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# The Structure of the Person's Technical Aptitude and Factors of its Development

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## Abstract

The relevance of the study is determined by the increasing role of engineering and technical workers in the socio-economic development of a society. Orientation of school leavers to the choice of engineering professions becomes one of the main tasks of secondary education in the 21st century. The article clarifies the concept of "technical aptitude ", determines its compositional structure, and reveals the main factors of its development. The authors proceed from the assumption that the most technically gifted person is characterized by professionally important qualities of an engineer. The results of the research conducted in Russia with 19 winners and runners-up of the national schoolchildren's Olympiad's regional stage in Handicraft, are presented to determine the main psychological and pedagogical factors in the development of the aptitude. It is shown that a high level of motivation to achieve success in the field of technical creativity plays a decisive role in the development of technically gifted children.

***Key words:*** *engineer, engineering activity, technical talent, technical abilities, technical thinking, motivation to achieve success.*

## Introduction

Recent years in pedagogical science the topic of the need to increase the prestige of an engineer among school leavers is very often discussed. Indeed, the role of engineering and technical workers in the economy of any country is very significant. However, a fairly large number of schoolchildren in Russia still, like twenty years ago, are oriented toward the professions of an economist, a manager and a lawyer (Buchneva & Trufanova, 2016). If we take into account the fact that the opinion of parents and the public has a significant influence on the professional choice of school leavers, we should admit that explanatory work on the prospects for this or that profession in the labor market is currently being conducted in Russian schools still poorly.

The shortage of specialists with professional competencies in the technical and technological sphere is reflected not only at the level of economic development of our country (Korableva et al., 2017a), but also people's ordinary life. It's no secret that finding a good plumber or fitter today is

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a big problem. Elimination of ordinary household technical problems causes people considerable difficulties (Bochkareva et al, 2013; Aminov, 2014; Tesleva & Belkova, 2014). All this is a consequence of the fact that schoolchildren are not motivated to study natural and technical disciplines, and they are not attached to technical creativity.

The school subject "Handicraft" has unique opportunities to form a man-creator, human master, and human worker. This is a very capacious practical and professionally oriented educational subject, aimed both at teaching students to labor operations, methods and elementary actions, and on preparing children for the work planning itself (selecting materials, determining the sequence of operations, selecting tools, calculating the cost price and other). The purpose of technological education is the formation of technological culture (Baytak et al, 2011; Osadchy & Akhmetshin, 2015; Tarman & Kuran, 2015; Il'Yaschenko et al., 2015). Technological culture of a personality is a certain measure of the preparedness of the graduate of the school to the world of professions. Such a culture includes the culture of work, graphic culture, design culture, information culture, entrepreneurial culture, the culture of human relations, ecological culture, home culture, consumer culture, project culture. In the classes on Handicraft, schoolchildren's creative work is organized (the creation of a product on a creative transformative basis), which determines the substantive essence of technological education as a whole.

In order to orient students to the professions that are in demand in the modern world and help them to make the right choice in accordance with their abilities and inclinations to certain activities, teachers should possess not only appropriate methods, but also personal interest in the success of their students (Shkilev et al, 2018; Korableva & Kalimullina, 2016). Teachers of Handicraft, in comparison with other subject teachers, have great opportunities to influence the professional choice of schoolchildren, since it is in the lessons of Handicraft where children try themselves in various activities, thereby revealing certain propensities in themselves. We can speak in this case about the competence of working with gifted children, the formation of which among teachers is considered today to be the most important task in the educational system. Therefore, among the priority areas of the work of Handicraft teachers should be the identification and development of gifted students.

A famous researcher of the phenomenon of the aptitude B.M. Teplov wrote that "aptitude is a qualitatively distinctive combination of abilities on which the possibility of achieving more or less success in performing one or another activity depends" (Teplov, 1982, p. 136). From this definition

it follows that aptitude does not guarantee success in any activity, but only gives " the building material" for its achievement. And if you do not develop aptitude from nature, then after a while you can find that the predisposition to a particular activity will become less presented, and further development of abilities will require considerable investment or even become impossible.

Albert Ziegler focuses our attention on the fact that aptitude is, above all, the ability of a person to achieve perfection in any field of art, professional or scientific activity. However, for the development of aptitude, it is necessary to improve oneself and learn effectively. If a gifted child does not develop his abilities, he will not be able to achieve outstanding results (Merzon et al., 2013).

Rena F. Subotnik, Paula Olszewski-Kubilius, and Frank C. Worrell believe that for the successful development of an individual's aptitude and his realization in a society, not only the high level of the development of certain abilities, but also such qualities of the individual as the willingness to take on strategic risks, the ability to cope with environmental risks and challenges, be able to criticize and positively relate to the constructive criticism, be competitive in the labor market, and have a high cognitive motivation and purposefulness (Savenkov, 2010).

Kurt Heller, author of the so-called "Munich model of the aptitude", considers the aptitude as the individual (cognitive and motivational) personal prerequisites for high achievements in one or more areas (Dimitriadis, 2010).

Albert Ziegler offers the model of aptitude Actiotope, which consists in including a gifted child in the educating environment, which will contribute to the development of his abilities. At the same time, a gifted child will develop only with active interaction with the developing environment. That is, the child must make active efforts to develop his abilities, and the learning environment must create the conditions for this development. Today, only enriched and accelerated educating programs are not enough; it is necessary to develop a system of mentoring and an e-learning program for gifted children (Leana-Tascilar, 2014).

Christos Dimitriadis believes that for mathematically and technically gifted children, special classes should be organized that will work on an enriched program. The researcher points out that "the work that capable or talented students do in the classroom (regular or special group) should not just be " the same work that they have already mastered, or more difficult work, but work different from the standard work for an average child who must prove his thinking skills" (Dimitriadis, 2010).

However, as noted by Vanille William Caldwell, an important component in the organization of the educating environment for a gifted child is the willingness of the teacher to differentiate talented children. In ordinary general education schools, as the authors note in their research, teachers are not ready to use the strategy of differentiated education for gifted children. Therefore, it is very important for children with attributes of the aptitude to be included into a specialized educational environment (Caldwell, 2012).

A.I. Savenkov notes that when conducting diagnostics and analyzing the factors of the aptitude's development, one should focus not only on what the individual does, but also on why he does it, what drives him, what makes him act (Savenkov, 2010).

In psycho-pedagogical science, along with such kinds of the aptitude as graphic, artistic, musical, literary, artistic, leadership, sports and others, they distinguish technical aptitude. Typically, when talking about technical talent, it is about the ability to understand, analyze and simulate technical processes, design and analysis of mechanisms (Korableva et al., 2017b). Children with technical abilities are characterized by technical thinking, high intellectual intellect, interest in technical objects and devices (Merzon et al, 2014).

What specific abilities and qualities of personality can be attributed to the signs of the technical aptitude? The answer, in our opinion, should be sought in the content of those requirements that are imposed on the professional and personal qualities of the engineer.

The concept of "an engineer" first appeared in Italy in the Middle Ages, they called so the gunsmiths and commanders of military vehicles. Today, speaking about an engineer, we mean a specialist with a higher technical education, applying scientific knowledge to solve technical problems, managing the process of creating technical systems, designing, organizing production, introducing scientific and technical innovations into it (Mauch & Tarman, 2016). Recently, attention is also focused on the social and humanitarian component of the profession of an engineer.

The following main categories of engineers are distinguished:

- production worker performs the functions of a technologist, production manager, operation engineer;
- The researcher-developer combines the functions of the inventor, designer and designer, participates in the process of integrating science and production;

- all-round craftsman (or system engineer) is a general engineer, whose tasks are to organize and manage engineering activities and create the main technical systems;
- The engineer in socio-technical design deals with the socio-cultural and anthropological aspects of engineering and its results.

Thus, the main purpose of engineering activity is the intellectual, scientific and technical servicing of the sphere of material production, the development of Handicraft, the provision of scientific and technical progress, the solution based on the scientific, technical and socio-humanitarian knowledge of technical, technological, engineering contradictions, problems and tasks.

From the job profile diagrams of various engineering professions we have chosen the most common and characteristic abilities and personal qualities that must be inherent in the modern engineer.

To the most important abilities of the engineer we have attributed the developed spatial thinking and imagination, logical thinking, technical thinking, ability to design and design, mathematical and analytical abilities, high level of memory development, developed finger motor skills, high level of distribution and switching of attention. Among the personal qualities of an engineer, first of all, one should distinguish creativity, responsibility, accuracy, attentiveness, perseverance, independence.

The structure of the technical aptitude can be revealed through the definition of such abilities as:

- the ability to evaluate and create functional technical systems starting from elementary ones;
- ability to operate with spatial, visual images of technical details and devices;
- development of the logical abilities of the intellect, aimed at processing products of technical creativity to adapt them to the real life situation (Khrustaleva, 2013).

T.M. Crystalyeva's study made it possible to construct the following model of technical aptitude: technical intelligence, technical creativity, activity components of technical aptitude, which include the description of methods of action and methods of solving problems (manual skill, manual dexterity) and specific motivation.

Sheffield in his turn considered mathematically gifted children who, according to the list of characteristics, were similar to those ones of the technical aptitude. In this regard, we would like to we turn our attention to the mathematical abilities. Sheffield highlights the following features of a mathematically gifted child:

1) High level of mathematical thinking (watches mathematics and structure in various situations, organizes and classifies information, has a deep understanding of simple mathematical concepts);
2) a high level of figurative thinking (can generalize the structure of the problem, correlates the quantitative and spatial relations of the subject);
3) mathematical creativity (flexibly processes information, applies original approaches to problem solving);
4) independence and criticality of mathematical thinking (asks "what if ..." when solving a problem, knows how to see and raise a new question, a new problem) (Sheffield, 2003).

Ilana Levenberg, Cahit Shaham, draw our attention to the fact that diversified, enriching and stimulating activities for the development of geometric thinking (spatial perception) should be also organized. For technically gifted children, in order to develop their spatial perception, not only the textbook assignments, but also additional exercises and tasks that promote the development of logical thinking when operating with images of objects should be used. Children with signs of technical aptitude should not only know the definitions of geometric figures, but also be able to develop, create problems in geometry (Levenberg & Shaham, 2014).

## Method

In order to clarify the main factors affecting the formation of technical talent of schoolchildren, we conducted our empirical study. As a sample of the study, we took 19 students of 9-11$^{th}$ grades who participated in the final stage of the All-Russian Olympiad of Schoolchildren in Handicraft in the 2016/2017 school year.

In the process of empirical research, we used the following diagnostic tools: Yu.M. Orlov's test "Motivation to achieve success", I.S. Yakimanskaya's test "Spatial thinking", a test for Torren's creativity, a technique for assessing intellectual lability.

## Findings

In the process of investigating spatial thinking, we obtained the following results: 47% of students have a high level of development of spatial thinking, 53% of students are intermediate. Therefore, summarizing the results of the sample, we can say that the level of development of spatial thinking among the subjects is above the average one.

Children who are keen on Handicraft can easily create spatial images and operate them in the process of solving various practical and theoretical problems, as well as creating new images, their modification and transformation on different visual basis. The subjects are well able to distinguish the spatial dependencies inherent in objects, to understand the geometric features of static objects, that is, what distinguishes one object from another: shape, magnitude, spatial relationship of parts and whole, the length of objects, position on the plane and in space.

At the second stage, schoolchildren were tested for intellectual lability. We obtained the following results: 18% of the subjects have a high level of intellectual lability, 54% of those participating in the study have an average level of intellectual lability, and 28% have a low level of intellectual lability. Analyzing the results of the study, one can come to the conclusion that the children participating in the final stage of the All-Russian Olympiad of schoolchildren in Handicraft are dominated by the average level of intellectual lability. For students with an average level of intellectual lability, it is not difficult to switch from one activity to another, they spend a small amount of time absorbing new information, or they quickly catch the content of the required task. Taking into account the peculiarity of modern reality, when a person has to process a huge amount of information in a short time (and in the sphere of high-tech industrial production there is a rapid increase in the speed of information and technical processes), it should be noted that rapid orientation in space and time is a rather important quality of the personality of the modern , a successful man (Merzon, Sterz & Panfilov, 2013).

However, it should be noted that not always quick decision making is qualitative and effective. On the contrary, sometimes it is precisely the careful and unhurried reflection of problems that characterizes a gifted person.

In addition, the dynamic characteristics of the course of mental processes, including attention, is influenced by the type of human temperament. Perhaps 28% of children who received poor results in terms of intellectual lability are phlegmatic or melancholic temperaments that affect the slowing down of the speed of mental processes, in our case, attention. In this regard, it would be incorrect on our part to suggest that the high level of intellectual lability is directly influenced by the technical talent of the individual, since we would exclude from the number of technically gifted those children who have melancholic and phlegmatic type of temperament. Also, when carrying out the correlation analysis, we did not find a statistically reliable relationship between the indices of development of spatial thinking and intellectual lability. However, a statistically moderate

reliable relationship was obtained ($r = 0.37$ for $p \geq 0.01$) between the level of development of spatial thinking and creativity. Therefore, it can be settled that the higher the level of creativity, creative imagination is, the easier it is for a person to operate with various spatial images and create new images on a visual basis. Creativity makes it possible for a person to look at the same subject from different points of view, to produce various ideas, to represent a variety of solutions to certain situations.

In the process of studying the motivation for achieving success, we obtained the following results: in 22% of the diagnosed students there was an increased level of achievement motivation, in 78% of the participants in the study - the average level of development of the motivation for achieving success. Therefore, for the majority of students who participated in the study, it is typical to show perseverance in achieving the goal, while performing interesting activities for them, they are trying to achieve high results. They have a certain need for creating new products, improving the way they work with different equipment.

At the end of the Olympiad, we conducted a comparative analysis of the differences in the indices of the development of spatial thinking, intellectual lability and creativity, depending on the achievement by the participants of significant results (winner or runners-up) at the final stage of All-Russian Olympiad of schoolchildren in Handicraft (Table 1).

As we can see from the indicators of this table, 50% of the students, who were among the winners and runners-up of All-Russian Olympiad of schoolchildren in Handicraft, found a low level of intellectual lability. Only 12.5% of schoolchildren among the runners-up have a high level of intellectual lability, and students who have not won prizes, a low level of intellectual lability is not observed, and 25% of them have a high level of development of intellectual lability. The statistical analysis of Student's t-criterion showed that there are statistically significant differences between the samples of winners, winners of the Olympiad and students who did not take prizes in terms of the level of development of intellectual lability ($t = 2.86$ for $p \geq 0.01$).

Consequently, this fact once again vividly confirms the earlier assumption that the level of development of intellectual lability is not the main indicator of the development of the technical aptitude of the individual.

**Table 1**

*Indicators of the development of spatial thinking, intellectual lability and motivation to achieve success, depending on the achievements of students in the final stage of All-Russian Schoolchildren's Olympiad in Handicraft*

| Indicator | Winners, levels | | | Runners-up, levels | | | Participants who did not win prizes, levels | | |
|---|---|---|---|---|---|---|---|---|---|
| | High | Medium | Low | High | Medium | Low | High | Medium | Low |
| Motivation to achieve success | 50% | 50% | 0% | 25% | 75% | 0% | 0% | 100% | 0% |
| Intelligent lability | 0% | 100% | 0% | 2,5% | 37,5 | 50% | 25% | 75 | 0 % |
| Spatial thinking | 0 | 100% | 0% | 25% | 100% | 0 % | 75% | 25% | 0% |

## Discussion

. Analyzing the data in Table 1, we can conclude that an important role in achieving success in any field, including participation in subject Olympiads, is played by motivation. If we look at the sample of winners and runners-up, among the winners, 50% have a high level of development of motivation to achieve success and 25% of schoolchildren from among runners-up have a high level of motivation to achieve success. Among the participants who did not win prizes, a high level of motivation for success is lacking, and despite the fact that 75% of them have a high level of spatial thinking (students who are winners do not have a high level of spatial thinking, only the average level of development (100%)), they were not included in the number of winners and runners-up. Statistical analysis by Student's t-test showed that there are statistically significant differences between the samples of winners and runners-up of the Olympiad and students who did not win prizes in terms of the level of development of achievement motivation ($t = 2.95$ for $p \geq 0.01$).

## Conclusion

Thus, the key role in the development of technical aptitude is played by motivation, desire and interest to be engaged by technical creativity, the need to create new products and in achieving meaningful, better results than other people. The presence and high level of development of such abilities as spatial thinking, technical intelligence and intellectual lability in the absence of motivation are not always a guarantee of the realization of a person's technical aptitude.

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