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DESIGN AND IMPLEMENTATION OF A MODEL FOR RESEARCH PROJECTS MANAGEMENT IN THE SCHOOL SCIENTIFIC AND EDUCATIONAL ENVIRONMENT

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The study is relevant as it aims at linking school education and science. This issue relates to school scientific and educational environment design and ways of improving the management of school students' research. To achieve this, we considered the specifics of the matrix model of research management. The methods used in the study included methods of literature search, system-structural analysis, instructional design and forecasting, as well as pedagogical experiment and statistical processing of quantitative experimental results. Six schools of Nizhny Novgorod and the Nizhny Novgorod region took part in the experiment, the total number of participants estimating 348 people (aged 12-15).

The study proved the effectiveness of the proposed matrix model which allowed to form strong links between schools and city bodies engaged in diverse research activities. The school students demonstrated considerable achievements at various contests and school scientific conferences. Most school students participating in research projects have increased the level of subjective research experience to medium and high. The research findings can be used by school educators, headmasters and school teachers, as well as school scientific supervisors. The matrix model can be applied in any school aiming to integrate educational and research activities of students – "education through discovery".

Key words: school scientific and educational environment, the model for school research projects management, school research project, design and implementation stages of the model for the management of school research projects, criteria and levels of subjective research experience of schoolchildren

INTRODUCTION

The modern system of school education is seen as a strategically important sphere of social life that should play a leading role in the processes associated with the radical restructuring of the value-cognitive foundations of human activity and culture. Innovative processes in school education aim to mould a person capable of living in rapidly changing socio-natural conditions, taking responsibility in situations of uncertainty, thinking outside existing concepts, and solving current and future problems.

In modern conditions, traditional school methods of passing on knowledge cannot fully meet the challenges of the time. Thus, it becomes necessary to find

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productive solutions promoting interactive ways of learning. Experts define interactivity as an active conversational interaction in teaching (Selevko, 2006) and active learning (Korotaeva, 2014).

Therefore, semantic emphasis of modern school education shifts to self-identification and self-organization of school students being "active designers" of themselves and their environment. The cognitive process is expanded to a problem-based situation – "education through discovery", where the acquisition of new knowledge, values and ideals occurs through the generation of new experience (Varela, 1987; Abrahams and Millar, 2011; Knyazeva, 2007). Such a view implies the integration of educational and research activities of school students.

The indicated trend is not a fundamentally new pedagogical phenomenon.

The retrospective review of the issue allows us to state that the idea of the complementarity of education and science was initially related to university education. For instance, there is an established model of a global research university, within which universities produce new knowledge and students acquire research experience participating in real projects and research programs (Demidova and Mamedov, 2015; Fedorov, 2013).

At the same time, educators have been recently discussing the issues related to the organization of research activity in schools, naming it one of the priority directions of personal development. Most scientists agree that research activities can facilitate learning, contribute to the development of critical thinking and independence of school students (Alekseev and Leontovich, 2006; Gershunsky, 2003; Klarin, 2004; Chechel, 2003; Clark, 2006 and others).

Some authors define research activity as a means of training that enables to "fill" the knowledge with valuable and practical meanings in the classroom and extracurricular activities of school students (Davydov, Panov, 2003; Lunetta et al., 2007).

Another relevant idea implies incorporating research elements into students' independent work (Krotova, 2016; Kiseleva, 2007; Ratcliffe et al., 2007).

Numerous publications consider issues dealing with the role of research in working with gifted children (Vock et al., 2007).

A wide range of specific methods to organize research-based instruction at schools can be found in the works by I.A. Savenkov (organization of research for pre-schoolers), L.A. Ibragimova (organization of research activities in primary school), L.E. Osipenko, L.M. Friedman (elements of research at science lessons), E.A. Barakov (research in studying history), Justin Dillon (school research using information technologies), M. Braund and M. Reiss (school students research in extracurricular activities).

Russian educators perceive project-based learning as a source for efficient approaches in the context of research management (E.S. Polat, G.K. Selevko) which reflects the idea of collaborative learning. This approach was chosen as the leading

one in our research. Seeing eye-to-eye with the abovementioned authors, we consider it promising to combine the research and project activities of school students as a specific educational phenomenon.

Thus, the theory and practice of school education consider a number of specific issues related to research activities management. At the same time, we believe education papers have not provided a thorough analysis on the creation of a universal scientific and educational environment and research activities management in school through research projects.

Our research aims to design and implement a model for school research projects management aimed at the development of the research environment at school. For this, the following tasks were accomplished: 1) to determine the essential conditions for creating the research environment at school which will allow implementing the model for research projects management; 2) to develop the optimal model for research projects management at school; 3) to design and implement a matrix model for the research projects management for school students (aged 12-15); 4) to verify the hypothesis with an experiment.

We assumed that the model for school research projects management developed by us will improve the research activities of school students by providing a better structure, facilitating the involvement of 12-15 year-olds in research activities at school, as well as increasing the formation of students' subjective experience in research by doing projects.

MATERIALS AND METHODS

Methodological research tools included interrelated system-environment and problem approaches used in the context of learner-centered learning and corresponding basic methods: literature search, system-structural analysis, expert evaluation, scientific forecasting.

A study of the effectiveness of the developed model for research projects management at school was conducted in six schools in Nizhny Novgorod and the Nizhny Novgorod region. The total number of participants estimated 348 people. The age composition of school students participating in projects was 12-15 years old.

The effectiveness of this model was evaluated according to the following criteria:

1. Measures to create the scientific and educational environment at school, ensuring effective interaction between school and other city bodies engaged in diverse research activities.
2. Qualitative and quantitative indicators of students' involvement in school research activities through projects done.
3. The level school students reach regarding their subjective research experience when doing projects.

To evaluate subjective research experience we analyzed works of school students. When interviewing scientific supervisors we assessed students' participation in research activities, their participation in various contests, presenting reports at school conferences, and the number of abstracts prepared. In addition, we identified levels and criteria for the subjective research experience of students in when working on projects (Table 1).

TABLE 1: THE LEVEL OF STUDENTS' SUBJECTIVE RESEARCH EXPERIENCE (12-15 YEAR-OLDS)

No.	*Level*	*Criteria*
1.	Low	School students "accept" the goals and motives of the research project, the action plan for solving a specific research problem. They can reproduce the following activities according to the example: use different sources to collect the information required to solve the problem; analyze this information; propose solutions to the problem; use various methods to find the optimal solution to the problem; determine the effectiveness criteria for alternative options. Communicative skills are poorly developed.
2.	Medium	School students are able to formulate the problem on the basis of the data presented. They can single out sub-goals of the activity from the general goal formulated in the project. Working in cooperation with others, they can develop an action plan aimed at solving the problem, and select conditions significant for solving the research problem. They can independently apply the skills listed for the low level, using the acquired algorithm for solving research problems. They tend to cooperate and help other students. At the same time, they can do the required tasks and perceive it as a natural thing.
3.	High	School students are capable of accomplishing the motivational and value component of the research project on their own. They can independently formulate a research problem and develop an action plan to solve it. School students can act as independent researchers and apply the acquired knowledge and skills for independent "extraction" of new knowledge necessary to solve problems. When solving research problems, students are capable of evaluating various options independently, in new situations, and choose the optimal ones, quickly navigating in different methods and explaining their choice. School students quickly join in collaborative project activities, take active part in discussing problems, and cooperate with other participants, showing their leader qualities.

The level of the research subjective experience of each child was determined according to the observations of project supervisors in accordance with the criteria specified in the table. The results were analyzed by statistical methods.

CONCEPT HEADINGS

In the course of the study, we established that it is possible to organize the systemic research activities of school students only in a comprehensive research environment in a school that meets the following conditions:

1. This environment manifests itself as a self-organizing "system-process", consolidating educational and research activities.

2. One should develop mechanisms for coordination of research activities within the educational institution.
3. It is necessary to create the effective system of network interaction between schools and universities, research organizations, industries. Obviously, one of the most difficult tasks is the development of an effective mechanism for such interaction, with school in its centre as a basic integrative platform.
4. Development of the material, technical, laboratory, software and hardware resources for the implementation of the research work with schoolchildren.
5. Motivation of teachers and school students for research.
6. Promotion of the measures aimed at early detection of students' aptitudes and talents.
7. Teaching teamwork as a key form of learning.
8. Active use of new educational products and technologies when designing research activities which can teach students the methods of scientific research, develop their research thinking skills, as well as skills of critical analysis of their own research experience.

We would like to note that the scientific and educational environment of the school is not passive: it is expressive, dialogue-oriented, and it includes various semantic, value and activity elements perceived by an individual as personally significant. Objectively, it acts as a single functional whole in the sense that for a particular school student, it performs a universal educational function – a function of their personal development. As a socio-cultural phenomenon, it allows individuals to be who they are and interact with others, co-developing at the same time. Transforming the resources of the scientific and educational environment, school students re-create its semantic elements, actively expanding the boundaries of their individual research experience. We assume that the school scientific and educational environment creates optimal conditions for children taking active part in their learning. This environment ensures their self-identification and autonomy. We would like to highlight that the scientific and educational environment should create all conditions and opportunities for carrying out research, so that students can make their own choice of the scientific and educational route.

Studying the scientific and educational environment, one should consider the management of the research activity of school students. Our research aims to address this issue.

RESULTS

In this study we adopted the ideas of effective, "soft" management of students research using a matrix model for the management of research projects.

In general, the model of students' research management is a matrix structure, implying the creation of temporary project teams within the school scientific and

educational environment. These teams solve specific short, medium and long-term problems and are comprised of students, school teachers, university teachers, staff of research institutes, etc.

All in all, we define a school research project as a holistic, structured process of arriving at certain conclusions, which means students' solving problems with a previously unknown result in various fields of science, technology, art. This also means there are main project stages intrinsic to scientific research. Implementation of research projects leads to the formation of a truly free individual capable of independent thinking, extraction and application of knowledge, who can consider the decisions made and plan actions clearly, as well as effectively cooperate in groups of various composition and type, being open to new encounters and relationships.

There are two types of research projects that can be applied within the model proposed. Project collaborations can be scientific and research, i.e. the scientific novelty of research, or educational and research focusing on acquisition of subjectively new knowledge.

The model of research projects management within the school scientific and educational environment as a new adaptive structure combines linear (vertical) and project-target (horizontal) structures.

A more detailed description of the matrix model for research projects management is presented in Fig. 1.

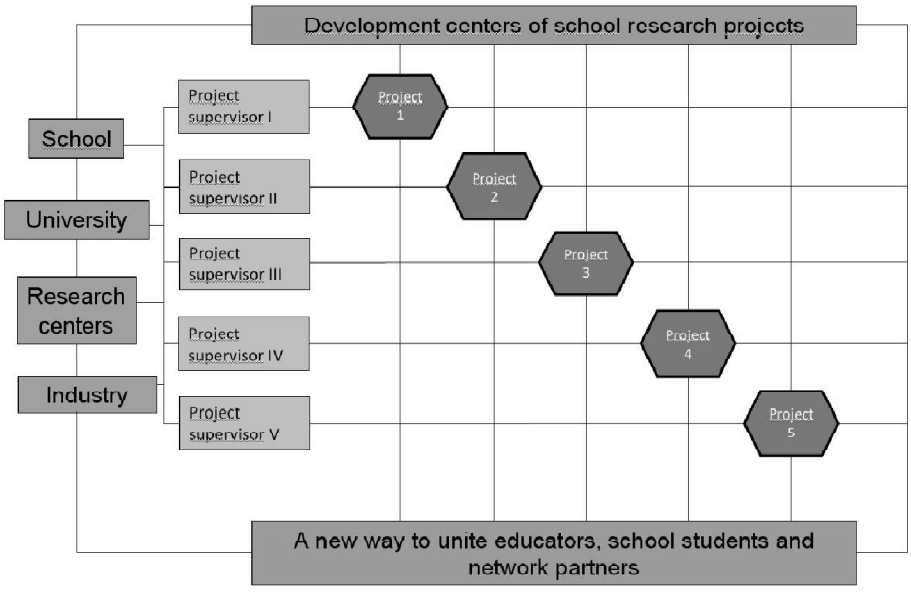

Figure 1: Matrix model for research projects management at school

Let us describe this model. The vertical structure of management includes the projects development center – project teams.

The horizontal management structure embraces project supervisors represented by school teachers or school network partners, i.e. representatives of universities, research centers, and industries. As a result, there is a transfer of responsibility to take decisions related to the functioning and development of research projects within the project team. The model assumes a new way of interaction among educators, students and network partners of the school. Projects can be initiated by all participants of the educational process. In addition, the matrix structure allows promptly launching new projects and completing them, as well as involving new participants in research projects, and consolidating efforts to implement "non-standard" research projects.

Table 2 presents the stages of design and implementation of the model for research projects management of 12-15 year-olds. Experts emphasize the fact that at this age students are able to fully participate in research projects (Klarin, 2004; Panov, 2003).

TABLE 2: STAGES OF DESIGN AND IMPLEMENTATION OF A MODEL FOR RESEARCH PROJECTS MANAGEMENT FOR SCHOOLCHILDREN

No	*Name*	*Activity type*
1	Stage 1	Creation or rental of material, technical, and laboratory facilities, purchase of software required for the organization of research activities of school students.
2	Stage 2	Development of an effective system of network interaction between school and universities, research centers, industrial enterprises.
3	Stage 3	Creation of a research projects development center at school that would coordinate the work of project teams and timely address the problems arising during the projects implementation as well as ensure the integrity of research activities in school.
4	Stage 4	Engagement of university teachers and staff of research centers, industry, appointment of leaders from school teachers who would form project teams and manage research projects.
5	Stage 5	Planning of research projects, creation of project teams and project documentation (project passports and road maps).
6.	Stage 6.	Implementation of research projects.
7.	Stage 7	Conducting regular interim events and presentations demonstrating the results of research projects (project sessions, scientific conferences, debates, roundtables, etc.)

In accordance with the goals and objectives of the study, the developed model was tested in a number of schools of Nizhny Novgorod and the Nizhny Novgorod region.

These schools created an integrated research environment that ensures the active involvement of teachers and 12-15 year-old students in research projects.

An important aspect of this work was the effective interaction between schools and other city agencies engaged in various research activities (the Laboratory of the Ecological Design of Megacity Urban Environment, Environmental Analytical Laboratory of Monitoring and Protection of the Environment of the Minin University, Kerzhensky State Nature Biosphere Reserve, the Nizhny Novgorod regional branch of Russian public organization All-Russian Society for Nature Conservation, Nizhny Novgorod Information Center on Nuclear Industry, Nizhny Novgorod branch of the Russian Bird Conservation Union, Cisco Networking Academy, etc.).

After two years of work, the following results were obtained.

Schools implemented a total of 32 projects that varied in topics, duration, and number of participants. Here are some of their titles: "Study on air pollution in the industrial areas of Nizhny Novgorod regarding the bark of trees", "Polymorphism of the Nizhny Novgorod population by blood groups and Rh factor", "Sources of pollutants intake and distribution in the city of Kstovo", "Geochemical characteristics of drinking water in the regions of the Russian Federation", "Comets and the calculation of the lifecycle of one of them", "Decay of soap foams", "Calculation of the radial velocity of stars by redshift", "Study on the diversity of bird species on the territory of the Nizhny Novgorod region as part of "World Bird Watching Days – 2016", etc.

Among other achievements are victories of the school students engaged in research at city contests in geography, physics, ecology, biology, chemistry.

The findings of 17 projects were awarded with diplomas at city conferences of the Eureka Scientific Students Society. Findings of practical-oriented research projects were implemented in real life. An example is the project "Solving the problem of water bloom in small reservoirs based on laboratory research".

The quantitative results received prove that a quarter of school students involved in research projects has a high level of subjective research experience. In the

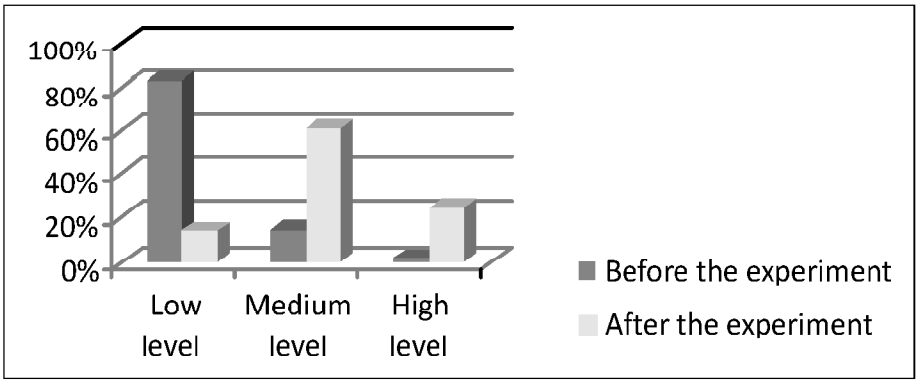

Figure 2: Levels of subjective research experience of school students

ascertaining assessment, conducted prior to students' engagement in projects, only 2% of them demonstrated a high level. The average level of subjective research experience after the experiment was 61%, with the same parameter estimating 15% before the experiment. Only 14% of students participating in research projects showed a low level of subjective research experience, with the low level estimating 83% before the experiment.

DISCUSSION

The results of the study enabled us to identify several positive aspects in the implementation of the matrix model of research projects management at school.

1. Implementation of this model, in our opinion, enables to form an integrated scientific and educational environment of the school, making it possible to design educational routes within research activities for each student. The school can carry out several projects on different subjects, so students have a choice.
2. A new role of an equal "partner" in the research adopted by students when working on a project allows them to see the importance of scientific research and motivates them to gain research experience, which results in the involvement of a large number of school students in research.
3. We believe that the effective management of school students' research can be achieved by schools interaction with other scientific institutions of the city. Representatives of research centers, industries, universities bring modern high-tech research and development approaches into school education, engage students in solving real research problems. In addition, network partners have well-equipped laboratories and centers, testing areas which can be used in projects.
4. The matrix model presents a new management form of school research project, promoting network interaction.

Further development of the matrix model for the school research projects management is possible by uniting several schools of the district, which increases the scope of projects and the possibilities of students' research interaction.

CONCLUSION

In modern education, new organizational and technological ideas come to replace the reproductive forms of passing subject-oriented knowledge. These new approaches require a rethinking of teaching in general, ways of communication between the parties in the learning process, as well as reflexive mechanisms that determine the effectiveness of their interaction.

The practical implementation of the matrix model for the management of research projects in school allowed us to reach a qualitatively new level of the

learning design. These activities led to the creation of the complex scientific and educational environment that makes it possible for a school to establish a productive cooperation with universities, research centers, and industries. Thus, this model aims to facilitate research activities of school students, which is an important condition for their preparation for life in today's changing world.

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