

## The Technique of Chemistry Lyceum Students' Research Position Development: Research of Effectiveness

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### Abstract

Reproductive ways of training make the core of a pre-university preparation system. In this regard, both the development of techniques aimed to form students' research position and their experimental verification in the conditions of lyceum are considered in the paper. The following has been chosen as the leading methods in the research of the proposed technique effectiveness: empirical (questioning, interviewing, conversation, testing, ranging); observation (direct, indirect, and long-term pedagogical survey); praximetric (analysis of activity products); pedagogical experiment (stating, forming and control stages); synthesis of pedagogical experience; methods of mathematical and statistical data interpretation (correlation analysis). The article provides the stages of students' research position development; the technique has been elaborated and its effectiveness has been experimentally proved; components of students' research position formation have been revealed. The validity of students' research position formation upon systematic use of didactic tools – complex educational and research tasks constructed on the object content of the studied discipline and providing multifactorial experimenting has been proved.

### Keywords:

Research Position, Development, Technique, Didactic Tools.

## 1. Introduction

### 1.1. The Problem Relevance

Modern reforms and modernization of Russian education are caused by attempts to reconsider its cultural mission, to create conditions for genuine personal self-determination, to gain personal subjectivity, to develop positive personal qualities. Instability and dynamism of processes in society, unprecedented volume of information demand initiative, ingenuity, flexibility, ability to find creative solutions, efficient strategies of behavior from a person. In the context of new conditions creative search, activity, and person's research position are considered as integral components of any human activity, as a basis of professionalism and competence, as a factor of modern society development [1] [2] [3] [4] [5].

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The quest for novelty, desire to be beyond the known, to gain the truth that plays an essential role in cognitive activity, in many respects defining its success, is peculiar for the person with a well-developed research position. However, a natural incentive research impulse often meets restrictions in the form of social sets, frames, instructions accompanying the personality formation. Traditions of "reproducing" training are still widespread at comprehensive school; they often lead to the situation when school students get used "to get knowledge" [6] [7] [8] [9]. As a result, many school leavers – future applicants prefer reproductive activity that does not imply considerable efforts in search of the unknown. It negatively affects subsequent professional education that assumes students' initiative and independence in mastering sciences, their familiarizing with research activity [10] [11]. This circumstance results in additional specialized training of future applicants to provide their readiness for higher school training specificity, and to form their specific attitude to knowledge that makes them study and investigate properties of surrounding reality comprehensively.

Educational researches in comprehensive schools are often substituted for reproductive activity that imitates research quest and does not assume independent research procedures [12] [13]. Teachers consider a research method of training laborious and of little use for daily work. However, explanatory technologies do not give experience of independent cognition of the world through its research; that makes the application of obtained knowledge impossible or very difficult in a new, unfamiliar situation. As a result, school students have a poorly expressed research position in relation to the cognizable.

## **1.2. Stages of Students' Research Position Development**

Observations showed that school students who entered the lyceum possess a low level of search activity; they prefer reproductive activity. Interest in research arises in conditions when research activity promotes person's self-actualization, disclosure of person's potential abilities, receiving experience of successful solutions of cognitive problems. This circumstance defined the expedient technological sequence of the process aimed to form students' research position determined by the degree of students' activity and independence in educational and research activity. Here we conditionally single out three steps (a step of stimulated search activity, a step of quest and intellectual independence, a step of intellectual creativity) that reflect the quality level of students' research position development; it allows changing teachers' tactics in work with school students, to reduce their leading role with students' independence and initiative increase.

At the step of stimulated search activity students gain experience of independent searching and processing of primary empirical information [14] [15]. All main educational procedures are carried out by students under the leadership of the teacher whose role is to develop and present tasks in the form of educational and research tasks system, to organize and manage students' research quest, to organize discussions of their search activity results.

At the step of students' quest and intellectual independence, the research repertoire is extended [16] [17] [18]. Methods mastered earlier allow choosing, changing and combining various strategies of behavior in the course of educational and research tasks solutions. It enables students to define independently a searching vector, to specify problems within the given situation, and to solve them applying the whole range of logical tools. Therefore, teachers' main function at this stage is to consult. The teacher induces school students to reflect their own actions, focuses them on the ways to overcome difficulties if they arise during independent work at a research task.

The step of intellectual creativity is characterized by a high degree of students' concentration on the research subject [19] [20] [21] [22]. They independently define a research problem, develop searching strategies, and use various logical and practical tools for its solution. Students are not limited to a rigid set of conditions, and freely include (virtually or really) new objects and links in the initial system to study its functional opportunities. The teacher's main task at this step is to build partnership relations to promote school students' aspiration to defend their views freely, to discuss on equal terms the nature of the cognizable and means of its cognition, and search results and analysis.

## **2. Methodology**

Systematic application of elaborated didactic tools – complex educational and research tasks – made the basis of the technique aimed to form lyceum students' research position. The complex educational and research task is understood as an open, multifactorial task providing versatile (imaginary, practical, virtual) experimenting. In the course of such tasks solution, cognitive abilities become more active; students' divergent thinking, emotional and volitional qualities are developed; research initiative is manifested. School students form poly-version vision of the world: an idea of development plurality and evolution of natural systems, knowledge relativity and infinity. The analysis of psychological regularities of creative activity and experience of research tasks application in educational process allowed formulating requirements for educational and research tasks:

- educational and research tasks should be built according to the object content of the corresponding academic discipline;
- a process (a number of processes) which is carried out (or can be carried out) in a complex dynamic system of interacting objects should be a task plot;
- openness of conditions and requirements of the task should give a chance to enrich the studied system with new elements and links;
- the assumed solution of an educational and research task should provide the application of theoretical knowledge from several disciplines or sections of the studied course;
- dynamic characteristics of a task system should be a complex function of its parameters that demands multifactorial experimenting in the course of which essential links and relations come to light;
- educational and research task solution products are theoretical regularities which can further be applied to the solution of private (mono-system) tasks.

The solution of an educational research task begins with the acceptance of background information on the structure and some properties concerning the dynamic system of task situation objects. Intra-system multifactorial experimenting (tests) is conducted to detect empirical regularities and private dependences shown in the dynamics of the system. Then, the processing of heterogeneous empirical information and analysis of obtained data take place to establish regularities having theoretical character. It can be the creation of the studied phenomenon model which can be expressed in a formalized way (e.g., in the form of a formula or a system of equations), and which represents an intellectual product that is subjectively new to students. The following step in the solution of an educational research task is associated with the generalization of a theoretical model, possible enrichment of the

studied system with new contents that makes it a system of higher order of generality and complexity in relation to the initial one. New questions, private problems are formulated and solved here; it facilitates knowledge gaining and its introduction into the already established system.

### 3. Results and Discussions

The proposed technique of students' research position development was introduced in two groups of evening lyceum students at Amur State University. 25 students of an engineering and mathematical grade made an experimental group. 18 students of a physical and mathematical grade were in the control group.

Pre-university preparation in the experimental group was carried out on the basis of a research approach; the complex of necessary pedagogical conditions was realized. The University resources were used to arrange educational research. The control group was trained traditionally; the main emphasis was placed on mastering methods of standard school tasks solutions in physics and entrance exams preparation.

The efficiency of research position development was verified according to the degree of expressiveness and dynamics of its components formation in compliance with selected criteria and indices.

#### 3.1. Indices of Students' Research Position Cognitive Component Development

*Cognitive* component development in the experimental group was supported by projecting of educational process based on systematic and stage-by-stage solution of complex educational research tasks. It promoted students' power of observation, hypothetical efficiency, and experimental skills. Two variants of test tasks were prepared to assess the dynamics of this component formation; they were used at initial and control stages of the forming experiment. Test tasks were assessed quantitatively on a three-level scale and qualitatively (with the use of nonparametric criterion  $\chi^2$ ). The research showed that in the absence of statistically significant difference between groups the distribution of assessments according to the levels of cognitive component expressiveness prior to the forming experiment ( $\chi^2=3,882$  that is less than critical  $\chi^2_{cr}=5,991$ ), at the control stage the essential increase in the categories "high level" and decrease in the category "low level" is observed only in the experimental group. Criterion  $\chi^2$  value indicates statistically reliable distinctions for two groups:  $\chi^2=9,143 > \chi^2_{cr}$ . Table 1 presents the research results of the level of cognitive component formation.

**Table 1. Dynamics of students' research position cognitive component formation**

Level	Control group (physical-mathematical grade)		Experimental group (engineering-mathematical grade)	
	start	finish	start	finish
High	0%	0%	0%	36%
Middle	22%	67%	52%	52%

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Low	78%	33%	48%	12%
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### 3.2. Indices of Students' Research Position Motivational-Valuable Component Development

Students' attitude to research activity as a significant value, their interest and involvement in research are main indices of students' research position *motivational-valuable* component development. The training process had subject - subject character of relations between participants of educational process based on cooperation and mutual interest in research. The research motive is mainly focused on the research activity process, but not the result. It is possible if students' position is strengthened, and they become subjects of educational process aimed to form steady interest in research activity.

Estimating students' orientation to "the process of activity" or "result of activity" in the course of training, it was noticed that in the experimental group the share of students that prefer research process to its result (table 2) significantly increased. The control group did not demonstrate such change. The calculation of criterion  $\chi^2$  statistics indicates the lack of reliable distinctions on this index of a motivational and valuable component between groups at the beginning of the experiment ( $\chi^2=0, 62$ ) and existence of such distinction after its completion ( $\chi^2=9,195$  at  $\chi^2_{cr}=5,991$ ).

**Table 2. Change of students' choice towards "the process of activity" (p) - "result of activity" (r)**

Orientation	Control group (mathematical grade)		Experimental group (engineering-mathematical grade)	
	start	finish	start	finish
p>r	17%	11%	28%	56%
p<p	56%	56%	28%	24%
p=p	27%	33%	44%	20%

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### 3.3. Indices of Students' Research Position Emotional-Volitional Component Development

Emotional-volitional component formation dynamics was assessed by two techniques. M. Luscher (2013) Color Test was applied to define the level of emotional attitude to elements and procedures of research. Students were offered to make rows of color association to the following concepts of research activity: "research", "hypothesis", "task", "experimenting". The research showed that prior to the experiment most students of control and experimental groups had neutral relation to research activity, there were no significant distinctions: the value of  $\chi^2$  criterion for different concepts does not exceed the critical: from  $\chi^2 =1,112$  to  $\chi^2 =8,028$  at  $\chi^2_{cr}=9,488$ .

Students of the experimental group mastered the role of a researcher and they had the opportunity to express themselves in this kind of activity due to systematic practice of independent experimenting, laboratory facilities and computer equipment. Besides, it created favorable emotional attitude to the activity. As for the control group, the problem situation caused mainly negative emotions; that can be explained by the relationship of subjects in the educational process and general atmosphere at the lesson; students experienced tension, they tended to avoid negative assessment that would follow an incorrect answer. It held down students' initiative and often formed negative emotional attitude to learning in general, as research results showed. Statistically significant change in the level distribution for this index in the control group was not found out:  $\chi^2$  criterion has values from 1,422 to 5,756; that is less than  $\chi^2_{cr}=9,488$ ; at the same time the experimental group had a statistically reliable positive increase for this index (values of  $\chi^2$  criterion are from 10,5 to 23,03, it is more than  $\chi^2_{cr}=9,488$ ).

Persistence and perseverance in overcoming cognitive difficulties were another index of emotional-volitional component of students' research position. Research activity is characterized by a high degree of uncertainty when ways to solve problems are looked for. Its success is associated with the manifestation of students' volitional qualities and aspiration to overcome difficulties. Emotional-volitional component formation is possible in such psychological and pedagogical conditions when a teacher and student collaborate during educational activity; when they are united by mutual interest in research quest. Personality focused character of a research method in training, opportunity to get positive experience of independent solution of cognitive problems, to carry out "individual discovery" promoted this. The questionnaire created by Ilyin and Feshchenko was applied to assess persistence and perseverance of pupils to achieve cognitive goals. Table 3 presents the results of this index dynamics.

**Table 3. Dynamics of students' persistence and perseverance manifestation to achieve a cognitive goal**

Level	Control group (physical-mathematical grade)		Experimental group (engineering-mathematical grade)	
	start	finish	start	finish
High	22%	28%	20%	56%
Middle	39%	39%	52%	40%
Low	39%	33%	28%	4%

Students of the experimental group showed essential positive increase on this index ( $\chi^2=9,155$  at  $\chi^2_{cr}=5,991$ ); at the same time statistically significant change was not observed in the control group ( $\chi^2=0,098$ ).

### 3.4. Indices of Students' Research Position Reflexive Component Development

Students of the experimental group were induced to *reflexive* behavior and research activity in the process of research position reflexive component formation. In case if difficulties appeared at any stage of a research task solution, students had to comprehend and formulate independently the problem that caused difficulty. Reflection of one's own activity was manifested in school students' independence, initiative, and independence of judgments, which they showed during the discussion of educational research results. Dynamics of research position reflexive component formation was studied according to the change of students' independent self-esteem and initiative in their educational and research activity (Table 4).

**Table 4. Dynamics of initiative self-esteem level and independence of students in cognitive activity**

Level	Control group (physical-mathematical grade)		Experimental group (engineering-mathematical grade)	
	start	finish	start	finish
High	17%	16%	16%	36%
Middle	72%	78%	60%	64%
Low	11%	16%	24%	0%

The share of students in the experimental group who estimated the level of independence and initiative as "high" increased by 20%, and the share of those who estimated it as "low" decreased by 24%.

Therefore, the development of students' initiative and independence was observed in the experimental group ( $\chi^2=7,955$  at  $\chi^2_{cr}=5,991$ ); that testifies to successful formation of school students' research position reflexive component and effectiveness of created conditions. At the same time, positive increase of this quality in the control group is statistically insignificant ( $\chi^2=5,310$ ). The obtained result is explained by the fact that learning conditions in the experimental group promoted systematic actualization of students' independence and initiative, and the development of their own activity reflection.

The realization of such organizational and pedagogical condition as systematic monitoring of students' research position formation on all its components allows to carry out an individual approach in work with school students and to estimate a forward movement, dynamics of their research position development.

#### 4. Conclusion

Thus, results of the forming experiment convincingly testify to the tendency and dynamics of research position formation in the context of concrete goal-setting that predict a particular degree of achievement on each of its components on the whole, about students' acquisition of rather steady positive attitude to research, their preference of it as a form of cognitive activity in educational and practical performance.

Technological realization of lyceum students' research position formation is determined by the degree of students' activity and independence in educational and research activity: from external search activity encouragement through search and intellectual independence, and further, to intellectual creativity.

Students' research position formation is promoted by systematic use of specific didactic means in teaching and educational process of a lyceum – complex educational and research tasks constructed on the object content of the studied discipline and providing multifactorial experimenting[23] [24].

The complex of psychology-pedagogical, organizational-pedagogical and information-technical conditions provides the effectiveness of lyceum students' research position formation at the stage of pre-university preparation[5].

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