ISSN 1070-3632, Russian Journal of General Chemistry, 2013, Vol. 83, No. 6, pp. 1257–1265. © Pleiades Publishing, Ltd., 2013.
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Abilities in Chemistry and Possibilities of Their Diagnosing

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Received April 24, 2011

Abstract—Experimental results indicating the existence of special abilities in chemistry were reported, with chemistry interpreted as the science about substances and their transformations in accordance with the classical definition. It was shown that the key component of abilities in chemistry is a learner's particular attitude to a substance. The possibilities of diagnosing schoolchildren's abilities in chemistry were discussed. Promising directions for further psychological and educational research concerning the abilities in chemistry were considered.

DOI: 10.1134/S1070363213060455

INTRODUCTION

Choosing the future profession is an important step in the life of school graduates wishing to continue their education, but by no means always is this choice made correctly. In this connection a question arises whether it is possible for all schoolchildren in their 8th or 9th grade to get information on their possessing or lacking in qualities required for successful performance of a specific activity? This issue gains additional relevance today in view of the planned (and already initiated) profilization of the general secondary education [1]. Any teacher is well aware of the fact that there can be only a few isolated of making well-informed vocational choices by 9-, and even 11-graders. For example, it is quite natural for mathematical abilities of children to be expressed at an early age. The first music and ballet dancing lessons are usually taken in childhood. Quite often, the vocational choice for children is made by their parents, or it is influenced by a teacher enthusiastic about their subject, relatives, and friends, both of the same age and somewhat older. However, the vast majority of senior schoolchildren are unable of taking a well-informed decision at the age of 15. This fact is of particular concern when it comes to vocational choice in the situation where the currently implemented profile training conception does not provide for changing from one profile to another. Therefore, the development of scientifically based methods for diagnosing schoolchildren's aptitude for performing different activities is a task of much psychological and pedagogic significance.

This study analyzes the existence of abilities in chemistry and the possibilities of their diagnosing for early vocational guidance purposes.

What is Meant by Special Abilities?

One of the major Russian psychologists S.L. Rubinshtein defined abilities as "a complex structure, a set of mental qualities making a person capable of performing certain historically developed types of a socially useful vocational activity. Any special ability means a capacity to do something" [2].

Life experience suggests that selected persons can reach very good results in performing many complex activities: outstanding mathematicians, musicians, painters, organizers, engineers, poets, pilots, teachers, linguists, physicians, and athletes. Undoubtedly, these are professionals whose level of expertise significantly surpasses the average for their sphere of activity. It is important to note that giftedness is mostly developed in one sphere: Talented poets are often absolutely incapable of mathematics, and talented mathematicians only in rare cases demonstrate high athletic achievements. Therefore, it may safely be said that special abilities to perform particular types of complex activities do exist.

Special abilities are determined by the anatomic and physiological features of brain and of the nervous system as a whole, as well as by individual structural patterns of cerebral cortex and its functionally mature areas. In popular speech, special abilities are usually as termed as “the makings” whose material basis is provided by the cerebral cortex structure (mental, nuclear, and cognitive-representative structures) [3], constituting the brain neural network. Clearly, this structure is developed to different extent in different people, among which very few, the so-called gifted persons, have a highly developed cerebral cortex.

Though predetermined genetically, special abilities cannot be successfully realized without adequate guidance and education. To be able to perform any activity, an individual should possess the general abilities: positive characterological personal features (diligence, self-discipline, persistence, etc.), as well as developed creativity and fairly high general intelligence.

Hence, a component differentiating the abilities is represented by the genetically predetermined makings, because other components are virtually necessary all types of abilities. Indeed, high intelligence, creativity, and diligence are needed by all top professionals. At the same time, the comparison of the psychological portrait of, for example, a talented composer with that of a talented zoologist, shows that the former possesses a tuneful ear, musical memory, and a particular attitude to the world of sounds, harmony, and artistic image, while the latter tends to express high interest in fauna and strong aspiration to study the animal life. As mentioned above, a person’s inclination toward a specific activity and a particular attitude to the specific features and the object of labor are caused genetically and are manifested as a person’s makings in childhood.

In this connection, it would be natural to raise a question as to whether the range of special abilities is open or closed? Does it increase in size over the years or remain unchanged? Clearly, the number of human activity spheres is steadily growing with time; the development of science and technology calls into being those professions about which nobody had any idea a century ago. At the same time, human brain has not undergone evolutionary changes over the past several millennia, which suggests that the aptitude to exercise any professional activity in the new emerging areas is determined by combinations of the already known makings and abilities. Special abilities are not too large in number: mathematical, natural-scientific, musical, artistic, pedagogic, technical, medical, linguistic, athletic, organizing, and entrepreneurial, to mention just a few. It should be noted that this list would look much the same a hundred and even two thousand years ago.

Thus, to achieve outstanding results in any field of activity, an individual needs to possess appropriate makings, positive characterological personal qualities, high intelligence, and creativity. Though essential, all these components taken separately cannot guarantee success in a professional activity. If not supported by diligence and persistence, the makings suggest potential idleness of an individual who is reputed to be a person who has ruined his/her abilities (in fact, makings). On the other hand, diligence, consistency, and self-discipline alone can hardly ensure achieving high results in creative activities. A combination of intelligence, creativity, and positive characterological qualities in an individual lacking any distinct professional makings is typical for striking personalities who tend to show good results in several spheres of activity simultaneously but reach outstanding results in neither of them.

Abilities in Chemistry

D.A. Epstein, the Academician of the URSS Academy of Pedagogic Sciences was the first to raise the question of existence of abilities in chemistry and their nature [4]. He interpreted the abilities in chemistry as an objectively existing combination of personal qualities: “chemical head” plus “chemical hands”. Within this framework, it is necessary to discuss what is meant by “chemical head” and what are the specific features of chemical thinking, and further (which is a significantly simpler task) to formulate the “chemical hands” criteria. The next step will consist in developing methods to identify the “chemical head” and to differentiate “chemical” hands from “nonchemical.”

It is necessary to give a definition to chemical science before undertaking the above-mentioned tasks otherwise a discussion of the abilities in chemistry makes no sense.

Modern chemistry is a science covering a very broad knowledge area stretching from theoretical (quantum) chemistry, which closely adjoins quantum mechanics and theoretical physics, to molecular biology and biochemistry which belong essentially to the scope of biological science. Integration and differentiation of sciences and broad application of physical methods and mathematical apparatus have brought chemistry into close relation to physics (physical chemistry, chemical physics). On the other hand, natural sciences areas such as geochemistry, biochemistry, soil chemistry, technical chemistry, etc. apply chemical methods for studying biological, geological, and technical objects and are closely associated with chemistry. Thus, to be successful, modern chemists should not only possess abilities in chemistry but also be aware of physics, mathematics, and other allied disciplines.

To simplify the task of drawing the psychological portrait of a chemist, we will restrict ourselves to the classical definition of chemistry, i.e., that of the science about substances and their transformations. Hence, chemists are persons who directly work with substances when performing their activities. This concerns, above all, synthetic chemists (organic chemists and inorganic chemists) and analytical chemists engaged in performing analysis by traditional, "wet," methods. Importantly, both synthetic and analytic chemists deal with really tangible, observable, fairly significant amounts of a substance.[1] Thus, the above-given definition of chemistry implies that a specific feature of the activity of chemists is the subject of their labor, a substance. Therefore, an essential aspect of the psychological portrait of a chemist is a particular attitude to a substance. There is by no means an original conclusion: The "sense of substance" term has long been used by chemistry professionals: To give a high opinion of the activity of a synthetic or analytic chemist, his/her colleagues use to say that he/she possesses a well-developed sense of a substance.

A particular attitude to substances and their transformations is a feature emphasized by the biographers of many undoubtedly talented chemists. For example, though having a very vague idea of chemistry in his childhood, A. M. Butlerov conducted many experiments; he was interested not so much in the practical results of the "magic" that he performed but in the process of transformation of substances. At the outset of their "chemistry careers," many outstanding chemists made themselves acquainted with pharmaceutical chemicals while watching their parents producing drugs (J.-L. Proust, H. Moissan, J. Liebig). The interest in mineral and rock collecting was brought into chemistry by A. von Baeyer, F. Wöhler, and T. Svedberg. In his childhood, W.F. Ostwald was fond of preparing photographic solutions and dyes, and D.I. Mendeleev often visited a glass plant when a child. One of the major modern chemists R.B. Woodward, since the age of 12, was absorbed in reading descriptions of chemical syntheses, many of which were reproduced by him as part of at-home experiments. Many (if not most) of modern Russian highly qualified professional chemists conducted chemical experiments at school laboratories and at home. There is a wealth of examples of this kind.

Let us now turn to a definition of the "sense of a substance" (and of a chemical process). This is a specific characteristic of a person whose attributes are as follows:

– great interest in properties of substances and their transformations, including the indications of the occurrence of transformations;

– strong desire to work with substances and exploit their useful properties;

– hypersensitivity to external characteristics of substances (color, smell, texture, dispersity, mass, volume, etc.) and hyposensitivity to their associated irritating properties; and

– sensitivity to qualitative changes and ability to observe them carefully over a prolonged time.

Indeed, chemists are distinguished from other professionals by a special interest in substances and their properties and transformations. Curiously, a distinguishing feature of a synthetic chemist consists in that he/she typically feels no negativism toward bad, pungent smells, repulsive appearance of the product in a flask, etc.

In this connection, a question arises: what was the occupation of persons who had an innate sense of substance in times preceding the formation of chemistry as a science, i.e., 250–300 years ago? Did ancient Greeks possess abilities in chemistry? The answer is simple: Abilities in chemistry existed in humans in previous times and were manifested as an inclination toward manipulating substances with a view to exploit their useful properties. In other words, in times gone by, those persons who most likely would become chemists in our time, chose professions of jewelers, pharmacists, potters, cookery specialists, soap-makers, perfumers, blacksmiths, etc.

[1] Physical chemists and analytical chemists performing analyses by instrumental methods typically deal with trace amounts of a substance.

The opinion prevalent among some of today's professionals in both natural sciences and psychology is that there exist abilities in natural sciences as a whole rather than in chemistry particularly. Certainly, this viewpoint has a right to exist but it is based on a too approximate approach. Let us compare, for example, the importance of terminological memory, spatial imagination, and ability in abstract thinking in three different types of natural scientists: theoretical physicist, synthetic chemist, and botanist. The above-cited qualities are undoubtedly needed by them all, but terminological memory is clearly much more important for a botanist than for a physicist, whereas the ability in abstract thinking is essential for a physicist, and spatial imagination is just the quality for a chemist. Also, it should be remembered that individuals hold different attitudes to the objects of study in different natural sciences. One can hardly imagine a person equally interested in elementary particles, transformations of molecules (from monoatomic to proteinic), flora (from unicellular to redwoods), and fauna (from lancelet to a whale).

It is fair to say that chemists possess a special, peculiar only to them, "chemical cast of mind" as manifested in a special interest in the composition, properties, and transformations of substances, as well as in the phenomena accompanying these transformations. Only a true chemist looks at the world through the prism of their science, whereby they are is able to notice and explain chemical processes and phenomena occurring in daily life, to change from macro level at which the process is observed to micro level at which it is described in terms of chemical formulas and equations (and vice versa).

An outstanding Russian psychologist E.A. Klimov, the Academician of the Russian Academy of Education, suggested that, for young people's career guidance purposes, all professions be classed into five types, depending on the subject of labor: person–person, person–symbol, person–nature, person–artistic form, and person–machine [5]. However, when discussing special abilities, each of these types needs to be subdivided into several subtypes. For example, the person–artistic form type is consistently subdivided into music, ballet dancing, poetry, painting, drama, and other subtypes. Each of these subtypes has its corresponding special abilities characterized by an individual's attitude to the subject of their labor: A musical form (according to Klimov, this is a part of artistic form) for musician, aqueous matter (a part of nature) for a seaman, and a mechanism (a part of machinery) for an engineer. As regards chemistry, in our opinion one should consider a specific person's particular attitude to a substance. Hence, the classification proposed by Klimov needs to be complemented with one more subject of a labor-based type, man–substance. This type integrates persons who deal professionally with transformation and processing of substances, preparation of different materials: metallurgists, pharmacists, cookery specialists, winemakers, perfumers, jewelers, and certainly chemists.

Diagnosing the Abilities in Chemistry

How can abilities in chemistry be identified in schoolchildren? At first glance, the answer is obvious: through suggesting to them chemistry assignments of varying degrees of complexity. However, this will make it possible to assess only the level of knowledge rather than the ability level. Certainly, knowledge and abilities are interrelated, though in an intricate and not always direct manner. Knowledge is determined not so much by abilities as by learning conditions and teaching quality. Hence, abilities in chemistry should be diagnosed via identifying all their components (sense of a substance, positive characterological features, intelligence, creativity) rather than via assessing the level of knowledge.

Based on the recognized nonidentity of assessments of the level of the level of ability and knowledge, a very important conclusion can be made: A person whose abilities in chemistry are to be diagnosed does not need to study chemistry. At first glance, this conclusion contradicts the well-established psychological postulate: The abilities in a particular activity can be identified only in those persons who have been engaged in this activity for some time [6, 7]. However, this is an illusory contradiction, because a widespread use of household chemicals allows virtually all children to get nowadays acquainted with the chemist's subject of labor, i.e., with a substance, long before they enter their eighth grade at school, when studying chemistry begins. Hence, all we need is to determine whether a schoolchildren is acquainted with a substance as the subject of labor and what are their particular sensations, perceptions, and manipulations with respect to a substance.

An original method for diagnosing abilities "by contradiction" was suggested by K.K. Platonov, Dr. Sci. (Psychol., Med.). In this method, an individual's aptitude for performing a specific professional activity is identified on the basis of the list of those components in this individual, whose lack cannot be compensated by growth of other components. This may concern, e.g., pathological disorders arising as a consequence of past diseases, visual defects, etc. A more interesting case is that of an individual who is healthy but whose personal characteristics and nervous system make their unfit for a specific profession. In some cases these counter-indications are obvious: For instance, an individual with slow response and poor visual estimation abilities is unfit to be a jet airplane pilot. At the same time, these shortcomings, although significant, are not fatal in experimental chemist. On the other hand, incapability for associative and visual thinking, lack of spatial imagination, reduced attention span, and high level of distractibility will prevent an individual from adequately performing as a chemist. An individual who feels panic when sensing a bad smell or gets disgusted at the sight of a surely poisonous substance fuming in a flask is not suited to be a synthetic chemist.

In 1979, the author if this article initiated a systematic study dedicated to the abilities in chemistry with the view of early career guidance of schoolchildren. The main array of experimental data for that study, whose Psychology Advisors were Prof. KK. Platonov (Institute of Psychology, USSR Academy of Sciences), Prof. B.A. Fedorishin (Research Institute of Psycho-logy, National Academy of Pedagogic Sciences of Ukraine, Kyiv), and E.Yu. Artem’eva, Dr. Sci. (Psychol.) (Psychology Department, Lomonosov Moscow State University), was obtained by L.A. Korobeinikova [8–11].

The approach developed in that study was that underlain by a simple concept: To establish the nature of abilities in chemistry it is necessary to determine the structure of abilities of high-ranking professionals in chemistry. The test participants were a group of 18 synthetic chemists (including organic and inorganic chemists) from the Chemistry Department, Lomonosov Moscow State University. They satisfied the following criteria: male; age 32±4; Candidate of Sciences; and high professional achievements (as validated by expert opinion). Using the scheme suggested by Epshtein, the “chemical head” and “chemical hands” groups were identified in the structure of abilities and complemented with the “sense of a substance”. Table 1 presents the ranked arrays according to the components of abilities in chemistry, derived from detailed testing of chemical professionals and young chemists (represented by schoolchildren from the specialized chemistry classes of school no. 171 in Moscow). It is essential that those young chemists were admitted to these classes after passing the major entrance examinations, which allows this schoolchildren group to be regarded as young professionals. Table 1 shows that the experimentally derived ranked arrays for the chemical professionals and young chemists largely coincide.

Table 1. Ranking arrays of the components of abilities in chemistry

Element of abilities	Professional chemists	Young chemists
“CHEMICAL HEAD”		
Attention qualities (span, sustainability, concentration, switching ability)	1	1
Memory (associative and terminological)	2	2
Logical, associative thinking based on:		
visual-spatial image perception	3	4
numerical image perception	4	5
Spatial perception	3	5
“SENSE OF A SUBSTANCE”		
Thermal sensation	2	2
Sensation of smell	3	3
Color vision	1	1
Visual estimation of mass and volume	4	4
“CHEMICAL HANDS”		
Motor coordination	1	1
Handling skills	2	2
Gravity sensation	3	3

The measurements of the components of the abilities in the “reference” synthetic chemists revealed the most essential among them (in descending order):

(1) sustainable attention;

(2) good attention switching ability;

(3) large attention span;

(4) capacity for logical and associative thinking;

(5) attention concentration;

(6) creative imagination;

Table 2. Tests to diagnose abilities in chemistry

Appointment of the test (s)	Test book numbers [12]	Links
Selecting and specifying the area of interest	1–3	[13–16]
Choose a specialty within the profession of chemist (researcher, teacher, technologist, Laboratory Assistant, Designer)	4, 29	[12, 17]
The quality of attention (sustainability, concentration, switching)	5–7	[7, 17]
Powers of observation and Visual memory	8	[12]
Quality memory	17	[17]
Feelings matter (gravitational and thermal sensations, smell, colour perception, nice)	10–16	[17]
Motor coordination	9	[17]
Spatial imagination	23	[17]
Intelligence	18–22, 24	[7, 13, 17–19]
Character traits	25	[17]
Self-assessment questionnaire	26	[17]
Communicative and organizational tendencies	27	[14]
Creativity	28, 29	[12, 17]

(7) associative memory;

(8) spatial perception;

(9) logical memorizing skills; and

(10) power of observation.

Interestingly, testing a group of 16 physical chemists (including those specializing in spectroscopy, kinetics, and thermodynamics, as well as theoreticians) selected, using the same criteria showed that the sense of a substance is not of decisive importance for them, and ranking arrays of components of abilities vary among the test participants. The abilities for this category of specialists have a more intricate structure, being dependent apparently not so much on the chemical as on the mathematical and physical components.

The data obtained were summarized, on which basis of a complex scheme was developed for testing schoolchildren’s abilities in chemistry [11, 12]. It is essential that the scheme includes 29 tests (for details, see [12]), of which only one presupposes that the test participants are acquainted with chemistry (Table 2).

This testing system provides an extremely useful tool for schoolchildren’s early career guidance. As early as in the 1980s there were applied in testing around 1000 senior schoolchildren and many of those chose chemistry as their future profession. It is noteworthy that the test kit [12] allows not only the potential aptitude for chemistry to be diagnosed in schoolchildren but also a specific job profile (research, technology, pedagogy) to be recommended. Interestingly, in a number of cases, L.A. Korobeinikova predicted the success in studying chemistry for 6–7-graders who had not yet begun studying chemistry at the time of testing and in which the tests revealed a sense of a substance and other components of abilities. Currently, this test kit is being successfully applied by pedagogic staff and schoolchildren in several regions of Russia and Belarus for professional consultation purposes.

In the mid-2000s, the studies of the abilities in chemistry gained a new momentum, after E.V. Volkova from the Ural State University [20–22] undertook a cycle of studies with the aim to identify the nature of abilities in chemistry. Those studies were based on the concept of regularities in the development of mental structures underlying the special abilities [23–25].

That experimental study involved over one thousand participants, including 428 schoolchildren (8–11-graders) from the city of Yekaterinburg and Sverdlovsk region and 575 students (in particular, 375 second-year students) of the Chemistry Department, Ural State University. Three blocks of diagnostic techniques were used: (1) special abilities in chemistry; (2) general cognitive abilities, and (3) individual psychological characteristics. The experimental results were carefully processed using a set of statistical methods (correlation, factorial, and dispersion analyses). That study provided E.V. Volkova with a huge array of experimental data on psychological characteristics of chemistry students [26, 27]. Based on numerous statistically valid data, the existence of special abilities in chemistry was proven.

Those studies used the specially designed GreatChemist computer-based test for diagnosing abilities in chemistry, which contains a large set of simple questions in general chemistry; the assessment criteria include the proportion of correct answers and the time on tasks. Also applied was the test for final knowledge quality control, developed by R.A. Lidin and L.L. Andreeva, as well as the "chemical dictation," "chemistry coding," "chemical memory," and "chemical concept classification" techniques; the performance in chemistry, demonstrated by the schoolchildren, was taken into account as well.

Also, the experiment involved the Torrance nonverbal battery testing of chemists (a picture-type creativity test whose participants are given a shape and asked to complete the picture by drawing lines so as a meaningful image could be obtained). That test gave an extremely important result: While performing this test, more successful chemists produced a significantly larger number of chemical images (test tubes, flasks, funnels, chemical formulas and symbols, etc.) than did less successful chemists. Thus, nonverbal Torrance battery test is suitable for diagnosing abilities in chemistry.

The intelligence tests showed that the mastery of chemical disciplines requires no lower than IQ 110 on the Wechsler Intelligence Scale, and effective implementation of abilities in chemistry, a higher general intelligence (IQ 130).

Based on the regularities in the development of mental structures, derived from the test data, E.V. Volkova developed a chemistry teaching program for secondary school to allow quick and permanent assimilation of knowledge of the subject and promote development of general and special abilities in chemistry [28]. This program is undoubtedly suitable for profile training applications.

The studies conducted by E.V. Volkova rely upon a solid theoretical base, but a few points at issue need to be mentioned. In particular, the tests were largely aimed to check the knowledge of the school chemical study material, which suggests that the contribution from respondents' learned knowledge could be of decisive importance. Essentially, in E.V. Volkova's interpretation, capable chemists are those test participants who know the elementary course of general chemistry and can quickly answer simple questions, which is a debatable point. The ability to quickly solve simple problems does not imply the ability to handle complex real-life problems.

Unfortunately, most of the test participants were students of the Chemistry Department, Ural State University, among which the proportion of "true" chemists is a priori low. It should be noted that, even in chemistry-oriented institutions of higher education in Moscow, such students are a few in number. Clearly, to adequately elucidate the nature of abilities in chemistry is was necessary to test "reference" chemists who have already showed good practical results. However, a valuable result of the above-described tests consists in that, even with such a far from ideal composition of the tested group (district university students), they provided statistically valid data that proved the existence of abilities in chemistry.

The last thing to be said in this connection is that only a professional psychologist can adequately assess the practical results from tests utilizing the techniques developed by E.V. Volkova; an ordinary teacher's qualification is not sufficient for properly organizing the tests and competently processing their results.

To conclude the discussion on diagnosing abilities in chemistry, it should be mentioned that the diagnostics of special abilities has traditionally been the focus of activities of Russian psychologists and has not gained great popularity among foreign scientists. In any case, relevant publications by foreign authors are few a number, to our knowledge.

Prospects for Future Studies

Though sufficiently understood in many respects, the abilities in chemistry quite possibly may constitute the subject of future research whose lines (closest to the author's area of research) are summarized below.

(1) Develop a more adequate technique for testing the sense of a substance and a chemical process. This concerns, in particular, a test for measuring the response of the examinee to "negative" properties of substances (bad smell, repulsive appearance, etc.).

(2) Substantially increase to statistically significant values (50 at a minimum) the number of "reference" chemists in the tested group. This is a difficult task, since its accomplishment would require the involvement of participants from several chemistry-oriented higher schools and research institutions. In this context, expert opinion-based selection of respondents is not the optimal choice. The use of Hirsch-index also causes complications in the case of young Russian scientists due to the fact that Russian-language publications are incompletely accounted for in Web of Science and Scopus bases, as well as due to the specific features of Russian scientific life, in which an average executive and administrator are placed in a position of inequality.

Valuable information could be obtained from the comparison of chemists' psychological portraits, physicists, biologists, engineers, and other "reference" specialists.

(3) Extend the concept of abilities in chemistry to incorporate physical chemists. Clearly, there would require taking into consideration the mathematical and physical, along with the chemical, components. The mathematical component was studied in detail previously [29], while the problem of identifying the abilities in physics still remains to be accurately stated.

(4) Determine how the abilities in chemistry vary with age and how they are influenced by chemistry teaching practices applied in secondary and higher school. Monitoring of the components of abilities in chemistry during the study process could significantly improve the content of education.

(5) Reveal, in the long term, the detailed mechanism of functioning of the neural networks responsible for chemical thinking, based on the use of advanced physical methods of brain activity studies, e.g., magnetic resonance imaging.

Clearly, the success of the research work along these lines is impossible without the involvement of both professional psychologists and professional chemists.

CONCLUSIONS

The main outcome of the above-described research work consists in that it provided a fairly convincing evidence for objective existence of special abilities in chemistry.

Kits of test techniques were developed for diagnosing all the components of abilities in chemistry. These kits are suitable for testing schoolchildren, from 6-graders to graduates, as well as students of chemistry-, chemical engineering-, and chemical pedagogy-oriented higher education institutions. The testing result should be treated as a recommendation (rather than a directive or a verdict), helpful for identifying weaknesses in the psychological portrait of a respondent and, thereby, purposefully making the necessary adjustments.

It is a well-known fact that, currently, natural sciences-related professions, particularly chemical profession, enjoy lesser popularity than prestigious professions such as that of a lawyer, economist, manager, etc., whose job market, however, has already reached saturation. It is not easy for freshly baked specialists in sales, marketing, and advertising to find a well-paid job. Moreover, as industrial revival and economy growth will be taking place, there will be an increasing demand for engineers, technicians, and skilled workers. In this situation, school graduates whose abilities still remain to be identified will have to choose a particular engineering and technical or natural sciences-related specialty. To this category of young people, the techniques for diagnosing the abilities, described in this study, will be helpful.

To conclude, the techniques discussed here were validated by a research dedicated to the fate of the "reference" chemists who were tested in 1982 and showed a high level of abilities at that time. Over the quarter-century that passed since then, 16 out of 18 respondents have defended their doctoral dissertations and are now successfully engaged in scientific activities in Russia and abroad. However, none of them has taken high offices (such as, e.g., those of Academician or Corresponding Member of the Russian Academy of Sciences) or has moved upwards into key administration roles. The reason is that, in the real world, the career success is determined not so much by abilities as by strong motivation, organizational talent, ability to communicate, and adaptability to a changing environment. Therefore, the scientific effectiveness should be differentiated from career achievements.

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