and-effect relationships), **tactical** (working with a graphic organizer; modeling; formulating a conclusion from experimental results), and **strategic** (analyzing a study from its description and proposing a research plan). The effectiveness of the work depends both on factors at the level of the subject (motivation, mastery of research methodology, subject knowledge, self-organization, ability to present results) and on the organizational environment – the school's orientation toward research activity and its material and technical resources [7].

Specifics of Research Work in the Course "Exploring Nature"

The model curriculum of the course is built on a spiral principle: in Grade 5, students master the basic concepts and objects of the natural sciences, including levels of organization of living things, the cell, viruses, prokaryotes, fungi, lichens, the diversity of plants and animals, and the human body; in Grade 6, the content is developed around interrelationships in nature – interactions of organisms with one another and with inanimate nature, their adaptations to environmental conditions, natural and artificial ecosystems, and the impact of human activity [3]. This structure, the activity-based and research approaches embedded in the curriculum, and its interdisciplinary character create favorable conditions for including research tasks at every stage of a lesson: when formulating the topic and aim, studying new material, performing laboratory and practical work, doing homework and in extracurricular activities [6; 8].

The greatest didactic potential lies in: laboratory and practical work whose content includes a problem situation; educational expertise (comparing statements with a text, finding and correcting errors); comparing regularities and building generalizations; solving biological problems; mini-projects; observations and

excursions; and the use of multimedia and virtual experiments [5; 13]. For the teacher, this implies two blocks of work: a pedagogical one (identifying research directions, selecting materials, planning, substantiating the topic, teaching research techniques, consulting and supporting the defense) and a student one (searching for information, analyzing the problem, becoming familiar with methods, conducting an educational study, generalizing, formatting and defending the results).

The Methodology for Organizing Students' Scientific Research Work

On the basis of the literature analysis and school practice, we developed a methodology whose productivity is ensured by four interrelated components.

The motivational-target component involves developing cognitive, social, and professional-value motives and the student's awareness of the aim of the research. Motives and goals are mutually conditioned, so they are combined into a single component of readiness for research work.

The content component was implemented through lessons with elements of research on the topics "The Invisible World of Living Nature", "What Makes Bacteria and Viruses Special", "How Animals and Plants Reproduce and Develop" and "On Natural Ecosystems and the Biosphere". In the experiments, students found out how bacteria affect the souring of milk, constructed food-web diagrams of an ecosystem, and determined the conditions for seed germination and their effect on plant growth.

The procedural component comprises three stages. At the *design* stage, the teacher supports curiosity, helps students choose and formulate a topic, define the aim, object, subject, and tasks, selects methods, and orients them toward the principles of academic integrity. At the *technological* stage, the teacher encourages data collection, analysis, and interpretation, and fosters students' self-organization and self-regulation. At the *reflective* stage, the teacher organizes the evaluation and self-evaluation of results, the preparation of the product and its presentation, and helps outline prospects for further work. Some experiments were carried out at home in a blended-learning format, with the results discussed in class afterwards.

The resultative component manifests itself in the emergence of new questions and problems among students and an interest in solving them, and in the growth of research skills (comparing, analyzing, generalizing, establishing cause-and-effect relationships, forecasting).

The effectiveness of the methodology is ensured by five pedagogical conditions: creating a situation of success; the educational environment (subject-subject relations, scientific and material-technical base); pedagogical support as a systematically organized activity that creates conditions for the student's optimal decisions; professional orientation; and a motivational environment that combines material, organizational, psychological, pedagogical and technological incentives. The methodology rests on the principles of systematicity, scientific validity, consistency, priority of research methods, psychological comfort, educational reflection, and immersion in research activity.

Organization of the Experiment

The experiment was conducted during the 2023–2024 academic year in Grade 6 classes of the Banytskyi and Nekrasivskyi educational complexes (27 students) according to a design that meets the requirements for pedagogical research [14; 15]. It had three stages: ascertaining (analysis of literature and the curriculum, a pilot survey of 26 teachers, a diagnostic assessment, formation of groups), exploratory (development of the methodology, its teaching and methodological support, criteria, indicators and levels) and formative (implementation of the methodology, repeat assessment, statistical processing). The experimental group (EG) consisted of the Grade 6 class of the Banytskyi complex (13 students), where the developed methodology was applied; the control group (CG) was the Grade 6 class of the Nekrasivskyi complex (14 students), where teaching followed the traditional methodology.

The level of research skills was determined by three criteria: **informational** (methodological and logical knowledge about research activity), **activity-based**

(independence in applying skills and the ability to apply them in non-standard situations), and **resultative-reflective** (the ability to analyze and evaluate one's own research activity). For each of the eight types of skills, indicators were developed for four levels – initial, intermediate, sufficient and high (which correspond, by the nature of activity, to the accumulative, algorithmic, partially exploratory and creative levels). For example, a student at the initial level of the skill of classifying identifies the odd object in a series and only partly explains the choice, whereas a student at the high level proposes several criteria of their own and designs their own classification tasks. Diagnostics were carried out in two assessments (before and after implementing the methodology) using questionnaires of identical structure but different task content. Pearson's χ^2 test was used to assess the reliability of differences.

Results of the Ascertaining Stage

The pilot survey showed that teachers use research tasks mainly in project lessons and when teaching new material, while preparation for subject olympiads and club work is periodic (Table 1). The main difficulties relate to inadequate equipment and teachers' insufficient methodological training. Only 2 of the 26 respondents (7.7%) rated their own research skills as high, while 24 (92.3%) would like to improve them – mainly through special courses and training and high-quality methodological literature.

The diagnostic assessment showed that the motivational-target component of the Grade 6 students was generally sufficiently developed: no initial level was found, 4 students (14.8%) were at the intermediate level, 15 (55.6%) at the sufficient level, and 8 (29.6%) at the high level. At the same time, 96.3% of students wanted more experiments in lessons, 62.9% would like to do science but were not confident in their abilities, and only 22.2% were ready to make an effort for it. Thus, a motivational reserve exists but needs purposeful development.

The level of research skills proved to be low: most students were at the initial and intermediate levels. The highest results were recorded for the skill of establishing cause-and-effect relationships (2 students in each class reached the high level); the

lowest among the basic skills was comparing: lessons mostly contain tasks on incomplete comparison, and the algorithm of full comparison is not discussed.

Table 1. Results of the teacher survey (n = 26)

Indicator	**Number**	**Share, %**
Formulate experiment conclusions together with students	15	57.7
Formulate conclusions themselves	9	34.6
Prepare students for subject olympiads	21	80.8
Lead clubs or run elective classes	12	46.2
Rated their own research skills as high	2	7.7
Need courses and trainings to improve their skills	17	65.4
Need high-quality methodological and scientific literature	16	61.5

Most students limited themselves to stating the obvious: in most papers the main conclusion drawn from the experiment was that a seed will not germinate without water. Strategic skills proved the weakest: about 92% of students found no errors in the proposed experimental design and agreed with its conclusions, and not a single sixth-grader could propose a research plan at the high level. The mean score on the four-level scale was 2.02 in both groups, and no statistically significant differences between the classes were found, which made it possible to form the EG and CG.

Results of the Formative Stage

After the methodology was implemented, the share of students with an initial level of research skills decreased in the EG and the shares of the sufficient and high levels increased, whereas the distribution in the CG remained practically unchanged (Table 2).

Table 2. Distribution of diagnostic task performances by level of research skills, %

Group	Assessment	Initial	Intermediate	Sufficient	High
EG	before the experiment	30.5	39.0	28.6	1.9
EG	after the experiment	16.7	41.7	30.6	11.1
CG	before the experiment	32.7	36.4	27.3	3.6
CG	after the experiment	32.4	36.0	27.0	4.5

Note. Shares are calculated from the total number of task performances at each assessment (sum across the eight types of skills).

To compare the groups, the mean level of skills was calculated (levels coded from 1 to 4), together with the relative increase of the indicator (Table 3). The increase was 16.8% in the EG and 0.8% in the CG. Tactical (+19.8%) and strategic (+19.0%) skills grew the most, although strategic skills remained the least developed after the experiment: the initial level in the EG decreased only from 46.2% to 38.5%. Notably, in the EG, no students remained at the initial level of the skill of working with a graphic organizer (there were 2 before), and 2 students reached the high level of the skill of classifying (there were none before).

Statistical verification by Pearson's χ^2 test (3 degrees of freedom; the critical value at $p = 0.05$ is 7.815) for the pooled distributions of task performances confirmed the reliability of the shifts in the EG (χ^2 empirical = 11.35 > χ^2 critical) and their absence in the CG (χ^2 empirical = 0.11). Because of the small number of students, these results should be regarded as preliminary.

Table 3. Mean level of research skills (points on a 1–4 scale) and relative increase

Groups of skills	**EG before**	**EG after**	**EG increase, %**	**CG before**	**CG after**	**CG increase, %**
Basic	2.06	2.35	14.2	2.10	2.13	1.6
Tactical	2.10	2.52	19.8	2.07	2.07	0.0
Strategic	1.62	1.92	19.0	1.57	1.57	0.0
All skills	2.02	2.36	16.8	2.02	2.04	0.8

The dynamics of the motivational-target component is shown in Table 4. In the EG, the share of students with a high level rose from 30.8% to 38.5% (by 7.7 percentage points), whereas in the CG it fell from 28.6% to 14.3%, and the share of the intermediate level increased from 14.3% to 42.9%. In the EG, the growth came from internal motives – the choice of more complex tasks and readiness to do research – rather than from grades as an incentive.

Table 4. Dynamics of levels of the motivational-target component, persons (%)

Group	**Assessment**	**Initial**	**Intermediate**	**Sufficient**	**High**
EG (n = 13)	before	0	2 (15.4)	7 (53.8)	4 (30.8)
EG (n = 13)	after	0	2 (15.4)	6 (46.2)	5 (38.5)
CG (n = 14)	before	0	2 (14.3)	8 (57.1)	4 (28.6)
CG (n = 14)	after	0	6 (42.9)	6 (42.9)	2 (14.3)

Methodological Recommendations

Based on the study, teachers of the integrated course “Exploring Nature” are advised to: 1) include a problem situation in every laboratory or practical work so that it becomes a research task; 2) develop skills step by step – from basic to strategic – paying particular attention to comparison by a full algorithm, and to planning and analyzing an experiment; 3) combine home mini-experiments with discussion of the results in class; 4) organize pair and team work with assigned roles and mandatory reflection; 5) use multimedia, virtual experiments and digital tools for modeling and data visualization; 6) provide pedagogical support at all stages of the research, observe the principles of academic integrity and arrange public presentation of the results; 7) involve external experts and partners and improve their own qualifications in the methodology of research activity [16].

Conclusions

1. Students’ scientific research work is a means of developing research skills, independence, critical thinking, and motivation to study nature; the specifics of the integrated course “Exploring Nature” (spiral structure, activity-based and research approaches, interdisciplinarity) create conditions for its systematic implementation as early as Grade 6.

2. The developed methodology includes motivational-target, content, procedural, and resultative components and relies on five pedagogical conditions: a situation of success, the educational environment, pedagogical support, professional orientation, and the motivational environment.

3. The ascertaining stage revealed a high motivational potential of students but an insufficient level of research skills, especially strategic ones, as well as teachers’ need for methodological support and for improving their own qualifications.

4. During the formative stage, the mean level of research skills in the EG rose from 2.02 to 2.36 points (an increase of 16.8%), the share of the initial level decreased from 30.5% to 16.7%, and that of the high level rose from 1.9% to 11.1%;

no substantial changes were recorded in the CG (an increase of 0.8%). The share of EG students with a high level of the motivational-target component also increased.

The limitations of the study are the small number of students and the duration of the experiment (one academic year). We see the prospects for further research in developing a methodology and methodological support for forming research skills in students of specialized secondary schools and in preparing teachers to organize students' research activity.

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