

**FORMATION OF EXTERNAL COGNITIVE TOOLS AMONG FUTURE  
TEACHERS OF CHEMISTRY**

**FORMAÇÃO DE FERRAMENTAS COGNITIVAS EXTERNAS ENTRE FUTUROS  
PROFESSORES DE QUÍMICA**

**FORMACIÓN DE HERRAMIENTAS COGNITIVAS EXTERNAS ENTRE  
FUTUROS PROFESORES DE QUÍMICA**

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**ABSTRACT:** It is important to understand the features of the instrumental side of the cognitive organization of each student, in the process of teaching and upbringing, as a reflection of the properties of the integral structure of the human cognition system. The article is devoted to the problem of identifying and using the prevailing styles of thinking of students, future teachers, in the process of their vocational training at the university. The research goal is to determine the prevailing style of students' thinking activity with a possible typology. The relevance of the problem under study is associated with the need to solve the issue of the optimal use of the individual thinking characteristics of bachelor students, future chemistry teachers, for the development of their methodical thinking as the integration of scientific thinking of a separate taught science, scientific - research pedagogical thinking and applied pedagogical thinking. The authors point out that the master's degree program should also use the idea of implementing and researching students' mental operations in a certain sequence: presentation of knowledge → structuring knowledge → transformation of knowledge in conjunction with the main tools of thinking, as the highest stage of human cognition - concept, judgment and inference. As a research methodology, the article proposes the use of diagnostics by A. Alekseeva and L. Gromova "Individual styles of thinking" to determine the styles of thinking, the purpose of which is to study the individual characteristics of thinking. It has been established that the implementation of the methodology used contributes to the study of the basic styles of thinking of students: synthetic, idealistic, pragmatic, analytical, and realistic. The information obtained will allow each teacher at the second stage of higher education, to rebuild the teaching method of his discipline with a focus on the personality

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characteristics of the cognitive tools of each student individually and the entire group together.

**KEYWORDS:** Cognitive didactics. Education. Cognitive tools. Thinking style. Cognitive activity.

**RESUMO:** É importante compreender as características do lado instrumental da organização cognitiva de cada aluno, no processo de ensino e formação, como reflexo das propriedades da estrutura integral do sistema de cognição humano. O artigo é dedicado ao problema de identificar e utilizar os estilos de pensamento predominantes dos alunos, futuros professores, no processo de sua formação profissional na universidade. O objetivo da pesquisa é determinar o estilo predominante de atividade de pensamento dos alunos com uma possível tipologia. A relevância do problema em estudo está associada à necessidade de resolver a questão do uso otimizado das características de pensamento individual dos alunos de licenciatura, futuros professores de química, para o desenvolvimento do seu pensamento metódico como a integração do pensamento científico de uma ciência distinta, pensamento pedagógico da investigação científica e pensamento pedagógico aplicado. Os autores apontam que o programa de mestrado também deve usar a ideia de implementar e pesquisar as operações mentais dos alunos em uma determinada sequência: apresentação do conhecimento → estruturação do conhecimento → transformação do conhecimento em conjunto com as principais ferramentas do pensamento, como o estágio mais alto da cognição humana - conceito, julgamento e inferência. Como metodologia de pesquisa, o artigo propõe o uso de diagnósticos de A. Alekseeva e L. Gromova "Estilos individuais de pensamento" para determinar os estilos de pensamento, cujo objetivo é estudar as características individuais do pensamento. Constatou-se que a implementação da metodologia utilizada contribui para o estudo dos estilos básicos de pensamento dos alunos: sintético, idealista, pragmático, analítico e realista. As informações obtidas permitirão a cada professor da segunda etapa do ensino superior, reconstruir o método de ensino de sua disciplina com foco nas características de personalidade das ferramentas cognitivas de cada aluno individualmente e de todo o grupo em conjunto.

**PALAVRAS-CHAVE:** Didática cognitiva. Educação. Ferramentas cognitivas. Estilo de pensamento. Atividade cognitiva.

**RESUMEN:** Es importante comprender las características del lado instrumental de la organización cognitiva de cada estudiante, en el proceso de enseñanza y formación, como reflejo de las propiedades de la estructura integral del sistema de cognición humana. El artículo está dedicado al problema de identificar y utilizar los estilos de pensamiento predominantes de los estudiantes, futuros docentes, en el proceso de su formación profesional en la universidad. El propósito de la investigación es determinar el estilo predominante de actividad de pensamiento de los estudiantes con una posible tipología. La relevancia del problema en estudio está asociada a la necesidad de resolver la cuestión del uso óptimo de las características del pensamiento individual de los estudiantes de pregrado, futuros profesores de química, para el desarrollo de su pensamiento metódico como integración del pensamiento científico de una ciencia separada, pensamiento pedagógico de la investigación científica y pensamiento

*pedagógico aplicado. Los autores señalan que el programa de maestría también debe utilizar la idea de implementar e investigar las operaciones mentales de los estudiantes en una secuencia determinada: presentación del conocimiento → estructuración del conocimiento → transformación del conocimiento en conjunto con las principales herramientas del pensamiento, como la etapa más alta de la cognición humana - concepto, juicio e inferencia. Como metodología de investigación, el artículo propone el uso de los diagnósticos de A. Alekseeva y L. Gromova "Estilos de pensamiento individuales" para determinar los estilos de pensamiento, cuyo objetivo es estudiar las características individuales del pensamiento. Se encontró que la implementación de la metodología utilizada contribuye al estudio de los estilos básicos de pensamiento de los estudiantes: sintético, idealista, pragmático, analítico y realista. La información obtenida permitirá a cada docente de la segunda etapa de la educación superior, reconstruir el método de enseñanza de su disciplina con enfoque en las características de personalidad de las herramientas cognitivas de cada estudiante individualmente y de todo el grupo en conjunto.*

**PALABRAS CLAVE:** *Didáctica cognitiva. Educación. Herramientas cognitivas. Estilo de pensamiento. Actividad cognitiva.*

## **Introduction**

Didactics as a theory of learning in modern pedagogy deals with the problems of the learning process as a whole, revealing the patterns of assimilation of educational material. We can say that didactics deals with generalized learning problems. But in the context of digital education (GILMANSHINA *et al.*, 2019a), sustainable development (GILMANSHIN *et al.*, 2019) and the current state of intensive generation of knowledge (especially natural science), the study of the process of individual acquisition and transformation of educational information by students becomes of great practical importance. In our opinion, it is precisely in the context of cognitive didactics, as an integral psychological and didactic section of cognitive pedagogy, which presupposes a personal centering of education (KAMALEEVA; MUKHAMETZYANOVA, 2019), that it is necessary to address the issues of accounting for cognitive personal cognitive tools in the form of concepts of cognitive didactics, focused on the technological transformation of didactic processes and the development of didactic regulators (KAMALEEVA, 2020; GILMEEVA *et al.*, 2020).

Cognitive learning theory, as a psychological and pedagogical basis for building didactic systems (EVANS, 2009), orients the active use of the possibilities of cognition and the development of cognitive abilities of students (SIEMENS, 2006), when learning is conducted not only on the basis of direct learning experience, but also on demonstration

and laboratory experiment (as in the case of student chemists) (KAMALEEVA, 2016; VAIDYA; CHANSKY, 1980; GILMANSHINA *et al.*, 2019b). This involves the study and use in the educational and cognitive activities of higher education both external tools in their direct physical form (laboratory instruments, indicators, ergate systems), and internal (intelligence, memory, attention, imagination etc.) (SERGEEV, 2012).

If we proceed from the fact that the process of cognition of any individual is “the process of reflection and reproduction of reality in the thinking of the subject, the result of which is new knowledge about the world”<sup>5</sup>, then the study of the individual characteristics of the thinking of students, especially future teachers, is of great importance. For a modern teacher, the ability to establish a constructive dialogue in the classroom becomes of paramount importance, the manner of asking questions and making quick correct decisions is often determining the success of this lesson. Speaking about the development of professional thinking of a teacher, a chemistry teacher in particular, it should be noted that a subject teacher forms methodological thinking as an integration of scientific thinking of a separate taught science, scientific research pedagogical thinking and applied pedagogical thinking (GILMANSHINA *et al.*, 2018; GILMANSHIN; GILMANSHINA, 2018).

For this purpose, we used the diagnostics “Individual styles of thinking” (A. Alekseeva, L. Gromova) (VODYAKHA, 2018). The authors of this diagnostics highlight the main thinking strategies for research: synthesizer, idealist, pragmatist, analyst, and realist.

*The purpose* of our study was to determine the prevailing style of students' mental activity with a possible typology and to solve the *problem* of maximizing the use of the information received about the early propaedeutic diagnostics of students' thinking types in order to determine the strategy and tactics of their teaching, to maximize the use of diagnostic data in the process of constructing the entire course and especially the flow chart classes considering the received personality-oriented result.

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<sup>5</sup> Available at: <https://gufo.me>. Access: 10 Jan. 2021.

## Methods

The educational and cognitive process, on the one hand, is the mastery of knowledge as a necessary condition for the brain building, and on the other hand, without the thinking process there can be no acquisition and mastering of new knowledge. And as the authors of the monograph on cognitive pedagogy justly point out, “the task of the pedagogical process is to create an effective cognitive organization of a person, equipping him with universal tools for solving life problems” (COGNITIVE..., 2016). Therefore, the definition of the prevailing style of mental activity of students of a natural science profile with a possible typology will allow us to increase our success on implementing the idea of carrying out mental activity of students in a certain sequence: knowledge presentation → knowledge structuring → knowledge transformation in conjunction with the main thinking tools, as the highest stage of human knowledge - concept, judgment and inference (KAMALEEVA, 2020). Moreover, the selected by us diagnostics A. Alekseeva and L. Gromova "Individual styles of thinking" (VODYAKHA, 2018) makes it possible to obtain brief qualitative characteristics of each type of student personality in accordance with his thinking style (Table 1).

**Table 1** – Brief qualitative characteristics of personality type

№	Thinking style	Brief overview
1.	Synthesizers.	They are always integrators, looking for a theoretical perspective, trying to create the broadest and most generalized concept that would "remove" the contradiction and thereby reconcile the opposing sides. Synthesizers have a passionate love for theories, mostly their own, and often very complex and abstract for others. They are distinguished by creativity, a sense of the new, sharpness of sight and language.
2.	Idealists.	These are people who, first of all, have a broad outlook on things. They are characterized by lofty ideals, high standards of morality and behavior, and criteria for evaluating activities. It takes a truly high quality of work and exemplary behavior to satisfy their needs. Because of their overly idealistic standards, they often become disillusioned with people whose aspirations and norms seem less lofty than their own.
3.	Pragmatists.	They stand out from the rest of the inclination to search for new ways to satisfy their own and others' needs, using only those materials and information that are at their fingertips. In solving any problem, pragmatists tend to demonstrate a gradual, incremental approach in order to get a specific result as quickly as possible. They are quite flexible and adaptive people in terms of both thinking and behavior, they usually have well-developed communication skills.
4.	Analysts.	The analytical style is distinguished by a logical, methodical, careful and careful manner of problem solving. Before deciding, they develop a detailed plan and try to gather as much information as possible. Analysts respect authorities, do

		not like to change their views and preferences, and try to regularly apply the learned theoretical knowledge in practice. They prefer rationality, stability and predictability.
5.	Realists.	Realists are primarily empiricists, not theoreticians. They are much closer to analysts than to any other type. Both are based on facts, focused on the objective, concrete and material, show a tendency towards methodology and practical results. A realist wants to do a specific matter as well as possible, relying on the facts that are at his disposal.

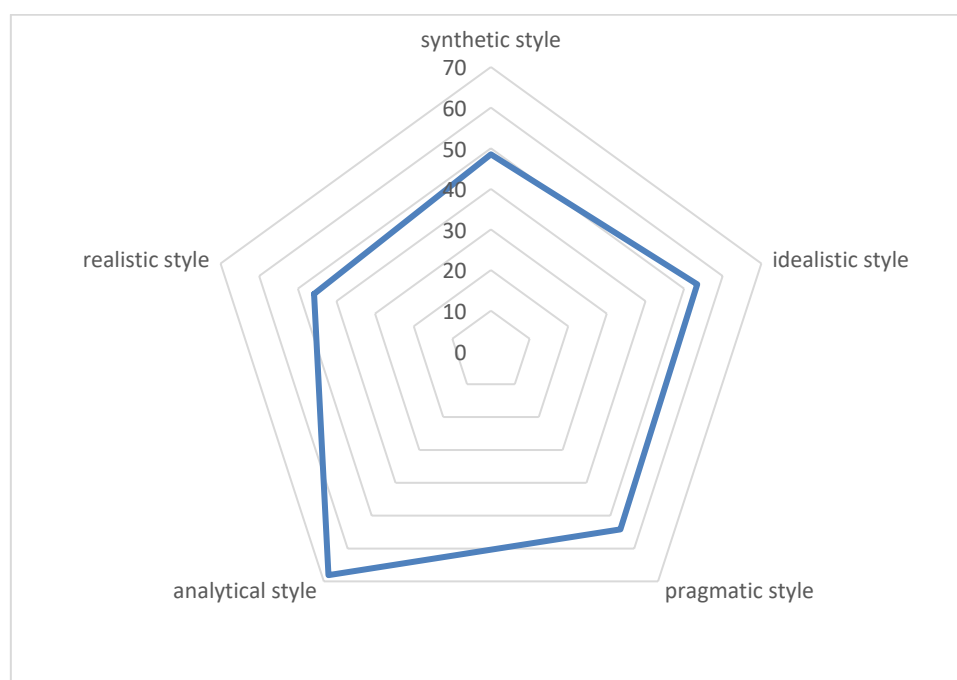
Source: Devised by the authors

## Results and Discussion

In accordance with the diagnostics “Individual styles of thinking” we used (A. Alekseeva, L. Gromova), students give preference to one of the styles of thinking identified by the authors, if, as a result of the calculation, 66-71 points corresponded to this style. In total, all points distributed by style should give 270 points.

The survey involved 20 students - future teachers of chemistry of the 4th year of the Alexander Butlerov Institute of Chemistry KFU. The average distribution of points for the selected types of thinking was as follows: synthetic style - 48.5 points, idealistic style - 53.4 points; pragmatic style - 54.2 points; analytical style - 68.1 points; realistic style - 45.8 points. The averaged results are shown in Figure 1.

**Figure 1** – The average results of determining the thinking style of students



Source: Devised by the authors

The analysis of the results obtained shows that most of the interviewed students are students with an analytical style of thinking. Thus, the results for this thinking style demonstrate that 70% (Table 2) of the respondents prefer to apply the theoretical knowledge acquired in the teaching process at the pedagogical department of the Institute of Chemistry in practice, having previously developed a detailed plan of their activities based on a careful selection of information, they are characterized by a methodical, thoughtful manner of solving the problems facing them.

**Table 2** – Brief qualitative characteristics of the student's personality type

Nº	synthetic style	idealistic style	pragmatic style	analytical style	realistic style
1	48	43	61	63	55
2	51	55	68	50	46
3	47	48	53	77	45
4	52	60	45	65	48
5	57	48	55	63	47
6	57	53	60	58	42
7	40	56	55	70	49
8	52	62	51	58	47
9	50	48	49	74	49
10	40	52	63	72	44
11	49	54	57	72	38
12	44	62	48	66	50
13	42	51	47	78	52
14	51	53	46	73	47
15	39	62	57	66	46
16	52	58	59	66	35
17	48	52	46	76	48
18	51	59	43	75	42
19	52	42	62	68	46
20	48	50	59	73	40

Source: Devised by the authors

It should be noted that out of 30% (6 people) not singled out in Table 2 in terms of the analytical style of students; almost 5 students (25%) also give moderate preference to the analytical style of thinking. And only one student (2) has a strong preference for another style - pragmatic, i.e., this student prefers to get a specific result as quickly as possible, using only those materials and information that is at his fingertips.

## Summary

The above comparison and the research conducted indicate that the majority of graduates - bachelors of the pedagogical department (profile - chemistry) prefer the analytical style of thinking, which, in our opinion, fully corresponds to the teacher training program in the conditions of modern realities.

This conclusion orients us to the maximum use of the information received about the early propaedeutic diagnostics of the thinking styles of bachelor students in order to determine the strategy and tactics of their education in a master's degree.

## Conclusions

So, we can state that:

- in the current state of intensive generation of natural science knowledge, great importance is attached to cognitive didactics, in which special attention is paid to studying the process of individual acquisition and reformation of educational information by students;

- cognitive didactics proceeds from the fact that each person has an individual set of tools (external and internal), which are used with varying efficiency in solving a wide class of problems, using the preferred style of thinking;

- in the context of an ambiguous situation with the formation of cognitive tools of university students in the process of cognitive activity (in the context of chemical education), the authors propose the idea of implementing and researching the mental operations of students in a certain sequence: knowledge representation → knowledge structuring → knowledge transformation in conjunction with the main thinking tools, as the highest level of human cognition - concept, judgment and inference;

- the use of the diagnostics “Individual styles of thinking” (VODYAKHA, 2018) to determine the styles of thinking allows one to describe both quantitative and qualitative characteristics of the personality characteristics of their cognitive tools identified in the process of interviewing students in order to project joint educational and cognitive activities of students and teachers in the magistracy.

This study cannot claim to fully consider the complex and multifaceted problem of the development of cognitive didactics under conditions of intensive generation of natural science knowledge. The problems of cognitive modeling of conceptual, notional,



procedural, structural and content characteristics of educational activities, educational processes and pedagogical situations, the operation of figurative-conceptual properties convenient for visual and logical perception, elements of knowledge and their transformation seem to be important for further scientific research.

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## REFERENCES

COGNITIVE pedagogy: e-learning technologies in the professional development of the teacher: a collective monograph. Yakutsk, 2016. 337 p.

EVANS, V. **How words mean:** Lexical concepts, cognitive models and meaning construction. Oxford: Oxford University Press, 2009. 396 p.

GILMANSHIN, I. R. *et al.* Methods of training specialists in the field of sustainable resource management and waste management. **IOP Conference Series: Materials Science and Engineering**, v. 570, n. 1, 012025, 2019.

GILMANSHIN, I. R.; GILMANSHINA, S. I. Stages of formation of scientific thinking of students in terms of engineering education at the university. **IOP Conference Series: Materials Science and Engineering**, v. 412, n. 1, 012021, 2018.

GILMANSHINA, S. I. *et al.* Science Education: Development of Environmental Thinking. **European Research Studies Journal**, v. XXI, n. 3, p. 690-704, 2018.

GILMANSHINA, S. I. *et al.* Digital learning technologies in the University education system. **IOP Conference Series: Materials Science and Engineering**, v. 570, n. 1, 012027, 2019a.

GILMANSHINA, S. I. *et al.* Formation of competencies of the 21st century by means of project activities. **IOP Conference Series: Materials Science and Engineering**, v. 570, n. 1, 2019b. DOI: 10.1088/1757-899X/570/1/012026

GILMEEVA, R. K. *et al.* **Cognitive pedagogy:** study guide. Under the scientific editorship of E.Yu. Levina. - Kazan: Institute of Pedagogy, Psychology and Social Problems, 2020. 228 p.

KAMALEEVA, A. R. Cognitive didactics concepts: focus on digitalization of higher education. **Kazan pedagogical journal**, n. 4, p. 31-38, 2020.

KAMALEEVA, A. R. The analysis and classification of technologies of implementation of natural-science and professional training of students of spo in the

conditions of competence-based approach. **Innovations in Education and Teaching International**, p. 5-10, 2016.

KAMALEEVA, A. R. The formation of the cognitive tools of university students in the process of cognitive activity (in the context of technological learning). **Bulletin of the Chuvash State Pedagogical University named after I. Ya. Yakovlev**, v. 2, n. 105, p. 146-153, 2020.

KAMALEEVA, A. R.; MUKHAMETZYANOVA, L. Yu. Algorithm of step-by-step cognitive modeling in the natural science and humanitarian components of professional education. **Bulletin of the Chuvash State Pedagogical University named after I. Ya. Yakovlev**, v. 1, n. 101, p. 129-136, 2019.

LARGE encyclopaedical dictionary. Available: <https://gufo.me/dict/bes-/%D0%9F%D0%9E%D0%97%D0%9D%D0%90%D0%9D%D0%98%D0%95>.  
Access: 19 Dec. 2019.

SERGEEV, S. F. Cognitive pedagogy: custom properties of cognitive tools. **Educational Technologies**, n. 4. p. 69-68, 2012.

SIEMENS, G. **Knowing knowledge**. 2006. Available: [www.knowingknowledge.com](http://www.knowingknowledge.com).  
Access: 10 Jan. 2021.

VAIDYA, S.; CHANSKY, N. M. Cognitive development and cognitive style as factors in mathematics achievement. **Journal of Educational Psychology**, n. 72, p.326-330, 1980.

VODYAKHA, Yu. E. **Psychological diagnostics of personality spheres: laboratory practice**. Yekaterinburg, 2018.

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