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Dynamics of adolescents' cognitive complexity and its consideration in the construction of the educational process

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***Abstract*—This article is devoted to the study of the dynamics of adolescents' cognitive complexity. The results of empirical research allow us to conclude that cognitive complexity increases during adolescence; cognitive complexity is associated with the level of intellectual development and school performance of the teenager. The authors give recommendations about using the data obtained in the construction of the educational process.**

Keywords—cognitive complexity, adolescents, integration, differentiation, educational process

I. Introduction

The most important task of modern school education is to improve the efficiency of education, which is associated with the search for and creation of new forms and systems of education that maximize the harmonious mental development of children. The creation of such training systems is possible only if they are built taking into account the General laws of mental development and the characteristics of each age period of intellectual development.

In the study of the General laws of the intelligence development modern psychology has achieved significant results, but the problem of studying the formal characteristics of the intellectual sphere remains relevant. One of these characteristics, reflecting the structure of the human cognitive sphere, is cognitive complexity. Under cognitive complexity understand the degree of categorical dissection of the individual's consciousness, characterizing how multidimensional a person perceives objects and phenomena of reality. A number of authors attribute cognitive complexity to one of the parameters of human cognitive style [1], some psychologists consider it as an integral personal characteristic [2].

The sensitive period of intensive restructuring of the cognitive sphere is considered to be adolescence. It is in adolescence that there is a significant shift in the cognitive activity of the child. Despite this fact, studies that would study the features of the development of thinking and other cognitive processes in adolescence, a little more often analyzed changes in the personal sphere, characteristic of the puberty period, or it turns out the dependence of intellectual development on the characteristics of the learning process.

According to studies conducted in the field of mental development of children [3], cognitive differentiation during adolescence increases. However, the process of development of the system cannot be reduced to a simple increase in the differentiation of its components; it also implies a restructuring of the links between them. Cognitive complexity allows assessing the degree of categorical dissection (differentiation) of the individual's consciousness and at the same timing the integration of the cognitive representations used. Cognitive complexity includes both cognitive differentiation of mental representations and their cognitive integration.

II. Methods

The aim of the study was to formulate recommendations for the construction of the educational process, taking into account the identified characteristic trends of cognitive complexity of the cognitive sphere during adolescence.

Research problem:

1.To characterize the main trends in the dynamics of cognitive complexity at different stages of adolescence.

2.To identify the relationship of cognitive complexity with the level of school performance of adolescents.

3.To develop guidelines for the consideration of cognitive complexity in the learning process at school.

Our study involved a sample of 208 people. The 6th, 8th and 10th grades of secondary schools of Vologda and Vologda region were examined, including 69 pupils of the 6th grades, 71 pupils of the 8th grades and 68 pupils of the 10th grades, a total of 105 boys and 103 girls. The sample is representative.

To measure the cognitive complexity of the method was used "Test of personal constructs" J. Kelly [4].

III. Results

Consideration of the results of the experimental study will begin with an analysis of indicators of cognitive differentiation of adolescents. The average values of the Bannister coefficient in different age groups are clearly shown in fig. 1. Number 1 is a group of younger adolescents, number 2 is a group of middle adolescents and number 3 is a group of older adolescents.

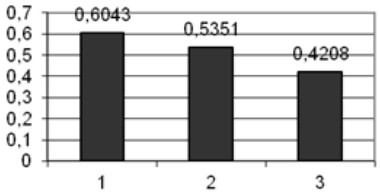

Fig. 1. Dynamics of indicators of cognitive differentiation from younger adolescent to older adolescence.

The diagram shows that the Bannister coefficient gradually decreases with age, which indicates an increase in cognitive differentiation during the adolescent stage of development. Differences in this indicator between groups of subjects of different ages were revealed using the u Mann-Whitney test. The indices of the Bannister coefficient of the 6th class significantly exceed the indices of the Bannister coefficient in the 8th class at the level of $p<0.05$, the indices of this coefficient in the 8th class are statistically significantly higher than those in the 10th class at the level of $p<0.01$. This fact confirms the information available in the literature on increasing the level of differentiation with age. The constructive system of older adolescents is more differentiated, has more elements and grounds for the classification of perceived objects than the system of younger adolescents.

Indicators of integration have a different dynamics of changes with age. Changes in this characteristic during adolescence are shown in fig. 2. The group of subjects of the 6th class is indicated by the number 1, the subjects of the 8th class – by the number 2, the 10th class – by the number 3.

In General, for the period from the 6th to the 10th class there is an increase in the integration of the structural system. However, at the age of 13-14 years (grade 8) there is some decline in the integration of cognitive structures.

Students of the 6th grade in most cases use compact articulated, and often monolithic structural systems. This means that children in early adolescence may experience difficulties when it comes to looking at the subject from different points of view, they can not simultaneously accept conflicting information about a particular phenomenon. Their perception is built around one or more strongly articulated constructs, so the design system is too simplistic. As a result, the perception of younger adolescents may be one-sided, incomplete, inadequate surrounding reality.

In students of the 8th grade cognitive differentiation indicators increase, so eighth-graders have compared with sixth-graders more differentiated constructive system. However, the constructs used by adolescents are not sufficiently interconnected. Such a system can not be called compact and articulated, as in younger adolescents. On the contrary, the constructive system becomes weakly structured, "loose".

This fact is important for understanding the essence of changes taking place in the cognitive sphere of a teenager at this stage. Teenager to this age period already accumulates a lot of new information, knowledge about the objects and phenomena of reality. The new experience acquired in interpersonal communication is poorly connected with the previous knowledge and ideas. The child finds himself in a situation of impossibility to explain certain phenomena, to establish a connection between them, to explain their causes and to foresee the possible consequences of certain events. All this causes a situation of psychological discomfort, increased anxiety, the emergence of conflict situations in interpersonal interaction. The child has the impression that others do not understand him. He himself is often unable to find a common language with adults and peers, as his thinking and perception of the environment begins to radically differ from other people.

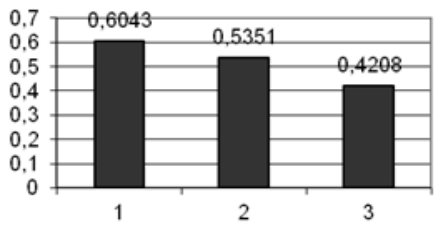

Fig. 2. Dynamics of indicators of cognitive integration from early adolescence to older adolescence.

Lots of new information is accumulated not only in the field of interpersonal communication, but also in the knowledge acquired in teaching subjects of the school curriculum. During the middle adolescence, a large number of new scientific disciplines are studied, such as physics, chemistry, drawing and others. New knowledge gained in the course of studying these subjects cannot be integrated into the old constructive system. It is likely that these facts are associated with the decline in performance of students in grades 7 – 8, which is noted by many teachers.

The links between the elements of the constructive system of the average teenager are beginning to break down; at the same time there are new elements that are not related to the existing ones. Cognitive differentiation increases, but since the links between the elements are very fragile, unstable, the indicators of cognitive integration in subjects at this age stage are reduced.

In older adolescence achieved intellectualization of mental functions such as perception and thinking, develop convergent and divergent thinking. At this age, there is a mastery of the most complex mental operation – generalization. Due to these tumors, the integration of a large number of disparate parts, their clear ordering is achieved. In this regard, the indicators of cognitive differentiation and indicators of cognitive integration are increasing in older adolescents. The constructive system of the tenth-grader is quite differentiated. Superordinate constructs appear, linking together disparate clusters of features used in the description of different people. Moreover, the number of such superordinate constructs increases in comparison with the 6th class.

The constructive system of the senior teenager can no longer be called compact. It is a complex, well-differentiated system, but at the same time it has strong internal interconnections. Therefore, despite the large number of outstanding factors, this system is not loose.

A person, who uses such a constructive system in the perception of phenomena and objects of the surrounding world, uses a large number of categories for comparison, but at the same time all these categories are connected in a certain way. New knowledge acquired by man, harmoniously included in the existing system of representations.

Thus, during adolescence, the constructive system becomes more perfect by increasing the indicators of cognitive integration and cognitive differentiation. From individual elements, related to each other by weak, unstable connections, cognitive structure turns into a complex network of concepts, forming groups, classes, a hierarchy of elements, related to each other by certain relationships, revealing the properties of these elements.

Cognitive complexity, being one of the characteristics of the cognitive sphere of man, is interconnected with his intellectual activity. One of the main types of cognitive activity of the younger teenager is educational activity, so we

suggested that there is a certain relationship between the indicators of cognitive complexity and the level of school performance of the child.

Success in the development of exact disciplines is positively associated with cognitive complexity at all stages of adolescence. From the analysis of the results of the performance of sixth-graders cannot conclude which of the indicators is the most important in the study of exact Sciences – cognitive differentiation or integration. However, high rates of both characteristics are significantly associated with academic performance in these disciplines among students of the 6th grade.

In the 8th grade, academic performance in the subjects of the exact block of school disciplines becomes more associated with the level of cognitive integration. Apparently, at this age stage cognitive integration plays the main role in mastering the subjects of the exact cycle of Sciences. Due to the change and complexity of the course of subjects there is a need to use in training not only the ability to differentiate the material, but also to integrate it. The appearance of such objects as geometry requires the ability to transfer the knowledge gained in one subject to solve problems in other subjects. This, in turn, is impossible without the ability to integrate knowledge in all subjects into a single system.

If in the 6th grade training was aimed mainly at the assimilation of many new concepts and the main task was to memorize a large amount of material, then to the 8th grade student should not so much remember how much to be able to extract from long-term memory the necessary material and use it correctly. New concepts also need to be able to integrate with existing constructs in order to build an optimal volume of elements cognitive structure. Probably, as a result of the changes in the learning process, such a characteristic of cognitive complexity as integration, begins to play a more important role at this age stage.

In the analysis of the relationship between academic performance in the subjects of the humanitarian cycle and indicators of cognitive complexity, it was found that the success in teaching in the subjects of the humanitarian cycle at all stages of adolescence is positively associated with cognitive differentiation. Cognitive integration seems to have less to do with academic performance in humanitarian subjects.

Academic performance in natural Sciences is also positively related to cognitive complexity. It was not possible to establish which of the indicators is the most important in the study of natural Sciences – cognitive differentiation or integration. However, high rates of both characteristics are significantly associated with academic performance in these subjects in students of the 6th grade. In the 8th grade, success in mastering such subjects is more related to cognitive integration than to cognitive differentiation. This fact, in our opinion, is also explained by the fact that in the 8th grade in the study of these Sciences it is very important to be able to draw analogies between different groups of knowledge, between knowledge from different scientific disciplines. Physics and chemistry use knowledge of algebra, geometry, biology – knowledge of geography, geography – knowledge of history, etc. Only a well-integrated cognitive system can effectively cope with such relatively new tasks for a teenager.

In older adolescence, the nature of the relationship between academic performance in the study of subjects of the school curriculum of the natural science cycle and the characteristics of cognitive complexity remains the same: academic performance is largely associated with the cognitive integration of the constructive system. Cognitive differentiation is associated with academic performance in natural science subjects in older adolescents to a lesser extent.

Summarizing the results of the study of the relationship between cognitive complexity and academic performance, we can conclude that in General there is a positive relationship between the level of cognitive complexity and academic performance in the subjects of the school program. However, in comparison with younger adolescence to the middle and older adolescence, there is an increase in the dependence of academic performance on the cognitive integration of the system of constructs. Academic performance in subjects of different disciplines is associated with different characteristics of cognitive complexity: in humanitarian subjects academic performance is more related to cognitive differentiation, in subjects of exact and natural Sciences – to a greater extent with cognitive integration.

Increasing from 6-th to 10-th class value, cognitive integration can be explained due to the increase in the volume and changes the content of the information that you need to learn in high school. The emergence of new subjects, such as chemistry, geometry requires the ability to transfer the knowledge gained in one school subject to solve the problems of other subjects. This, in turn, is impossible without the ability to integrate knowledge in all subjects into a single system.

IV. Discussion

The study showed that at all stages of adolescence there is a relationship between academic performance and cognitive complexity of adolescents. Therefore, cognitive complexity should be taken into account in the preparation of curricula and in the training of students.

In early adolescence, the cognitive system is characterized by low rates of cognitive differentiation and integration. However, this stage of development is characterized by the beginning growth of cognitive differentiation. In this regard, teachers can be encouraged to pay special attention to children with poorly formed skills to find similarities and differences between phenomena and objects. These children are at risk at this stage of development. Sixth-graders with low academic performance have low cognitive complexity. It makes sense to try to increase their cognitive complexity in the learning process through specially organized exercises. To this end, B. Lou leaver proposes to use the OST technique (training-fixing-testing) [5]. According to this training approach, training and testing (meaning control and testing of knowledge) should contain the least use of skills due to differentiation and integration of knowledge. It is possible to fix the past material using the exercises directed on development of skills of integration and differentiation. Students in this case do not "fall out" of control – they are forced to use the skills of differentiation and integration only after they have already learned the material. In addition, the testing procedure is becoming fairer, and it gives equal opportunities to all participants in demonstrating what they know or know.

In the middle adolescence, difficulties in mastering the material begin to experience mainly students with low cognitive integration. Therefore, when teaching middle-aged

teenagers, it is necessary to introduce more exercises that develop this intellectual function. It is necessary to help students in the formation of skills to establish links between subjects and phenomena, the use of knowledge from one area of academic disciplines to another, etc. Tasks aimed, for example, at the ability to find analogies, to build a variety of relationships, to build a chain of dependencies of phenomena, etc. will help children to develop cognitive integration.

In older adolescence, cognitive differentiation and integration are associated differently with academic performance in different disciplines. When teaching Humanities, teenagers with low cognitive differentiation have great difficulties, when mastering subjects of exact and natural science disciplines – with low cognitive integration. Therefore, subject teachers in the learning process should focus on the development of those intellectual functions that are required in this particular subject. Teachers of Russian and foreign languages, literature, history, etc. should teach children to allocate as many signs in these categories to sort objects into various classes, to classify the studied properties, etc. of Teachers of mathematics, chemistry, physics, etc. necessary to develop in students such skills as the ability to find analogies, to build a variety of relationships, to build dependency chains of phenomena, etc., as these skills require children to study these subjects.

The learning process should also take into account that students with existing skills of differentiation and integration of subjects can really help each other. Therefore, it is useful for students with low cognitive complexity to pair with students who show high cognitive complexity.

The teacher himself / herself can also modify tasks related to text, textbook lessons and the use of handouts to adapt them to all groups of students. In the middle class, many children have an average cognitive complexity for a given age. Only a few are at risk, and it is the teacher's job to notice and help these students in time. This approach requires the teacher to pay attention to the composition of the class to take into account its characteristics when planning lessons, selecting materials and choosing teaching methods, as well as to provide individual assistance to individual students with low cognitive complexity.

It is also necessary to take into account the gender-specific cognitive complexity of adolescents in the learning process. It is established that the cognitive system of girls is characterized by greater cognitive differentiation, while boys usually show greater cognitive integration of the system [6]. Thus, teachers can give individual tasks to children, taking into account their gender characteristics. When consolidating the material passed girls better offer a job that will develop their cognitive integration, while boys – a task for the development of cognitive differentiation. For example, girls can be asked to find similarities between objects, and boys – to find as many differences. Girls can be asked to find as many ways as possible to use the acquired knowledge in other subject areas, boys – to make a list of the studied properties of the subject, etc.

Of course, there are a large number of public and private counseling centers, offering courses of training for those students who experience difficulties in understanding and assimilating the materials (they teach children, not corresponding to the basic profiles, to work in ways that would be consistent with the requirements for the main thread), but teachers can have a far greater impact and achieve much greater results with a simple teaching with a focus on basic composition and direct assistance to students at risk.

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