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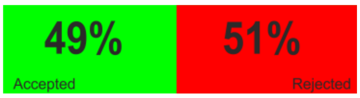

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Almir Anfirovich Miniakhmetov
Askino Secondary School №1
Headmaster's assistant, Teacher of
Physics, Computer Science and
Information Technologies
Republic of Bashkor tostan,
Russian Federation
minalmir@yandex.ru

Gulnaz Fardatovna Akhmadullina
Askino Secondary School №1
Teacher of Russian and Literature,
Republic of Bashkortostan,
Russian Federation
gulamolod@mail.ru

Elena Leonidovna Khanzhina
Askino Secondary School №1
Teacher of Russian and Literature,
Republic of Bashkortostan,
Russian Federation
elena-71hel@mail.ru

Tatyana Anatolyevna Shcherbinina
Askino Secondary School №1
Teacher of Russian and Literature,
Republic of Bashkortostan,
Russian Federation
tatjanascherb08@mail.ru

Elvira Galeevna Lutfullina
Askino Secondary School №1
Teacher of Russian and Literature,
Teacher of Bashkir and Literature,
Republic of Bashkortostan,
Russian Federation
elvira2015@yandex.ru

THEORETICAL AND METHODOLOGICAL TECHNIQUES FOR STUDYING THE REFLECTION OF THE NATIONAL MENTALITY IN PHRASEOLOGISTS OF THE RUSSIAN AND BASHKIR LANGUAGES (ON THE BASIS OF «GROWTH POINTS» ASKINO SECONDARY SCHOOL №1 REPUBLIC OF BASHKORTOSTAN)

***Abstract**: The article examines the character of the Russian and Bashkir people, their mentality, and their close mutual influence on each other. The connection is shown through phraseological units as an integral component of the Russian and Bashkir languages. The characteristic features of the national character of the Russian and Bashkir peoples are revealed precisely through the prism of phraseological units. A detailed analysis of a large number of literary sources on this topic was carried out. This article can be used as not only additional theoretical, but also practical material on working on phraseological units. The given phraseological units and figurative (catchphrase) expressions will help to better prepare secondary school graduates for the Main State Exam (9th grade) and the Unified State Exam (11th grade). The article reveals the national culture of peoples, their material and spiritual values. The equivalent phraseological units of the Russian and Bashkir languages when used in speech are presented. On the basis of a general education organization, sociological surveys and questionnaires were conducted among middle (grades 5-9) and senior (grades 10-11) students in order to determine the degree of awareness of schoolchildren about phraseological units that reflect the national character of both cultures. The work is of great theoretical and practical importance for university teachers, secondary school teachers, students and graduates for preparing for exams. The work takes into account the Federal State Educational Standards of the new generation when compiling lessons on this topic. The scientific article was written within the framework of "Growth Points", a structural unit of a rural secondary school within the framework of the "Modern School" for digital, natural science and humanities profiles.*

***Key words**: education, upbringing, rural educational institution, Growth point, modern school, final essay, Unified state exam, Main state exam, Russian language, literature, Bashkir language, Federal state educational standards, mentality, character, phraseological units, picture of the world, spiritual life, questionnaire, survey, vocabulary, grammar, semantics, concept, culture, jargon, tracing paper, synthesis, analysis.*

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Introduction

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It is believed that the fate of the country is closely connected with the mentality and character of the people. They mutually influence each other. Therefore, when thinking about the further history of the country, it is impossible not to take into account the color of the national character of its people, the value systems inherent in them, cultural and mental characteristics [1].

And phraseological units are special units of language that store the wisdom, feelings and emotions of the people, their moods, and assessment of the world around them. The history of the country is reflected in phraseological turns.

To us, a group of proactive subject teachers of Russian language and literature, Bashkir language and literature, the task of identifying typical features of the national character of the Russian and Bashkir peoples, embodied in phraseological units, seemed interesting.

To answer these and other questions, we decided to conduct our own theoretical research and comparative analysis of the relationship between the Russian and Bashkir peoples from the position of phraseological units on the basis of *"Points of Growth"* Askino Secondary School №1 Republic of Bashkortostan [2].

2. Purpose of the study.

In this regard, the *purpose* of the study of this work is to identify the features of the reflection of the national mentality in the linguistic picture of the world on the basis of Russian and Bashkir phraseological units. The *relevance* of addressing this topic is determined by increased interest in the problems of the linguistic picture of the world and increased attention to phraseological units from the point of view of science, because, in our opinion, it is always necessary to study language.

We identified the following *tasks* for ourselves, which we solved during the writing of the entire article:

(1) Identify the essence of concepts – the linguistic picture of the world and mentality;

(2) Highlight the main features of the mentality of the Russian and Bashkir peoples;

(3) Try to find how these main features are reflected in vocabulary and phraseological units.

The *object* of study is the spiritual life of the Russian and Bashkir peoples.

The *subject* of the study is the mentality of the Russian and Bashkir peoples, viewed through the prism of their phraseological units.

We have put forward a *hypothesis* that there really are features of the reflection of the national mentality in the linguistic picture of the world based on Russian and Bashkir phraseological units.

As a brief overview of the *literature* and *sources* when working on the chosen topic, we began by getting acquainted with leading scientific articles, dissertations, monographs of Russian and Bashkir linguists. In their works they explain what the concept of a linguistic picture of the world and national character means in both language groups. Some of the dissertations we studied discuss the mentality of the Bashkir’s, based on their literary creativity, as well as their close relationship with the Russian people.

The research *methods* are the study and analysis of literature, questioning, generalization and systematization of material. The work uses elements of systemic and comparative analysis, the method of ascent from the abstract to the concrete.

The *practical significance* of the study lies in the fact that theoretical and practical material on working on phraseological units is summarized and brought into the system.

The *scientific novelty* lies in the fact that we made an attempt to understand the mentality of the Bashkir and Russian peoples, based on their phraseological turns.

3. General concepts about phraseology, mentality, worldview, national culture of the Russian and Bashkir peoples.

As is known from the Russian and Bashkir languages [3], phraseological units are living witnesses of the past, knowledge of them enriches our mind, makes it possible to better comprehend the language, and use it more consciously.

Understanding set expressions, as well as their correct use in speech, is considered one of the indicators of perfect speech skills and a high level of linguistic culture. The richer a person’s vocabulary, the more interesting and vividly he express his thoughts. But, for some reason, even in our time, what phraseological units are is an open question.

According to the Soviet encyclopedia [4], a phraseological unit is a stable combination of words, which is characterized by a constant lexical composition, grammatical structure and a meaning known to native speakers of a given language (in most cases, figurative) that cannot be deduced from the meaning of the constituent phraseological components. This meaning is reproduced in speech in accordance with historically established norms of use.

On the other hand, the study of phraseological material in the world's languages suggests that there is a close connection between phraseological semantics, national mentality and national culture [5].

By definition in [6], mentality is a combination of soul, spirit, mind as a connection between the genitive case and the adjective suffix in a word, which means a mindset, a set of mental, emotional, cultural characteristics, value orientations and attitudes inherent in a social or ethnic group, nation, people, nationality.

By national culture we understand the material and spiritual values created by the people, and by national mentality we mean the totality of the characteristics of the psychology and thinking of the people [7].

Of course, all three of these concepts (phraseologies, mentality, and national culture) turn out to be quite complex and ambiguous. At first glance, it seems that there is nothing unusual either in phraseological semantics, or in the national mentality, or in the national culture.

However, analyzing specific phraseological units [8], you understand that this is far from the case. Thus, phraseological semantics has been identified with lexical semantics for a long time. The term lexical meaning was usually used in relation to phraseological units. As for the national mentality, universal human characteristics are often presented as national ones. It is very difficult, within the framework of cognitive studies (brain studies) that are fashionable today, to quite objectively determine, based on the analysis of linguistic material, the features that truly constitute the national character of a particular people.

Often, something inherent in many related peoples is presented as national. The phraseological system of a language at the conceptual level contains the names of cultural realities, which allows us to talk about the direct participation of national culture in phrase formation.

Summarizing the last three sources of the cited literature, we can say that any phraseological unit is one way or another, connected with national culture. However, a special place in the system of national phraseology is occupied by units associated with mythology, religion, cuisine, music, the environment, the names of historical figures, literary heroes, and so on. In the semantic structure of such phraseological units, the connection between the actual phraseological meaning and the concept that can be conventionally designated as cultural is clearly visible.

Bashkir and Russian languages belong to different language groups [9]. The Russian language belongs to the Slavic branch of the Indo-European family of languages, and the Bashkir language (in the Bashkir language *"bashkort tele"*) is a Turkic language, the national language of the Bashkir’s. It belongs to the Volga-Kypchak subgroup, the Kypchak group, of the Turkic family of languages.

Finally, the concept of a picture of the world is a fundamental concept that reflects the relationship between man and the surrounding world [10]. According to the author of this source, language reflects the national specific vision of the world. Of particular interest to science are those aspects of language that reflect the person himself.

A natural question arises: what is national character? First of all, according to [11], this is a set of the most significant features by which one can distinguish a representative of one nation from another. Each nation has its own character, different from others.

The development of national consciousness influences the shape of the worldview and the formation of the culture of each nation. Integration of people is possible only when there is mutual penetration into the spiritual worlds of some peoples into others, that is, a common system of worldviews is needed, which can be based on a component of cultures.

In this regard, it seems necessary to turn to the cultural part of the vocabulary – to phraseological units of the Russian and Bashkir languages. Mastering phraseological material in different languages activates intercultural communication and contributes to the formation of a tolerant linguistic personality.

4. Basic values and mentality traits of the Russian and Bashkir people.

The main basic components of the mentality of the Bashkir people [12] are metaphysical, social, psychological, which in turn are based on the following values:

(1) Freedom placed above any other good;

(2) The prevalence of sensory knowledge over rational knowledge;

(3) The pursuit of justice and equality in all aspects of manifestation.

The most characteristic features of the mentality of the Bashkir people are hospitality and generosity, belligerence and serenity, modesty and simplicity, tolerance and pride, straightforwardness and the desire for competition. The following points are considered to be the basis, reasons for the emergence and development of the peculiarities of the mentality of the Bashkir people: surrounding nature, nomadic way of life, originality of national thinking, pre-Islamic religious beliefs and Islam.

Features of the Russian mentality [13], reflected in phraseological turns, and are:

(1) Humility, renunciation or rebellion in the name of justice;

(2) Pity – cruelty;

(3) Kindness, gentleness – *"it's better not to fall under the hot hand"*;

(4) Despotism – freedom, self-praise, humanity, tolerance;

(5) Sloppiness, laziness – the ability to work with dedication – *"tirelessly"*;

(6) Religiosity – atheism;

(7) The desire to *"check if it's weak"*, the desire to refute a lot of things *"we ourselves know"* – a calculation *"at chance"*, faith in a miracle and the presence of ingenuity.

Thus, making a micro conclusion, we can assert that the definition of the mentality of the Russian and Bashkir people is a holistic spiritual attitude. At the same time, we highlight a feature of the Russian mentality as the duality of consciousness.

5. A brief history of phraseological units in the languages of Russian and Bashkir peoples.

All phraseological units of the Russian language [14] can be divided by origin into two groups: phraseological units of Russian origin and borrowed phraseological units. The vast majority of phraseological units are of original Russian origin. The main source of Russian phraseology are free phrases, which, as a result of figurative use, are subject to phraseologization: *"to wash dirty linen in public"*, *"to make a mess"*, *"to go with the flow"*, *"to cast a fishing rod"*, *"to cover up your tracks"*, *"to reel in fishing rods"*.

Russian phraseology in its composition goes back to various spheres of life and human labor activity. The most important source of its replenishment is everyday speech: *"turn shafts"*, *"chase dogs"*, *"tell fortunes with beans"*.

The source of replenishment of phraseological units is the professional speech of artisans, hunters and other representatives of the profession: *"cut like a nut"*, *"without a hitch"* (from the speech of joiners and carpenters); *"to baffle"* (from the speech of the railway workers); *"to give up"*, *"to drop anchor"*, *"to take in tow"*, *"to run aground"* (from the speech of sailors) and so on.

In literary phraseology there are phrases that come from various jargons: *"to climb into a bubble"*, *"to take it to the gun"*, *"not to kick it in the tooth"* and so on.

A constant source of replenishment of Russian phraseology are works of oral folk art: *"the fairy tale about the white bull"* – endless repetition of the same thing; *"under King Gorokh"* – a very long time ago; *"Lisa Patrikeevna"* – a very cunning person; *"Koschey Immortal"* – a very thin and scary person; from works of fiction – *"stigma in fluff"*; *"with feeling, with sense, with arrangement"*; *"to grandfather's village"*; *"at a broken through"*.

Many phraseological phrases arose on the basis of Russian proverbs: *"you can't go around a crooked horse"* – *"you can't go around a rogue on crooked horse"*; *"water off a duck's back"* – *"trouble falls like water off a duck's back"*; *"you swim shallowly"* – *"swim shallowly, touch the bottom"*.

The phraseological system of the Russian language is constantly enriched, developed, improved and at the expense of its own (phraseological) resources. Their component composition, semantics, environment, context may change, new variants and phraseological units are formed: *"stand at the stern"* – stand at the helm; *"take note"* – take a pencil; *"to tear a skin"* – to tear three skins; *"measure by your own yardstick"* – measure by your yardstick; *"soar in the empyrean"* – fly in the clouds; *"feed with breakfast"* – feed with promises.

Each craft in Russian territories left its mark, each new profession gave its own phraseological units. The phraseological vocabulary is also being replenished due to the author's phraseological units. Often these units come from other languages.

The sources for replenishing the composition of phraseological units in the Bashkir language [15] are different compared to Russian phraseology. The Bashkir language also distinguishes between native and borrowed phraseological units. According to the time of their origin, primordial phraseological units are divided into three layers:

(1) Common to Mongolian languages (the most ancient);

(2) Common to Turkic languages;

(3) Actually Bashkir.

Phraseologisms reflect various aspects of the life of the people, their customs and morals: *"kuz teyeu"* – jinx, evil eye; *"ak yul"* – good luck; *"yyly tenende tuzhyn"* – wear for health; *"Allah haklahyn"* – God forbid and others.

As for the borrowed phraseological units, they are mainly tracings from the Russian language: *"hyuzan koro sygyu"* – get out of the water unscathed; *"hai yozou"* – shallow swim and others.

In interlinguas equivalents, there are exotic variants when one language has a folklore image, but another does not: *"you won't find anything with fire during the day"* (Russian version) – *"et menen ezlehen de taba almashyn"* (Bashkir version), which literally translates as *"you can't find it even with a dog"*, this is how they say *"about a missing person"*.

As you can see, in the Bashkir phraseological unit, unlike the Russian one, there is an image of a dog: *"with grief in half"* (Russian version) – *"et belehe menen"* (Bashkir version), which literally translates to *"dog with grief"*.

Here is another option in both languages: *"to tear (beat) like Sidorov's goat"* (Russian version) – *"ber kat tirehen tunau"* (Bashkir version), which literally translates as *"tear one part of the skin"* in the meaning of *"cruelly, mercilessly flog, flog, beat someone"*.

Drawing another micro conclusion, we can assert that from these examples it is clear that each language is dominated by its own, actually national – native Russian and native Bashkir – phraseological units. This is precisely what explains the discrepancy between the structure and lexical composition of most phraseological units of the Russian and Bashkir languages.

As for semantic equivalence in the absence of structural and lexical similarity of many phraseological units in two languages, this is explained by the similarity of the worldview of different peoples and the specificity of how it is reflected in their languages.

6. Sources of original Russian and Bashkir phraseological units.

When describing different thematic groups of phraseological units in each language, we wanted to show, along with the universal human elements of the linguistic picture of the world, specific, national features. Let's turn to phraseological units.

Among the Bashkir's, the main occupation was associated with cattle breeding; the presence of livestock in a person was considered a sign of wealth and well-being: *"mal maldy taba"* (Bashkir version) – *"wealth increases wealth"* (Russian version); *"maldy tota bel, ashty yota bel"* (Bashkir version) – *"know how to keep cattle and consume food"* (Russian version); *"maly barzyn, nazy bar"* (Bashkir version) – *"he who has cattle has joy"* (Russian version); *"mal (donya) artynan kyuyu"* (Bashkir version) – *"try to get rich"* (Russian version).

There are a lot of phraseological units with the word dog. A dog for a horseman is a friend, a symbol of a faithful guard, an assistant in cattle breeding: *"ethez kuyan totolmai"* (Bashkir version) – *"you can't catch a hare without a dog"* (Russian version); *"et ashamas"* (Bashkir version) – *"and the dog won't eat"* (Russian version); *"et botkohoz"*, *"et bashyna erket tugelgen"*, *"et tubygynan"* (Bashkir versions) – there is a lot of meaning; *"et beylehen, torgohoz"* (Bashkir version) – meaning very cold.

Both peoples have a very serious description of the image of a hard (dog) life: *"et konon kureu"*, *"et kononde yasheu"* (Bashkir versions) – *"see a dog's life"*, *"live like a dog"* (Russian versions); *"et tirehen bitene kaplau"* (Bashkir version) – *"cover the face with a dog skin"* (Russian version).

There are phraseological units in the Bashkir language with the component dog (*"et"*, from the Bashkir language) in a negative meaning: *"et (bure) azygy"*; *"et algyhyz"* (Bashkir versions) – literally means bad, worn out; *"et koikahy"* (Bashkir version) – literally means humiliating, insulting; *"et koirogonan toz bulyu"* (Bashkir version) – literally means to pretend to be too fair; *"et auyzyna agas tygyp yorou"* (Bashkir version) – literally means to idle; *"etlek iteu"* (Bashkir version) – literally means to scold, scold; *"et hugyryu"* (Bashkir version) – literally means to spend time idly; *"et ashamas"* (Bashkir version) – literally means very bad, unscrupulous; *"et oror, bure yoror"* (Bashkir version) – literally means *"the dog barks – the wind carries"* (Russian version).

The lifestyle also leaves its mark on the choice of dishes and national cuisine. The symbol of wealth and well-being of the Russian family is bread. Let's consider phraseological units for Russian and Bashkir variants of manifestation in speech: *"bread and salt"* (Russian version) – *"mailagan keuek"* (Bashkir version), which literally means *"butter and honey"*, meaning without hindrance, without difficulties and complications; *"may esendege (esendə yozgen) boyor keuek"* (Bashkir version) – literally means very good, *"rolling like cheese in butter"* (Russian version); *"bal da may"* (Bashkir version) – which literally means *"honey and butter"* (Russian version).

Each nation has its own traditions and customs for each member of society. A lot of Russian phraseological units are associated with signs, witchcraft: *"tell fortunes on beans"*, *"evil eye"*, *"water off a duck's back"*, *"stand on your left foot"*, *"lay out the cards"*, *"black cat"*, *"vicious circle"* and other. Hospitality is honored in the Bashkir language: *"khozay kunagi"* (Bashkir version) – *"God's guest"* (Russian version); *"kunak kureu"* (Bashkir version) – which literally means *"to be invited"* (Russian version); *"kunak kurheteu"* (Bashkir version) – *"show the guest"* (Russian version).

In the Bashkir language, customs and traditions are associated with Muslim society, a woman is a keeper of the hearth, a mother and a teacher of children: *"yakshy katyn – donya totkahy"* (Bashkir version), which literally means *"a good wife is the support of the house"* (Russian version).

Linguocultural analysis of phraseological units [16] of the Russian and Bashkir languages makes it possible to conclude that phraseological units of both languages are rich in cultural meaning; they reflect the cultural and national traditions of the peoples. For example, in Russian and Bashkir phraseological units, a person represents a part of reality, universal human values, which are a criterion for behavior and relationships between people of different nationalities.

But at the same time, we clearly highlight and note the differences associated primarily with the specific national mentality, with the characteristics of the Christian and Muslim religions. Most of the Russian and Bashkir phraseological units are associated with life, customs, and traditions, namely:

(1) Ancient customs of punishing criminals: *"shorten the tongue"* (Russian version) – a type of punishment for insults and insolence; *"it is written on the forehead"* (Russian version) – they branded criminals;

(2) Details of Russian and Bashkir life: *"washing dirty linen in public"* (Russian version) – talk about quarrels occurring between close people; *"kalgan eshke kar yaua"* (Bashkir version) – *"snow falls for the remaining work"*; *"the remaining work will never be completed"* (Russian versions);

(3) Appearance, clothing: *"walk as a trump card"* (Russian version) – walk important, with pride, with self-esteem. In Ancient Russ, boyars, unlike commoners, sewed to the collar of their ceremonial caftan a collar embroidered with silver, gold and pearls, which was called a *"trump card"*, which stuck out impressively, giving the boyars a proud posture;

(4) Ancient Russian and Bashkir measures of length: *"altylagy – altmyshta"* (Bashkir version) – *"that which is at six and at sixty"* (Russian version), which literally means *"character is formed from childhood"* (Russian version); *"forty forties"* (Russian version) – a large number, a lot of something, according to one version they counted sable skins, according to another – this is what they said about a large number of churches;

(5) Education: *"starting with the basics"* (Russian version) – starting with the simplest, from the very beginning, from the very basics. The fact is that the first letter in the Old Russian alphabet was called *"Az"*, hence the meaning of the phraseological unit;

(6) Traditional crafts and work: *"to carry water"* (Russian version) – to burden someone with extremely difficult and humiliating work, to mercilessly exploit someone, taking advantage of his flexible character; *"not sewn with bast"* (Russian version) – originally meant *"not simple"* (Russian version), later *"not such a simpleton"* (Russian version). The phrase was formed on the basis of ideas about weaving from bast; products and shoes made from bast were considered a sign of poverty and peasant origin.

Thus, we show that almost every craft in Russ left its mark in phraseology. Let us give additional examples from life, taking into account the transfer of meaning in phrases of the Russian and Bashkir versions: *"two boots of a pair"* (Russian version) – which among shoemakers literally means identical; *"to reel in fishing rods"* (Russian version) – which among hunters and fishermen literally means to leave hastily; *"cast a fishing rod"* (Russian version) – which among hunters and fishermen literally means to carefully find out something; *"to cover up tracks"* (Russian version) – which among hunters and fishermen literally means to hide something; *"to play first violin"* (Russian version) – which among musicians literally means to excel; *"to drop anchor"*, *"at full sail"*, *"to run aground"* (Russian versions) – which for sailors literally means to settle, quickly, to get into an extremely difficult situation.

At the same time, we do not forget that phraseological units also came from folk tales, epics, oral folk art, and from other sources of folk life.

You can also observe that for a Russian person *"a dog is a friend of man"* (Russian version), and for the Bashkir's a dog is an assistant in cattle breeding.

The Bashkir's have led a nomadic lifestyle for centuries, therefore, in Bashkir phraseological units, the free wind is highly valued – a symbol of freedom and strength: *"elge osorou"* (Bashkir version) – which literally means *"to let it go with the wind"* (Russian version); *"bekhetsezge el karshi"* (Bashkir version) – which literally means *"the unfortunate man has the wind in his face"* (Russian version).

Each nation has its own specific trades and crafts. For a Russian person, this is carpentry, the manufacture of wood products: *"sharpen woodwork"*, *"peel off like sticky wood"* (Russian versions). Among the Bashkir's, this is beekeeping: *"umarta korto"* (Bashkir version) – which literally means *"working bee"* (Russian version); *"ere kort"* (Bashkir version) – which literally means *"drone"* (Russian version).

Making another micro conclusion, we can again assert that the phraseological units of the Bashkir language are equivalent in some cases, and in other cases there is an absence of Russian phraseological unit's correlative with the Bashkir in meaning.

This means that we can conclude that exactly those figurative expressions that are associated with cultural and national standards, stereotypes, and which, when used in speech, reproduce the mentality characteristic of a particular linguocultural community are fixed and phraseologies in the language.

7. Sources of borrowed Russian and Bashkir phraseological units.

Stable combinations, catchphrases that came into the Russian and Bashkir languages from other languages are borrowed phraseological units. Here we highlight borrowings from Slavic languages, which are phraseological units of the Old Church Slavonic language.

Old Slavonic phraseological units [17] were firmly entrenched in the Russian language after the introduction of Christianity; most of them originate from books and the Holy Scriptures as well.

Basically they are of a bookish nature: *"a proverb"*, *"seek and ye shall find"* (Old Russian versions) and others. These phraseological units most often represent expressions taken from biblical and evangelical texts translated into Old Church Slavonic: *"by the sweat of your brow"* (Old Russian version) – which literally means *"to work very hard"* (Russian version); *"forbidden fruit"* (Old Russian version) – which literally means *"about something tempting, but forbidden"* (Russian version); *"stumbling block"* (Old Russian version) – which literally means hindrance, difficulty; *"holy of holies"* (Old Russian version) – which literally means *"the most dear and cherished"* (Russian version); *"daily bread"* (Old Russian version) – which literally means *"that which is necessary for existence"* (Russian version); *"promised land"*, *"poor in spirit"*, *"do not make yourself an idol"* (Old Russian versions) and others.

As for borrowed phraseological units in the Bashkir language, they are mainly tracings from the Russian language: *"akkosh yiry"* (Bashkir version) – *"swan song"* (Russian version); *"berense karlugastar"* (Bashkir version) – *"first swallows"* (Russian version); *"urtak tel tabyu"* (Bashkir version) – *"find a common language"* (Russian version).

Concluding the next point of our research, we can assert that phraseological units are the concentration of folk wisdom and linguistic flair. Many phraseological units familiar to us reflect the traditions, customs, and beliefs of the Russian and Bashkir people. Since ancient times, these languages have preserved many words and expressions that we easily, without thinking, use in conversation, but often we do not even know about their origin and true meaning, and yet their history is interesting and instructive.

8. The meaning and use of Russian and Bashkir phraseological units.

For the correct, timely and decorative use of phraseological units, it is necessary to have a good knowledge of the meaning and image that underlies it. Almost all phraseological units arose initially to designate specific events, facts and phenomena.

For various reasons, these figurative expressions gradually began to be used to refer to other situations, sometimes in a figurative sense, and not even always similar to the original versions.

Based on the work [18], we can determine that all phraseological units can be conditionally divided into several subgroups:

(1) Figurative expressions reflecting folk customs and beliefs;

(2) Phraseologisms related to the history of a particular people;

(3) Stable combinations of words that arose from various crafts;

(4) Catchphrases.

One of the famous expressions *"holy simplicity"* (Russian version) literally means a naive, simple-minded, trusting person. As a rule, it is pronounced in the exclamatory form *"Oh, holy simplicity!"* (Russian version), surprised at someone's gullibility and naivety, bordering on stupidity.

The expression *"grated kalach"* (Russian version) literally means a person who has a very rich life experience. To prepare high-quality kalach (wheat bread), bakers had to rub the dough on ice with their bare hands for a very long time and diligently to improve its properties, which is where the proverb *"do not grate, do not wrinkle, and there will be no kalach"* (Russian version) came from. From here we conclude that a person who has not passed the tests of life cannot be a full-fledged person.

The expression *"one's own hand is the ruler"* (Russian version) literally means the ability to freely, in unlimited quantities, carry out something. This is a well-known and generally accepted version of the expression in the Russian language, a colloquial term about people who have power and the ability to dispose of something at their own discretion.

The following expression *"get it out of the ground"* (Russian version) literally means get it out, no matter the cost. There were times when people simply had nowhere to store money or hide it from prying eyes. It was then that the peasants buried their savings, although not large ones, underground. And when the master demanded to pay the tax, and the peasant said that there was nothing, then the master answered: *"Get it out of the ground, but give it back"* (Old Russian version).

We especially highlight and show the connection between the Russian and Bashkir languages in that the origin of many phraseological units is closely connected with the historical past of the people.

The expression *"Between two fires"* (Russian version) – *"ike ut arahynda"* (Bashkir version), which literally means a difficult situation when danger or trouble threatens from two sides. We believe that this expression comes from the custom in the Golden Horde of leading Russian princes to the khan between burning fires, for the purpose of consecration and purification.

A very strong expression *"went through fire, water and copper pipes"* (Russian version) – literally means and shows a person who is no longer afraid of anything, because he has gone through many trials, overcome and already knows everything. We assume that the expression arose in its full form (*"fire and water"* were previously in the Old Russian version), most likely in wartime – the Patriotic War of 1812. And *"copper pipes"* are seen here as a test of glory, but there is also a second meaning of this phraseological unit with a saying – *"like wine"*, associated with the process of preparing bread wine (moonshine). In the process of preparing Russian moonshine, fire, water, and copper pipes are involved.

The expression *"to shelve a matter"* (Russian version) is a phraseological unit known to many, literally meaning to postpone some matter indefinitely, for a long time, to delay the resolution of any issue. But there is no consensus on the origin of this phraseological unit. According to one version, the *"deposit box"* is the place where the will is kept, that is, to put on the back burner literally means to remove the document (will) for an indefinite period of time (until the time of death).

In the Russian and Bashkir languages there are many stable combinations of words that arose from various crafts and work activities.

The expression *"like a squirrel in a wheel"* (Russian version) literally means a lot of busyness, constant worries and troubles. This phrase took root from Ivan Andreevich Krylov's fable *"The Squirrel"* (1832), in which the running of a squirrel on a wheel in a cage demonstrates the activity of a person [19], who *"busts about, rushes about, breaks out of his skin, but everything doesn't move forward, like a squirrel." in the wheel"* (Russian version).

Well-known expressions: *"golden hands"* (Russian version) – *"altyn kullar"* (Bashkir version) literally means the ability to reach the heights of excellence in some matter, to be the best in the profession; and *"jack of all trades"* (Russian version) – literally means the ability to do any job that one takes on. In Old Russian, gold has always been considered the most valuable and expensive material. And good workers were also valued always and everywhere. That is why among Russians and Bashkir's the word *"golden"* gives the formative expression the meaning of something best, valuable – the best workers are worth their weight in gold.

Let's look at another expression *"to beat your thumbs"* (Russian version) – literally means idle pastime, idleness, laziness. In the old days, the blanks necessary for the further manufacture of dishes were called baklushi and they were entrusted to apprentices to make them, and this was considered the easiest thing, trivial, not requiring special skill.

Or another expression *"to pour bullets"* (Russian version) – literally means to lie boastfully, to tell something implausible. A superstitious custom in ancient times for the sake of success in metal casting involved inventing and telling all sorts of fables. Therefore, the original expression *"to pour guns"* (Old Russian version) began to mean: to lie and invent. The inventor and writer began to be called *"gunner"*. And later the expression *"cast bullets"* or *"cast a bullet"* (Russian versions) appeared.

In relation to representatives of high positions and positions held, there is also an expression *"you are heavy, Monomakh's hat!"* (Old Russian version), literally means the weight of power, responsibility, unpleasant, burdensome obligations. The expression was first used in the tragedy of Alexander Sergeevich Pushkin "Boris Godunov" (1825). In fact, Monomakh's cap is a crown, a symbol of royal power, with which the Moscow kings were crowned on the throne.

Finally, the last expression in this block of the article, *"out of a molehill"* (Old Russian version) – literally means to unreasonably exaggerate something. The expression came from antiquity, from the pen of the Greek satirist Lucian of Samosata in his work *"Praise of the Fly"* (circa 2nd century AD). Today, the origin of this expression is clearly understood. Fly and elephant are in this case antonyms, opposing words. A tiny fly – and a gigantic elephant. Between them there is a *"huge distance"* (Russian version). It's impossible to make a molehill out of a molehill: there won't be enough *"material"*.

Making a micro-conclusion on the current block of our article, we believe that all phraseological units, as a rule, have an interesting, fascinating history of origin. Customs, beliefs and traditions have become the basis for some figurative expressions that are still popular and interesting.

9. Identification of the degree of awareness of Russian and Bashkir phraseological units.

In order to most accurately identify the degree of awareness of modern rural schoolchildren about phraseological units that reflect the national character, we conducted a sociological survey [20]. About half a thousand middle (5-9) and senior (10-11) students from our school took part in the survey.

Students were asked a questionnaire consisting of four questions:

(1) Do you know what phraseological units are?

(2) Do you think there is a connection between history and language?

(3) Do you agree that phraseological units reflect the Russian and Bashkir national character?

(4) Give examples of phraseological units that reflect the character of modern man.

During the survey, we set and solved the following tasks:

(1) Ask the students surveyed the questions presented above;

(2) Conduct a full and detailed analysis of the responses received;

(3) Conduct a synthesis of the results obtained;

(4) Draw a conclusion.

The presented results of our surveys and questionnaires are relevant, since all the work was carried out at the beginning of the fourth quarter of the 2023-2024 academic years. Here we provide a detailed analysis of the surveys conducted.

Having conducted a survey among students of our school about their knowledge of phraseological units reflecting national character, we received the following results: 80% of the students surveyed have a fairly good idea of what phraseological units are and can define this word; 20% were not able to show their knowledge of the subject about phraseological units at all. However, after we said the definition, almost all the students said that they still knew what it was and could even give examples, but did not think that it was called that.

Similar to the first proportion of responses received, 80% of the students surveyed agreed with the existence of a connection between the history of a people, their language and character. At the same time, the remaining 20% of respondents did not see any connection at all.

Finally, 60% of students agreed with the statement that phraseological units reflect the national character of the Bashkir and Russian peoples. The remaining 40% of students surveyed simply doubted their statements, which is tantamount to a negative answer.

The most interesting and succinct answers turned out to be to the last question – to give examples of phraseological units that reflect the character of a person, where different options were given, the respondents answered quite variedly, but most often the following phraseological units were heard, which we divided into separate groups.

Group 1. *"Industriousness and talent"*: *"The master's work is afraid"*; *"Skillful fingers"*; *"Rolling up my sleeves"*; *"Small, but daring"*; *"Grab Stars from the Sky"* (Russian versions).

Group 2. *"Laziness and parasitism"*: *"Be careful"*; *"Pound water in a mortar"* (Russian versions).

Group 3. *"Strength, love of freedom, courage"*: *"Good fellow"*; *"Free Bird"* (Russian versions).

Group 4. *"Breadth of the Russian and Bashkir soul, generosity, hospitality, kindness"*: *"Soul wide open"*; *"Holy simplicity"* (Russian versions); *"Kunak kureu"* (Bashkir version) – *"To be invited"* (Russian version); *"Kunak kurheteu"* (Bashkir version) – *"Show the guest"* (Russian version).

Group 5. *"Patience and Fortitude"*: *"Iron Will"*; *"Take the bull by the horns"*; *"Turning Inside Out"* (Russian versions).

We make the last micro conclusion in our work. After conducting a survey and finding out the most frequently used phraseological units by students, we concluded that those phraseological units that, although rarely, are used in the speech of modern schoolchildren, occupy a very small share of what exists in the Russian and Bashkir languages.

For the most part, students know expressions about human labor (in various forms) and a fairly small percentage – about character and strong-willed qualities.

The result of this survey indicates that modern schoolchildren and young people practically do not know, and therefore do not use phraseological units for the beauty and imagery of speech, both written and oral.

Phraseologisms, which so accurately and accurately reflect the history, morals, and customs of our people, are little used and forgotten, which cannot but disturb true lovers of their native language, in particular the Russian and Bashkir languages.

10. Conclusion. We believe and affirm that the goal of this work has been fully achieved. The hypothesis we proposed at the beginning of the article, that there really are features of the reflection of the national mentality in the linguistic picture of the world based on Russian and Bashkir phraseological units, was completely confirmed.

As we have shown and proved, the phraseological units of the Bashkir language are equivalent in some cases, and in other cases there is an absence of Russian phraseological unit's correlative with the Bashkir in their meaning. This means that we can conclude that exactly those figurative expressions that are associated with stereotypes and which, when used in speech, reproduce the mentality characteristic of a particular linguocultural community are fixed in the language.

The Russian and Bashkir linguistic picture of the world, of course, mainly reflects universal human traits determined by the unity of the material world as an object of knowledge. At the same time, the Russian and Bashkir peoples developed their own idea of the world, their own norms of behavior, assessments, traditions and customs, determined by the way of life of the people, their national psychology, and culture. This needs to be appreciated and protected.

Based on the enormous work we have done, we consider the following to be the result:

(1) Students of a regular rural secondary school receive new knowledge about how the national mentality is reflected in phraseological units.

(2) Students of an ordinary rural secondary school are convinced of the expressiveness of phraseological turns, seeing in them how accurately and vividly the character of the Russian and Bashkir people is expressed.

(3) Students of a regular rural secondary school get acquainted with new stories of the origin of Russian and Bashkir phraseological units.

(4) Every student of an ordinary rural secondary school is imbued with a feeling of gratitude, pride and respect for the Russian and Bashkir peoples, who have lived side by side peacefully for many centuries in the territory of our region.

The practical significance and application of the work is also important and necessary. We propose to use the article and material collected on the topic for the scientific and pedagogical community in extracurricular activities in middle and high school.

The material of this work can be used as additional material in Russian language and literature lessons, in extracurricular activities, in conversations, in class hours dedicated to the beauty of native languages, Russian and Bashkir.

The collected material allows us to better understand the Russian and Bashkir people. Whatever he wants to store in his memory is expressed and stored in language. Mastering phraseological material in different languages activates intercultural communication and contributes to the formation of a tolerant linguistic personality.

It is important to note that all the material we offer allows teachers to better prepare current lessons taking into account the Federal State Educational Standards of the new generation, as well as secondary school graduates for the Main State Exam (9th grade) and the Unified State Exam (11th grade).

We want the invaluable experience captured and stored in language to be passed on from generation to generation. And our task is to preserve and pass on this experience to our descendants, to the future generation as much as possible.

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Issue Article

Daria Dmitrievna Danilova
Peter the Great St.Petersburg Polytechnic University
Bachelor

Oleg Yurievich Sabinin
Peter the Great St.Petersburg Polytechnic University
Candidate of Engineering Sciences, Docent

DATA ANALYSIS AND VISUALIZATION OF SIMILAR PRODUCTS

Abstract*: This paper presents the continuation of the development of a system for collecting and searching for similar products in various online stores. A visualization system for the analyzed data is also implemented.*

Key words*: data marts, SQL queries, visualization, Python, Streamlit.*
Language*: Russian*
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Scopus ASCC*: 1701.*

АНАЛИЗ И ВИЗУАЛИЗАЦИЯ ДАННЫХ ПОХОЖИХ ТОВАРОВ

Аннотация*: В данной статье представлено продолжение разработки системы сбора и поиска похожих товаров в различных онлайн магазинах. Также реализована система визуализации анализируемых данных.*

Ключевые слова*: витрины данных, SQL запросы, визуализация, Python, Streamlit.*

Введение

На сайтах магазинов, маркетплейсов или агрегаторов скидок на товары часто есть раздел с похожими товарами, но они не предоставляют информацию об изменении цен и скидок на них и соответственно не визуализируют эти данные. В данной статье предлагается проанализировать похожие товары и визуализировать результаты.

Система сбора и поиска похожих товаров представлена в докладе на международной научно-практической конференции «Инжиниринг и прикладные науки: новые технологии, инновационные решения» (TEEAS 2024) с последующей публикацией в сборнике материалов конференции.

Описание хранилища

В реализованной системе для каждого товара подбираются наиболее на него похожие товары на основе текстовых данных: категория, название и описание (состав) товара.

На рис.1 представлен основной слой хранилища, спроектированный по методологии Кимбалла [3; 4, с. 9], в котором хранятся структурированные данные, и слой витрин данных [5]. В таблицах измерений содержатся данные о магазинах, товарах, времени извлечения данных с сайтов онлайн магазинов. В одной таблице фактов содержится информация об изменении цен и скидок на товары, во второй – для каждого продукта массив кортежей из товаров и веса их схожести. Хранилище реализовано в колоночной СУБД ClickHouse [7; 8].

В данной статье витрина данных Mart.SimilarItems дополнена детальной информацией о похожих товарах, и в таблицу Dim.Items добавлено поле status – статус работоспособности ссылки на товар.

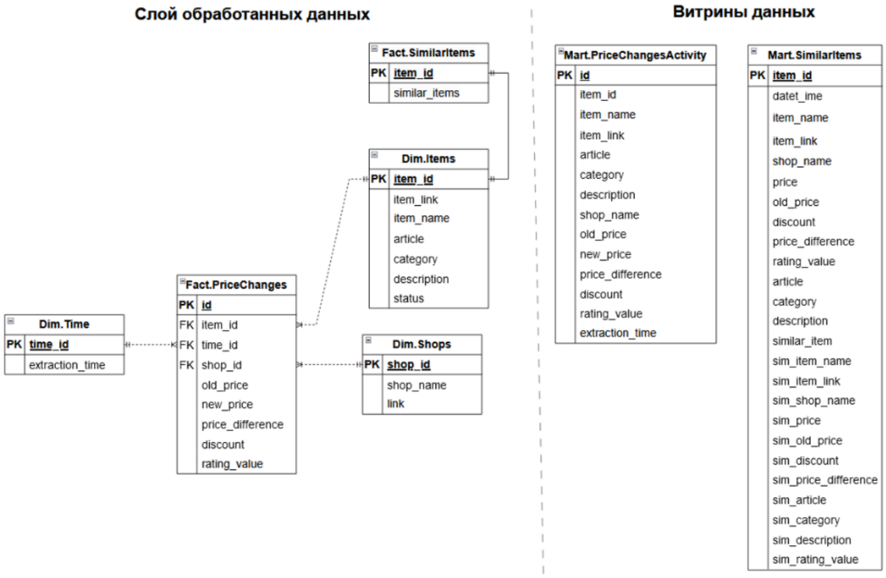

Рисунок 1. Слои хранилища данных.

Анализ цен и скидок похожих товаров

Среди похожих товаров найдем три товара с наибольшим весом похожести, с наибольшей скидкой и с наименьшей ценой. Для этого создадим витрину данных Mart.SimilarItems, которая будет определять такие товары и содержать подробную информацию о каждом из них. Витрина данных будет состоять из денормализованных таблиц фактов, организованных по гораздо более простой схеме по сравнению с хранилищем данных [2, с. 36; 6, с. 298].

Из таблицы изменяемых данных о товарах Fact.PriceChanges необходимо извлечь данные о товарах за текущий день, а именно идентификатор товара, дату извлечения, идентификатор магазина, предыдущую и текущую цены, разницу между ценами, скидку и рейтинг товара. Код SQL запроса приведен на рис.2.

```
CREATE or replace VIEW Mart.SimilarItems AS
WITH
-- извлекаем основные данные о целевом товаре
discounts AS
    (
        SELECT DISTINCT
            item_id,
            toDate(dictGet('Dim.Time', 'extraction_time', time_id)) AS date_time,
            shop_id,
            old_price,
            new_price AS price,
            price_difference,
            discount,
            rating_value
        FROM Fact.PriceChanges
        FINAL
        PREWHERE toDate(dictGet('Dim.Time', 'extraction_time', time_id)) = toDate(now())
    ),
```

Рисунок 2. Код извлечения данных о целевом товаре.

Далее нужно соединить таблицу Fact.SimilarItems с результатом предыдущего запроса по идентификатору целевого товара. Также необходимо извлечь наименование товара, ссылку на него, название магазина, артикул, категорию, состав и похожие товары. Воспользовавшись оконной функцией row_number() [9; 10], в рамках каждого целевого товара пронумеруем строки, отсортированные по весу и по скидке в убывающем порядке и по цене в возрастающем порядке, на рис.3 представлен код SQL запроса.

```
-- извлекаем данные о похожих товарах
    sim_items AS
    (
        SELECT
            item_id,
            similar_items AS similar_item
        FROM Fact.SimilarItems
        FINAL
        LEFT ARRAY JOIN similar_items
    ),
-- вместо идентификаторов указываем название целевого товара, ссылки, магазина
-- артикула, категории, описания, находим самые похожие (с наибольшим весом похожести, с наибольшей скидкой и с наименьшей ценой), используя row_number
    results AS
    (
        SELECT
            date_time,
            si.item_id,
            dictGet('Dim.Items', 'item_name', si.item_id) AS item_name,
            dictGet('Dim.Items', 'item_link', si.item_id) AS item_link,
            dictGet('Dim.Shops', 'shop_name', shop_id) AS shop_name,
            price,
            old_price,
            discount,
            price_difference,
            rating_value,
            dictGet('Dim.Items', 'article', si.item_id) AS article,
            dictGet('Dim.Items', 'category', si.item_id) AS category,
            dictGet('Dim.Items', 'description', si.item_id) AS description,
            similar_item,
            row_number() OVER (PARTITION BY si.item_id ORDER BY si.item_id ASC, similar_item.2 DESC, discount DESC, price ASC) AS rn
        FROM sim_items AS si
        LEFT JOIN discounts AS d ON si.item_id = d.item_id
    )
```

Рисунок 3. Код извлечения данных о похожих товарах.

Чтобы получить изменяемые данные о похожих товарах, нужно выполнить соединение с первым из запросов по полям этих товаров.

Чтобы вывести товары с наибольшим весом похожести, с наибольшей скидкой и с наименьшей ценой, при фильтрации необходимо оставить только строки, где значения оконной функции row_number() равны 1, 2 и 3. Код SQL запроса представлен на рис.4.

```
-- отбираем три самых похожих товара, дополняем основной информацией о похожих товарах
SELECT
    date_time,
    item_id,
    item_name,
    item_link,
    shop_name,
    price,
    old_price,
    discount,
    price_difference,
    rating_value,
    article,
    category,
    description,
    similar_item,
    dictGet('Dim.Items', 'item_name', similar_item.1) AS sim_item_name,
    dictGet('Dim.Items', 'item_link', similar_item.1) AS sim_item_link,
    dictGet('Dim.Shops', 'shop_name', d2.shop_id) AS sim_shop_name,
    d2.price AS sim_price,
    d2.old_price AS sim_old_price,
    d2.discount AS sim_discount,
    d2.price_difference as sim_price_difference,
    dictGet('Dim.Items', 'article', similar_item.1) AS sim_article,
    dictGet('Dim.Items', 'category', similar_item.1) AS sim_category,
    dictGet('Dim.Items', 'description', similar_item.1) AS sim_description,
    d2.rating_value AS sim_rating_value
FROM results
LEFT JOIN discounts AS d2 ON (similar_item.1) = d2.item_id
WHERE rn IN (1, 2, 3)
;
```

Рисунок 4. Код извлечения данных о трех самых похожих товарах.

Задачи и требования к системе визуализации

У магазинов, маркетплейсов и агрегаторов товаров нет визуализации изменений цен и скидок, а также не представлена детальная информация о схожих товарах. Но покупателям эти данные могут оказаться полезными, чтобы представлять, когда следует ожидать скидки на те или иные товары.

Определим следующие задачи для системы визуализации:

A. Отображение минимальной, максимальной и медианной скидки целевого товара.

B. Отображение текущих цены, предыдущей цены и скидки на целевой товар.

C. Построение графиков изменений цены и скидки со временем для целевого товара.

D. Отображение детальной информации о целевом товаре.

E. Отображение детальной информации о похожих товарах на целевой товар.

Среди требований выделим, что все элементы визуализации должны находиться на одной странице и должны иметь названия, также должна быть возможность выбора целевого товара.

Данные из пунктов A и B достаточно представить в виде скалярных значений. Для данных из пункта C необходимо построить два отдельных графика. Данные из пунктов D и E необходимо представить в виде двух различных таблиц.

Построение визуализация данных

Для визуализации выбрана библиотека Streamlit с открытым исходным кодом, она позволяет писать на языке программирования Python. Кроме того, с помощью Streamlit можно размещать различные элементы – графики, наборы данных, скаляры и т.д. – на одной веб-странице [1].

Для начала необходимо создать раскрывающийся список всех ссылок на товары в онлайн магазинах на основе витрины Mart.SimilarItems.

Затем на основе исторических данных витрины Mart.PriceChangesActivity необходимо определить минимальную, максимальную и медианную скидки на товар.

Текущую и предыдущую цены и текущую скидку на товар необходимо определить из данных витрины Mart.SimilarItems.

Графики изменения скидок и цен на целевой товар строятся на основании исторических данных витрины Mart.PriceChangesActivity хранилища. Для обоих графиков выбрана диаграмма рассеяния, поскольку, в случае если данные не будут собираться какое-то время, то на графиках это будет видно. В случае линейного графика пропуск отобразится как изменение цены либо скидки, что приведет к ложным представлениям.

Кроме того, визуализируем детальную информацию о товаре: дата извлечения данных о товаре, название товара, ссылка на товара в онлайн магазине, название магазина, текущая цена, предыдущая цена, скидка, разница в цене, рейтинг товара, артикул, категория товара, описание (состав).

Также визуализируем детальную информацию о похожих товарах: дата извлечения данных о товарах, ссылка на целевой товар, названия схожих товаров, ссылки на схожие товары в онлайн магазинах, названия магазинов, текущие цены, предыдущие цены, скидки, разницы в ценах, рейтинги товаров, артикулы, категории товаров, описания (составы).

Результаты визуализации

Ниже на рис.5 представлена часть веб-страницы для одного из продуктов магазина ВкусВилл с найденными похожими товарами в магазине Перекресток. В верхней части присутствует раскрывающийся список, из которого можно выбрать веб-ссылку целевого товара.

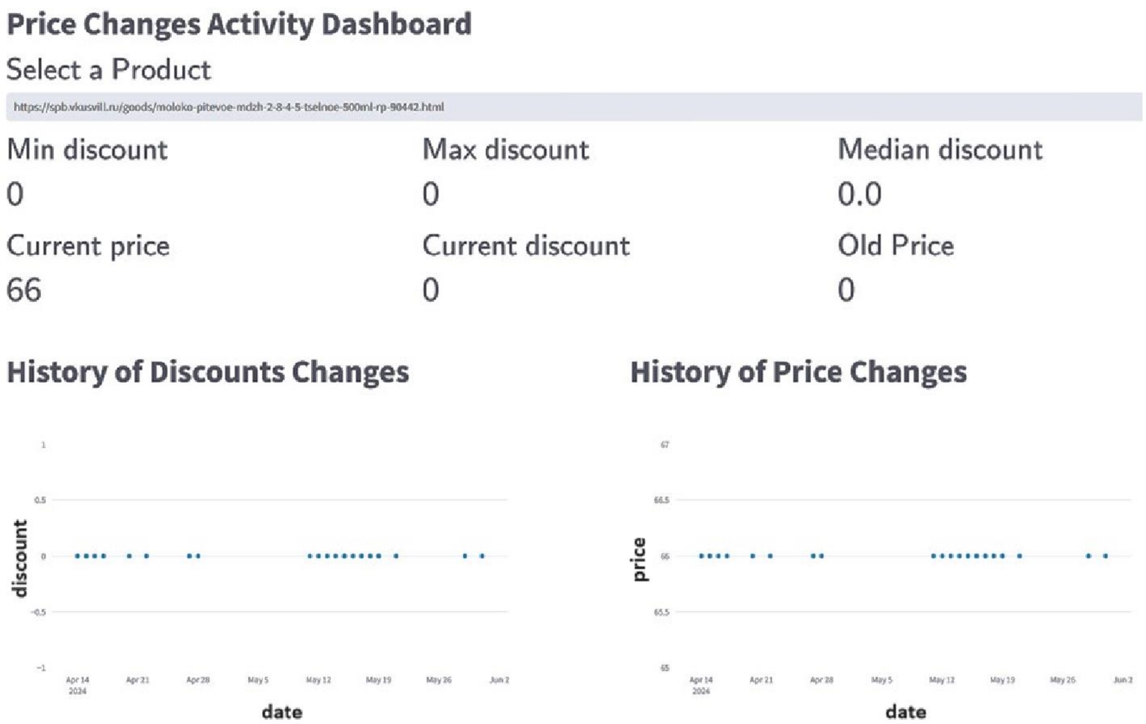

Рисунок 5. Графическое представление информации о цене и скидках на целевой товар.

Далее представлена информация о минимальной, максимальной и медианной скидке. Затем приведена информация о текущих цене и скидке, а также о предыдущей цене на товар. За ними располагаются два графика, на которых можно отслеживать изменения цен и скидок на товар с течением времени.

На рис.6 представлено продолжение визуализации.

В верхней таблице представлена детальная информация о целевом товаре: дата извлечения данных с сайта, название товара, ссылка на него на сайте магазина, название магазина, текущая и предыдущая цены, разница между ценами, рейтинг, категория и описание (состав).

Detailed Data For Product Description

	date	item_name	item_link	shop_name	new_price	old_price	discount	price_difference	rating_value	article	category	description
0	2024-05-31	Молоко питьевое мдж 2,8-4,5% цельное 500мл_РП	https://spb.vkusvill.ru/goods,	Вкусвилл	66	0	0	0	4.7		Молоко, сливки	молоко цельное коровье

Detailed Data For Similar Products

	date	target_item_link	item_name	item_link	shop_name	price	old_price	discount	price_difference	rating_value	article	category	description
0	2024-05-31	https://spb.vkusvill.rı	Молоко Асеньевская Ферма пастеризованное 3.4-6%, 900мл	https://www.perek	Перекрёсток	104	104	0	0	4.9		Молоко	Молоко коровье цельное.
1	2024-05-31	https://spb.vkusvill.rı	Молоко Правильное Молоко пастеризованное 3.2-4%, 2л	https://www.perek	Перекрёсток	219	219	0	0	4.93		Молоко	Цельное молоко.
2	2024-05-31	https://spb.vkusvill.rı	Молоко питьевое топленое 2.5% Зелёная Линия, 900мл	https://www.perek	Перекрёсток	79	79	0	0	4.94		Молоко	Нормализированное молокс

Рисунок 6. Графическое представление данных о товаре и похожих на него товаров-аналогов.

В нижней таблице представлена аналогичная информация, но для товаров-аналогов.

Выводы

В статье представлен инструмент для анализа скидок и цен на похожие товары с помощью построения витрины данных. Также сформулированы задачи и требования к системе визуализации и приведены результаты поиска похожих товаров из магазинов Перекресток и ВкусВилл при помощи разработанной системы.

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Issue **Article**

Artur Aleksandrovich Blagorodov
Institute of Service Sector and Entrepreneurship(branch) DSTU
master's degree
Shakhty, Russia

Marika Vladimirovna Taube
Novosibirsk State University architecture design and arts named after. A.D. Kryachkova
Ph.D., Associate Professor

Natalya Viktorovna Bek
Novosibirsk State University architecture design and arts named after. A.D. Kryachkova
Doctor of Technical Sciences, Professor

Natalya Valerievna Volkova
LLC TsPOSN «Ortomoda»
PhD in Law, Director

Galina Yurievna Volkova
LLC TsPOSN «Ortomoda»
Doctor of Economics, Professor
Moscow, Russia

ON THE EFFECTIVENESS OF THE RELATIONSHIP BETWEEN THE ART OF ENGINEERING AND THE TASKS OF ENGINEERING ACTIVITY WITHIN THE FRAMEWORK OF ITS SYSTEMATIC APPROACH TO INNOVATION

***Abstract**: in the article, the authors, when switching to a two-level training option (bachelor's and master's degrees), focused on preparing masters in technical areas, found that a group of relatively new disciplines has appeared, which, first of all, should include the methodology of scientific creativity, protection of intellectual property, fundamentals of scientific research, technical aesthetics, philosophy and methodology of science. In this regard, the practice of teaching the above training courses, as well as the experience of production and research work convincingly prove not only the need to introduce such subjects into the master's training system, but also the urgent need to understand the relationship of the educational material in question with the practice of engineering and scientific activities, in including publications about these features. Just as in the 19th century blocks of academic disciplines were formed related to the targeted training of specialists in engineering specialties, so now there is a need to form a new block of academic subjects that reflect the needs of innovative development of society. A new block, reflecting the level of development of modern civilization and focused on the humanistic path of its development, is the following group of disciplines: fundamentals of engineering, history of science and technology, philosophy of science and technology, methodology of scientific and technical creativity, protection of intellectual property, technical aesthetics, fundamentals of scientific research. With such an organization of training, one can count on the emergence of graduates of higher educational institutions who master the basics of engineering and are capable of independent innovative activities. In this article, the authors made the first attempt to combine the material necessary for students in preparing the above courses into a single complex called "Fundamentals of Engineering."*

Key words: *masters, bachelors, fundamentals of engineering, higher education institutions, innovative activities, engineering art, functional theory of art, sociological relevance.*

Language: *English*

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Introduction

UDC 001.94:303.17.

The general principles of the main principles of engineering ethics are the support and development by engineers of the purity, honor and dignity of the engineering profession. To do this, engineers must:

Use your knowledge, skills and abilities to increase human well-being.

Serve the public, employers and customers fairly and impartially.

Respect the competence and prestige of the engineering profession.

Uphold the disciplinary standards of professional and technical communities.

Basic canons of engineering ethics

Engineers, in the performance of their professional duties, must place the safety, health and welfare of society above all else.

Engineers must carry out work only within the scope of their competence.

Engineers must respond objectively to public inquiries.

Engineers in their professional field act as loyal representatives or trustees for each employer or customer and must avoid conflict.

Engineers should build their professional reputation on integrity and should not compete unfairly with others.

Engineers should support their own professional development and provide opportunities for professional development to engineers under their supervision.

Typical scenarios of conflict situations.

Situation "Paradox"

The formula of any invention is drawn up in such a way that it considers exclusively the positive aspect. However, each invention, in its internal essence, is based on the resolution (removal) of a technical or social contradiction in its dialectical interpretation and development (this thesis is developed in more detail in the “Theory of Solution of Inventive Problems”). Therefore, in every innovation there are inevitably and then always manifest negative consequences. This provision especially concerns environmental issues. Such situations are observed in all typical technical innovations: an increase in engine power leads to increased environmental pollution; an increase in flight speed leads to the appearance of ozone holes; An increase in the carrying capacity of vehicles leads to the destruction of roads and soil, etc. What should an engineer do? Where are the boundaries of ethical and unethical, moral and immoral technical solutions?

Situation "Good and Evil". We are talking about military inventions. The engineer understands that the invention is aimed at destroying industrial facilities, natural resources, technical means, and enemy manpower. The engineer, as a performer and manager of work, is professionally prepared for this type of activity. However, he lives in the real world and understands that devoting his life to the direct or indirect destruction of other lives is clearly evil.

What should a future engineer do during his training? During the period of designing military equipment? During the period of organizing work and managing other people?

Situation “Spiritless Automation” The issue of new technologies that make it possible to automate production is being discussed. Products put into production give birth to a world devoid of soul, a world that promotes the development of inertia, impersonality, and without spirituality. Panel and block construction of houses gave rise to dull neighborhoods and “gray” residents. Furniture made from particle boards consists of identical walls and tables with sharp, right angles, which respectively affect the human psyche: prickly, sharp angles appear in the behavior of the growing and already grown-up generation.

What should an engineer do? Should we cancel the automation of production processes? How to build both cheaply and beautifully? How can we make sure that things produced in continuous production bring joy to people?

Situation “Internal conflict”

The company has a large order, for example, for the production of an automatic line. However, individual units and components are not sufficiently developed and require improvement. The alternative is this: either a long but reliable way to debug individual units, or a relatively quick production of the entire line at once, for which the customer is already paying a lot of money, which has a beneficial effect on the financial situation of the engineer himself.

What to do? Argue with management, whose prestige depends on the timing of the order? Give information to the customer without informing the management of your company? Silence?

Situation “Innovation is routine”

A typical problem when designing new technology. The device is designed the old fashioned way. Where electronics can be used, mechanics or hydraulics are used. The engineer understands that he needs to take a risk and give the new design a try to break into the market. But management is afraid of failures, inoperability and unreliability and therefore is “pursuing” an outdated, but already proven option.

What should an engineer do? Resign yourself? Conduct research yourself? Looking for sponsors?

Situation “Instant result”

The age-old debate about quality, quantity and cost. There are two options for completing any order. The first is to design and make things that are truly strong, reliable and durable.

The second is to imitate strength, reliability and durability through the use of externally similar materials and design solutions (color, shape, weight, speed, etc.). At the same time, the main attention is paid not to the product itself, but to advertising and packaging. Many companies from the so-called developing countries took this path: the “yellow assembly” version of personal computers, toys from China, etc. What should an engineer working in a company do according to the second option? Don't think about the consequences? Struggle to improve quality? Quit your job?

Situation “Domestic priority” A Russian company offers an organization (possibly state-owned) its own invention for use in the production of products. The invention promises high efficiency and low implementation costs. But the organization is going to negotiate the purchase of similar products in one of the Western countries, for which its representatives are going to travel to this country in the near future. The engineer, who must evaluate the proposal as an expert, is reminded of the priority of developing relations with this country (political aspect) and of the interest of managers in the trip (personal aspect). How should an engineer behave if the effectiveness of a domestic invention is obvious to him?

Situation "Service invention"

An engineer works on an invention during office hours, using office equipment. When he is close to completing the work, he leaves the company and sells the product as his own invention. Perhaps the engineer received a low salary and, moreover, irregularly.

How to evaluate an engineer's behavior from an ethical point of view?

Situation "Choice"

The problem of fairness and reliability in engineering. An engineer works for a government organization that prepares reports on the environmental impacts of projects currently planned by the government. The engineer reports the results of his work to management, after which the manager asks him to change some of the conclusions presented in the report and/or remove some data from it.

What should an engineer do?

Situation "Personal Interest"

The engineer is expected to make an unbiased decision in the best interests of the client, but the engineer has his own interests (related to investment, family relationships, etc.) that may influence the decision. For example, an engineer is expected to help a company decide which product to purchase for the company's needs, and the engineer is the owner (or partner) of a company that offers those products. Should an engineer remove himself from a situation in which he has a conflict of interest? Should the engineer tell the client that self-interest makes him biased?

Situation "Security"

The engineer is concerned about the safety of the project. Events can develop as follows. The engineer reports his concerns to his boss, but the boss is reluctant to take any action and advises him to remain calm. The engineer must decide whether to “sound the siren”, i.e. contact the authorities, the press, etc. At the same time, the employer can treat the engineer very well. How to combine a loyal attitude towards the employer with protecting the interests of society? When should an engineer “sound the siren”?

“Risk” situation (an aggravated version of the “safety” situation)

An engineer must make difficult decisions regarding the degree of risk associated with the equipment he is designing. How to decide on the acceptable level of risk?

Situation “Young specialist” (a specific version of the situation “Innovation - routine”)

The circumstances are such that you have to choose between a traditional and a new solution that promises increased efficiency and reduced costs. The choice, however, should be based only on preliminary testing. The young engineer's boss unexpectedly informs a group of colleagues that the recommendations must be substantiated within two days. At an engineering school, a young employee had the opportunity to research a new device, but now, in production conditions, there is no time for thorough research. Nevertheless, the device is promising. The engineering team agrees with the boss and recommends an old, proven device. The boss instructs a young employee on how to write a report praising an old device and recommending its use. The report should not contain a word about a new alternative. What should an engineer do?

Summarizing the above, it should be noted that against the backdrop of an increase in the number of publications devoted to certain aspects of engineering work, the scarcity of studies in which it would be considered as a spiritual and practical activity becomes noticeable. The creativity of an engineer has not yet been studied deeply enough in the sociological and philosophical literature. Scientific, technical and engineering activities as a cumulative source of technological innovation in a number of important aspects are outside the field of research. Therefore, the need arose not so much to optimize the processes of scientific and technical creativity and scientific and technical activity, but to develop a general concept for the further development of a system for training specialists with higher technical education and a methodology for managing this system. The creation of a new paradigm for the educational process has become not only a pedagogical, technological or environmental problem, but also becomes a philosophical and socio-economic problem, on the successful solution of which scientific and technological progress throughout the country depends. It should be noted that until now the process of both theoretical and practical understanding of the categories “engineering activity”, “engineering thinking”, “scientific and technical creativity” has developed in such a way that its psychological, logical and epistemological aspects have received the greatest development, and general sociological , in essence, have been studied very little, and, as a rule, are in the nature of general recommendations that are difficult to actually implement in the socio-technical activities of an engineer. Therefore, it is natural that the public consciousness is dominated by the idea of scientific, technical and engineering activity as a special kind of spiritual activity, as if divorced from creativity in general and especially from art. Without accepting the limitations of such views, the author came to the conclusion that engineering activity should be considered as a dialectical unity of change in the object and subject of activity, as a constant divergent-convergent process of scientific and technical activity, including its subject, spiritual and organizational components. Engineering activity can be understood and revealed only through a specific historical study of socio-technical and socio-economic processes. Such an analysis makes it possible to understand the inextricable connection between the method of production and scientific and technological progress, scientific and technological progress and culture, the connection between engineering activity and art, with the moral values of a creative person. Modern highly industrialized and largely technocratic society is in dire need of such theoretical works that carry the potential of practicality and make it possible to harmonize the processes of scientific and technical activity with the help of technological innovations. It should also be noted that there has been a sharply increased public need to unite representatives of different scientific disciplines in solving technical problems. This is confirmed by the material incentives Japanese and American firms provide for scientists and engineers to obtain second and third degrees, including the study of foreign languages and non-technical sciences. The real embodiment of this trend is the synector teams in manufacturing performance analysis consulting firms. An example indicating the negative impact of differentiation of sciences is the division of engineering departments of a higher educational institution into departments for equipment and technology in the same branch of production. Such a separation, formally convenient for organizing the educational process and for compiling a range of specialties, led to a deep and long-term mutual alienation of the style of engineering thinking of process engineers and mechanical engineers, as a result of which many unsuccessful and ineffective decisions arose in the design and manufacture of technical objects. Giving universal recommendations for changing the entire system of higher technical education is not a realistic task. This work is only an attempt to fill the “blank spots” that have arisen between the socio-philosophical and subject-technical areas of training in the education system, with the help of concrete sociological and concrete methodological research.

Solving the problems posed in the work is complicated by the fact that during times of crisis many social contradictions appear that are inherent in the existing social system. Therefore, this study does not claim to solve all problems associated with scientific, technical and engineering activities. Considering the multifaceted nature of engineering activity in the light of the onset of a new period in the education system, conditioned by the need to develop students' systems and computer styles of thinking, the author puts forward the following thesis as a basic one: the process of development of natural intelligence should not be identified with the development of increasingly universal artificial intelligence systems, including including computerization. The authors also disagree with the statements that engineering activity will become art only when, on the basis of fully automated and computerized labor, the techniques and methods of scientific and technical technology are combined with artistic creativity. The emergence of value-based approaches to human activity is a long-standing humanistic tradition. Mythology is actually considered the beginning of humanitarian culture. Religion divided the world into material and immaterial (mystical, otherworldly, supernatural), which led to an awareness of the importance of the spiritual in this world, which can also be attributed to humanistic cultural studies. Philosophy develops a rationalistic picture of existence, based on the human mind and scientific achievements. The humanistic orientation of philosophical concepts is expressed in value systems developed by philosophy. As shown in this article, art, including technical art (techne), originating in the springs of myth-making, religious teachings, and philosophy, ultimately led humanity to the development of rationalism, which degenerated in the 20th century into technicism and technocracy. There has been a shift in the value system towards greater satisfaction of human material needs. In the history of its development, humanity has moved further and further away from truly humanistic ideals, moving away from the social-humanistic direction of progress towards scientific and technological progress. Frightened by the results of such a movement, which led to an environmental and moral catastrophe, the world community, at least its leading part, is trying to change the course of human development towards humanization. This process is most important for the education system. In the education system itself - to humanize the process of technical education. Using various sociocultural approaches (social, philosophical, systemic, structural-functional, general systems theory), we tried to formulate a technology paradigm for the formation of engineering thinking associated with the destruction of ideologies of utilitarian-pragmatic goals. We also tried to contribute to the work of streamlining the mass of recommendations, conglomerative in form and eclectic in content,introducing a sociotechnical approach to solving technical problems using NTT and innovative technologies. In contrast to the descriptive (descriptive) method of constructing humanistic concepts adopted in socio-philosophical works, the study proposes a constructive definition of the methodology for moving the system of higher technical education along the path of humanization. To reveal this approach, the present study raised issues of dialectics, ethics and aesthetics as necessary.

Over the past decades, society's requirements for specialists have significantly transformed. In addition to being highly qualified in their field, workers in science, technology, and management must be capable of creative activity and self-improvement. Engineering activity began to have a planetary character, technogenesis became commensurate with natural scales, covering the entire territory of the earth. The humanization of scientific and technological progress to mitigate technocratic blows should be directed primarily towards the humanization of the process of education of engineers. Nowadays, the disciplinary, narrowly subject paradigm of education continues to operate, fostering “chauvinism of special disciplines.” Those who call for a shift in the training of engineers to a paradigm shift, to the introduction of a problem-based method, and the like, are right, in fact. The difficulty of such a transition lies in the fact that there are no simple and quick solutions leading to successful results in education. It is obvious that the transition period requires not only time, but also special techniques. During this period, an understanding should come of how to move from technical knowledge, how to move from technocratic thinking to sociotechnical knowledge, to humanistic thinking.

First of all, the purpose of education must be changed; it is not knowledge itself that is important, but the development of personality with the help of knowledge. Such goal setting requires solving the problem of teaching students creativity and self-improvement. It is not enough to call for internalist activities focused on self-education. Tools for this activity need to be developed. If this is successful, then both the student and the graduate engineer will be able to take advantage of the content and scope of knowledge that is already available in existing educational programs, using this knowledge to humanize technical activities. The stated position is the main goal of this work. It is to achieve this goal that it is shown how, with the help of a sociotechnical approach, using the polyvariance of such concepts as “consumer properties” and “result quality”, one can arrive at a full-fledged creative educational process.

Therefore, in this article, significant attention is paid to the consideration of the transcendental in engineering activities, i.e. such categories as faith, intuition, imagination, fantasy, creativity, “working” for the humanization of engineering thinking. The introduction of such conventional concepts as “efficiency coefficient” is associated with the need for an instrumental and constructive description of innovative processes in engineering activities. The ability to operate with these concepts will enable the engineer not only to adapt to innovation, but also to actively participate in the creative process and master the art of solving real life problems. The tools that the NTT methodology has in its arsenal will help the engineer make the transition from a system of conceptual knowledge to a system of instrumental knowledge, and move on to real creativity.

The search for effective criteria for optimizing engineering activities is a fundamental point to which considerable attention is paid in the study. The anthropological aspect of performance results can be realized with a sufficiently in-depth analysis of the concept of “result quality”. This will help in teaching to move from explanatory and illustrative methods to problem-search methods.

A few words about the semiotic (linguistic) aspect of engineer training. The main operational means of engineering thinking is the ability to express one’s thoughts using symbolic means and understand the meaning of regulatory texts, the form of which can take different forms: diagrams, drawings, specifications, etc. That is why it is necessary to use a large amount of illustrative material, which allows a methodical, step-by-step introduction to the subject of training, who has already learned the language of “technical graphics” from special courses (where, in addition to drawings and diagrams, various formulas can also be included, expressing graphical dependencies in a different symbolic form), to the social and philosophical categories revealed in our research using the language of the constructive and conceptual apparatus of the systems approach. For this reason, we considered it necessary to provide in the appendix a dictionary of concepts, which should form the basis of an engineer's thesaurus and reveal to the learner the main categories of an engineer's humanistic thinking. As we part with the reader, let us draw his attention once again to the fact that in addition to knowledge acquired in a rational way, an engineer, relying on a system of moral values, in real life uses will, emotions, intuition, faith and other irrational components of human activity. Therefore, the strategy of higher technical education should be associated with the growth of the student's self-awareness, with training that performs the function of humanizing the individual.

The authors hope that the material presented in the article will help Russian engineers develop creative abilities, develop a sense of confidence in their knowledge and realize life goals through education and engineering.

Main part

There are quite a few different definitions and various interpretations of the concept of "technology". Their content varies depending on the specifics of the activity that they define and the field of knowledge in relation to which the definition is given. One of the most common and most general approaches can be given in the following interpretation.

A technique is a set of techniques aimed at achieving a goal. Or in another version: technology is a set of techniques aimed at combating the forces of nature and interchanging matter.

A more modern version of the definition is as follows: technology is a set of skills, abilities, techniques and knowledge that allow humanity to use the reserves of raw materials and energy available in nature. The following definition is quite capacious and quite accurate: technology is an activity aimed at satisfying human needs, which leads to changes in the material world.

Variants of definitions used, as a rule, in real production conditions include the following: technology is all the material conditions necessary for the production process to take place. Or: technology is the means of labor developing in the system of social production. There are also options for socio-economic approaches to defining the concept under consideration. Technology is a set of means that, based on a given situation, allows the most satisfactory way to achieve the intended goal; technology is a set of actions of a knowledgeable person aimed at dominating nature; technique is a skill whose methods are external to the goal.

As can be seen from the analysis of the above definitions, the concept of "technique" is based on categories such as art, skill (techne), or master of skill (technicos). If, with a very general consideration of the process of technology development, we can say that technology is based on the use of the laws of nature, then with a more in-depth analysis, we can distinguish two sources of the process of technology development, namely:

use of achievements of natural science;

social basis of technology.

Natural science, while guiding and demonstrating possible solutions to technical issues, does not in itself determine either the direction, volume, or pace of their resolution. It is possible to understand the direction of development of technology only based on the social conditions within which the development of technology takes place. Technology, unlike science, does not develop outside a specific method of production. The economic laws of a given social system, determined by the method of production, help to understand the origins and directions of development of technology. The implementation of innovations and inventions depends to a large extent on economic conditions. Often, inventions remain unrealized due to unfavorable socio-economic conditions.

In passing, we note that to invent means, by working creatively, to create something new, previously unknown. Or in a more academic and technical version of the definition: an invention is a new and significantly different technical solution to a problem that produces a positive effect. To summarize, we can highlight the following features of the development of technology, namely:

technology is directly related to the laws of natural science, and economic phenomena are related to the laws of natural science through technology;

revolutionary transformations in technology (industrial and scientific-technical revolutions) occur through the accumulation of elements of a new quality (innovation processes);

The dynamics of technology development depends on the social (socio-economic) system.

At the same time, the goals of technology development can be divided into two groups:

improvement of technology and production (scientific aspect of development);

improvement of production itself (production aspect of development).

The first group of goals is determined by social life, the second by the technical needs of production.

If the goals of development include social, economic, aesthetic, psychological, political and others, then the motives for the development of technology can include: passion for invention, ambition, ease of labor, improvement of financial situation, domination over others, etc.

Particularly noteworthy is the role of individuals and peoples in the development of technology. The importance of major scientists, inventors and engineers lies in the fact that they, before others, notice the contradictions that arise in production, and, relying on the achievements of modern science and technology, develop solutions that most fully and correctly meet the needs of production and open up prospects for the further development of science and technology. technology. Each nation, depending on specific historical conditions, makes its own contribution to the development of world technology.

Thus, the authors of pioneering inventions in heating engineering were the Russian inventor Ivan Ivanovich Polzunov (1728–1766), the English inventor James Watt (1736–1819), and the French scientist Sadi Carnot (1796–1832). The founders of many achievements in the field of aviation were: German engineer Otto Lilienthal (1848–1896), Russian inventor Alexander Fedorovich Mozhaisky (1825–1890), American aircraft designers and pilots brothers Wilbur Wright (1867–1912) and Orville Wright (1871–1912). The history of technology is a science that studies the general laws of development of productive forces in different periods of the development of human society. Or more specifically, the history of technology is a science that shows the development of the means of labor in the system of social production, both in connection with the forms and methods of labor, and especially in connection with the object (subject) of labor. From the point of view of the natural sciences, the history of technology shows how man is more and more actively and deeply mastering the laws of nature, ensuring a deeper and more versatile use and application of the matter and energy of nature. From a social point of view, the history of technology reveals the social driving forces, the social conditions for the development of technology and shows the role of individual creators of technology. The world surrounding a person consists of nature, society and technology. In relation to natural phenomena, to phenomena of social life and to technical phenomena, the laws of dialectics apply. Dialectics (from the Greek dialektike - the art of conversation, argument) is a theory and method of understanding reality in its development and self-movement, the science of the most general laws of development of nature, society and thinking. The most important categories of dialectics are: contradiction, quality and quantity, chance and necessity, possibility and reality. These categories, as well as the basic laws of dialectics - the unity and struggle of opposites, the transition of quantitative changes into qualitative ones, the negation of the negation - are directly related to the processes associated with the development of invention. At the same time, in the development of technology two types of opposites can be distinguished, namely:

technology and social conditions for its use;

the struggle of opposites in technology itself.

Technology develops at the intersection of natural science and social life. The laws of natural science (physics, chemistry, biology) give an idea of the potential capabilities of technology. The laws of social development determine the very development of technology. For a correct and deep understanding of the processes of technological development, it is necessary to know the laws of development not only of technical (usually applied) sciences, but also the fundamental laws of natural and social (humanitarian) sciences.

As an example, we give the stages of development of metalworking (Table 1).

Table 1. Stages of metalworking development

Stage number	Type of processing	Shape of the processed surface
1	Metal cutting	Processing by point
2	Processing by broaching, rolling	Processing by line
3	Stamp processing	Surface treatment
4	Processing by volume	Crystallization process

The history of technology reveals the connection between technology and science, shows how scientific principles are formed under the influence of practical needs and how science develops technology. Technology can be considered as a set of things and processes united by man into artificially created systems that have the elements and structure necessary for these artificially created systems to function and be used as material means of purposeful human activity (primarily labor and especially production). Table 2 shows the periods of technology development and their chronology associated with the development of European civilization.

Table 2. Periods of technology development

Period No.	Name of the period and its contents	Chronological framework of the period
1	The emergence, development and spread of simple tools of labor in the conditions of the primitive communal method	700–600 thousand BC e. — 4–3 thousand BC e.

	of production	
2	The emergence, development and spread of complex tools of labor under the conditions of the slave-owning mode of production, powered by humans	4–3 thousand BC e. - 4th–5th centuries n. e.
3	The development and spread of complex tools of labor under the conditions of the feudal mode of production, driven by the forces of nature	4th–5th centuries n. e.
4	The emergence of prerequisites for the creation of machinery in manufacturing conditions	14th–15th centuries - end of the 18th century - beginning of the 19th century
5	Distribution of working machines based on the steam engine under the conditions of the capitalist mode of production	end of the 17th century - beginning of the 19th century — 70s of the XIX century.
6	Distribution of a system of machines based on an electric drive under conditions of a monopolistic production method	70s of the XIX century. - beginning of the 20th century
7	The emergence, development and spread of automata and automated machine systems	beginning of the 20th century — 60s of XX century.
8	The emergence, development and dissemination of information technologies	60s of XX century. - beginning of the 21st century.

Along with the biological relationship that man has in common with all living nature, he has a specific type of material interaction with nature - the process of labor. The level of development of tools and means of labor determines the nature of this relationship. The concept of “production” reflects the fact that human labor activity is productive in nature - in the process of labor, things are created that can satisfy one or another human need. People, producing the material goods necessary for life, at the same time produce and reproduce their social relations of production, into which they enter in the labor process. The nature of these relations is determined not by the will and consciousness of people, but by the achieved level and the needs of the development of their material productive forces. Therefore, the concept of production also expresses the fact that labor activity is social in nature and is carried out within the framework of material social relations.

The concept of “method of production” characterizes a historically specific, qualitative definition of production. At the same time, it should be noted that during all periods of technological development there was an accumulation and addition of technical means, many of which took a frozen form (bow, oar, sail, windmill, hammer, etc.). In this sense, some methods of production as technologies exist in our time: manual work on a potter's wheel, transportation of goods on a cart, etc.

A mode of production is a historically determined method of obtaining material goods; unity of productive forces and production relations. The method of production is the basis of any socio-economic formation. The replacement of one method of production by another occurs in a revolutionary way. At the same time, the method of production is the material basis of a socio-economic formation, determining its characteristics, and changes in the method of production determine the development of socio-economic formations, the transition from one function to another. The development of the mode of production is subject to the general sociological law of the correspondence of production relations to the nature and level of productive forces.

Productive forces are a system of subjective (human) and material (technology) elements that carry out “exchange of substances” between society and nature in the process of social production. Productive forces form the leading aspect of the method of production. Each stage of the productive forces corresponds to certain production relations. In the process of their development, productive forces come into conflict with existing production relations. From stimulating forms of development of productive forces, these relations turn into their fetters. If necessary, we will provide a definition of the concept of “labor”. Labor is a purposeful activity of a person, during which he, with the help of tools of labor, influences nature and uses it to create objects necessary to satisfy his needs. The labor process includes labor itself, objects of labor and means of labor. In the process of labor, people enter into production relations.

Production relations are a set of material economic relations between people in the process of social production and the movement of a social product from production to consumer. Production-economic relations differ from production-technical relations in that they express the relations of people through their relations to the means of production, i.e. property relations. Production relations give all social phenomena and society as a whole a historically determined social quality.

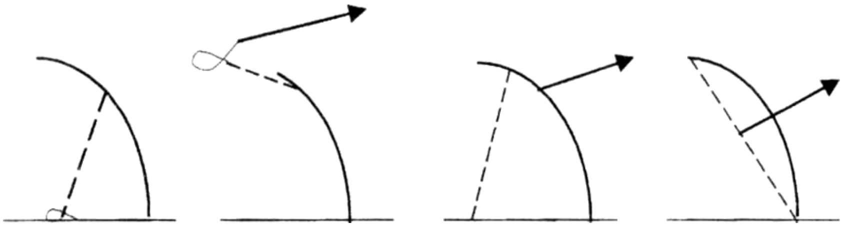
Production relations are the social form of productive forces. Productive forces and production relations together constitute two sides of each mode of production and are connected with each other according to the law of correspondence of production relations to the nature and level of development of the productive forces. As they develop, productive forces outgrow the framework of existing production relations and begin to slow down the further development of production. The contradiction between productive forces and production relations is growing, turning into conflict. It is resolved in a social revolution that destroys outdated and establishes new relations of production corresponding to the developed productive forces. A new method of production is emerging. The primitive communal system is the first socio-economic formation of human society. The main features of this formation are the absence of both classes and the state itself, as well as the absence of exploitation. Inventions in the primitive communal method of production are associated with the emergence and spread of simple tools. The invention of tools meant that an object given by nature (stone, stick, bone, shell) was turned into an organ of human activity.

Labor activity in the production of tools led to the development of productive forces. First, in primitive society, a division of labor by gender and age arose; then there was a social division of labor in two directions: cattle breeding and agriculture. The development of productive forces led to a contradiction between them and production relations. The opportunity arose to obtain a surplus product, and, consequently, to create an individual farm.

Table 3 shows an enlarged diagram of the main stages in the development of technology in the primitive communal system. As a commentary on the most significant inventions of this period, it is necessary to mention the emergence of methods for making fire by friction and drilling, as well as the development of a whole group of various hunting weapons. These include: loops for birds and animals, crossbows, spring traps. The invention of the knot made it possible to create snares and lasso. Groups of houses (the first settlements) with floors and walls coated with clay also appeared. Figure 1 shows the logic of the invention of the bow, from the appearance of a closed structure (Figure 1, a), the possibility of using human organs (Figure 1, b, c) to the possibility of movement in space (Figure 1, d). With the subsequent development of technology, we can observe the transformation of the ideas shown in the figure into a whole series of inventions: flat springs, membranes, springs, spiral springs, etc.

Table 3. The main stages in the development of technology of the primitive communal method of production

Epochs	Time	Types of tools	Technological processing	Dwellings	Branches of the economy	Stages of formation	Stages of technology development
Ancient Paleolithic	800,000 before n. e. — 40 000 BC e.	Hand chopped. Incisors. Bone tools. Pointed points	Upholstery. Receipt plates Application of fire	Caves	Gathering	Herd. The origin of the tribal system	The emergence of simple tools
Late Paleolithic. Mesolithic. Early Neolithic	40,000 before n. e. — 4000 BC e.	Silicon cutters. Bow and arrow. Clay dishes. Axes, knives	Skol. Modeling	Earthlings. Buildings made of piles	Hunting	Matri-arhat. Tribal system	Accumulation of simple tools
Late Neolithic. Chalcolithic	4000 to n. e. — 3000 BC e.	Axes with lugs. Saws. Hoes, sickles. Copper weapon	Grinding. Drilling. Sawing. Spinning. Weaving. Copper hammering	Mud dwellings	Cattle breeding. Hoe farming	Patriarchy. Heyday tribal system	Appearance complex tools labor



A b V G

Figure 1. Scheme of using forces:
a - shaft; b - throwing arrow; c - trap; g - onion

Private property and property arose, which began to lead to the disintegration of the primitive communal system. Thus, technology and various technical inventions contributed to changing the system with the help of a social revolution. Inventions under the slave-owning method of production are associated with the development and spread of complex tools. The production relations of the slave system are characterized by the private ownership of slave owners in the means of production, as well as in the worker himself—the slave. The main feature of the slave-owning mode of production is the exploitation of the slave, who performs the function of a “living thing.”

The development of technology during this period was slow, since production was based on the labor of slaves who were not interested in improving tools and labor processes. The division of labor that arose under the slave system led to its specialization and to changes in the tools of labor. For example, a hammer takes on the following forms: blacksmith's, carpenter's, shoemaker's, stonemason's, etc. The specialization of labor also led to the invention of the plow, mill, presses (for grapes and olives), stamping and etching of metals, soldering, and technology for making sour bread. Conscious attempts arose to replace human power with animal power and natural resources (water and wind power). A class of merchants emerged, which determined a number of new areas of development in technology and production: improvement of roads, creation of means of transportation (wheeled carriage, sailing ship) and containers, luxury goods, money. Military equipment also continued to improve (iron swords, iron armor, fortress walls, siege weapons). A division into mental and physical labor arose. “Professional” inventors appeared - Archimedes (c. 287-212 BC), Heron of Alexandria (c. 1st century), and theorists - Aristotle (384-322 BC), Euclid (3rd century). BC.).

There are many inventions related to the production of metals. The first artificial alloy of copper and tin, bronze, was produced. The so-called Bronze Age began (3 thousand - 1 thousand BC). Mass production of weapons using bronze castings becomes possible. The Iron Age in Europe (first millennium BC) was preceded by the invention of iron in Egypt (2800 BC) and China (2357 BC). The greatest invention was the cheese-making process (using leather bellows) for producing iron. The first blower appeared in Egypt around 1580 BC. e. Surface hardening and welded iron were known in Armenia around 1400 BC. e.

The plow, plow, and iron ax are widely used in agriculture. Various irrigation structures appeared - dams, water-lifting devices (shadufs). Drawer wheels and Archimedean screws could be used as drainage mechanisms. The principles of leverage and counterbalance used in them are now widely implemented in both household and industrial equipment.

The specialization of crafts led to the invention of the potter's wheel; in 4–3 thousand BC e. in the Ancient East, in the 7th century BC. e. in the Northern Black Sea region, in the 9th–10th centuries AD. e. in Central Rus' and Germany. Spindles and looms were also invented, mainly for processing flax.

Major changes were also taking place in the construction industry. During excavations of ancient cities, paved streets, water pipes, and sewers were discovered. In Ancient Babylon there were three defensive walls up to 8 m thick. The Great Wall of China, the construction of which began in the 4th–3rd centuries BC. e., had a length of up to 4000 km and a height of up to 10 m. Arches and vaults were invented. Concrete was invented by the ancient Greeks. For example, the Roman Pantheon had an outer diameter of 43 m, a height of about 22 m, a wall thickness of about 7 m and a cast concrete dome. Brick making began in Egypt (4000 BC). First, wooden and then bronze nails, as well as various blocks for lifting weights, began to be used. Engineer Diad led the siege of Tire (under Alexander the Great) and other cities. He invented and used collapsible siege towers, a drill for drilling walls, and battering rams for destruction. During the siege of the city of Rhodes (304 BC), a siege tower 53 m high on 8 wheels was built. During the siege of Syracuse (213–212 BC), Archimedes built throwing machines as defensive mechanisms that could throw stones and arrows weighing up to 150–200 kg over distances of 500–1000 m.

Means of transportation were also improved. Rollers were widely used to move heavy loads; in 4 thousand BC e. Carts with wheels appeared in India. The wheel with a hub appeared in 2 thousand BC. e., then wheels with spokes and metal axles appeared. Rafts steered by poles were used, and trireme ships appeared with three rows of oars and a crew of 150–200 people. Greek Lithius in 325–320 BC. e. traveled to the Arctic Circle and back through the Strait of Gibraltar to England and Norway.

The needs of production and natural science led to the invention of sun (3rd century BC) and water (Ancient Egypt) clocks. Heron of Alexandria wrote the work "On the Art of Making Automata," which describes how to obtain automatic movement of figures using simple mechanisms using weights, blocks, gears, and levers. He also invented the aeolipile, or "heron's ball," which receives rotational motion with the help of steam. Chemical processes appeared: the preparation of paints, wine, soap; alchemy arose, which existed from the 1st to the 16th centuries. The general conclusion for the period of the slave-owning mode of production may be the following. A transition was made from stone tools to metal ones, as well as to the cultural cultivation of plants, iron smelting was mastered, construction was developed (the formation of cities), military equipment was used mainly for the extraction of slaves. The main motive force was people and animals. Feudal production relations presuppose the feudal lord's full ownership of the land, the means of production, peasants and artisans. It should be noted that the serf peasant, unlike slaves, could have some means of production that were used for his own needs.

Under the feudal mode of production, serious changes occurred associated with the separation of the city from the countryside. In the 11th century there were 86 cities in Rus', in the 12th century another 120 were added, and by the beginning of the 13th century there were already about 250 cities. The average number of inhabitants in a Russian city was 10–20 thousand people, which corresponds to 20–30 houses in a modern microdistrict. In such a large city for that time as London, in the 14th century there were 40 thousand people.

There is a process of uniting artisans into workshops. Guilds are a feudal form of craft organization (the origin of the word craft is "handicraft," i.e., tools powered by humans). At the beginning of the 14th century in Paris there were more than 300 workshops, employing about 5.5 thousand artisans. Inventions in the feudal mode of production are associated with the process of dissemination of complex human-powered tools.

The main inventions and discoveries of this period: an alloy of copper and zinc - brass, a horizontal loom, window glass, the production of paper, glasses, compasses, gunpowder, automatic watches. New industries arose related to book printing, windmills, sailing ships, a plow with an iron share and knife, and a harrow with iron teeth.

The appearance of blast furnaces in Europe in the mid-14th century led to the creation of mountain towns in which artisans lived - miners engaged in mining, producing tools, weapons, jewelry, and minting coins. The first provisions of mining law were developed in the Czech Republic. The first mining law was introduced in 1249 by King Wenceslas for the mountain town of Ihlava. Exploration work was often carried out with the help of a "magic vine". An artisan miner took a fresh birch rod, split its end and, holding the split parts of the rod with both hands, walked through the area. When approaching minerals (ore), the rod should have deflected downwards. This method has been used in Europe for several centuries. The first mention of black powder - an explosive mixture consisting of potassium nitrate, sulfur and charcoal - dates back to 1232 (China). Black gunpowder appeared in Western Europe in the 14th century and was used for about 500 years.

Paper appeared in Europe in the 11th–12th centuries (it was invented in China by Chai Lun in the 2nd century). The main operations in paper production include: cooking paper pulp, such as bamboo or rags or straw, washing and grinding the pulp, casting sheets and drying. Printing from printing boards also first appeared in China in the 9th century AD. e. A print made in this way is now called an engraving. The relief image on the board is covered with paint, after which a sheet of paper is pressed against it. In the 11th century, the Chinese blacksmith Bi-Sheng (Pi-sheng) made letters from clay and fired them. Thus, he was the first in the world to use movable type. In the 13th century, bronze letters were introduced in Korea instead of clay ones. The first person to print from movable type in Europe was Johann Guttenberg (1400–1468). He improved the use of metal typesetting. First, a matrix was made, a lead alloy was poured into it, and a letter was cast. They began to be placed in typesetting cash desks. Around 1440, hand-operated printing presses were developed with a capacity of about 100 impressions per hour. From 1440 to 1500, more than 30 thousand book titles were published, with a circulation of about 300 copies per book. These books were called incunabula. In total there are about 40 thousand titles with a total of approximately 500 thousand copies. In Rus', the founder of book printing was Ivan Fedorov (c. 1510–1583). In 1564, together with his assistant Fyodor Mstislavets, he published the first dated book "Apostle".

Glasses appeared in Europe in the 13th century, in Venice. In the 14th–15th centuries, glass grinding was actively developing, especially in Holland. Following the invention of glasses, the telescope and microscope were invented. The first mention of a compass dates back to the 3rd century BC. e. in China. In Europe, the compass appeared only in the 12th–13th centuries. Alchemy, astrology, magic, and the cabalistics of numbers became widespread in the field of natural science. The German chemist and physician Joachim Becher (1635–1682), speaking about this period, wrote: "Eight things the learned and the inquisitive sought tirelessly to find, namely: the philosopher's stone, the elixir of long life, glass softening agents, eternal light, the hyperbole of concave glass, degree of longitude, perpetual motion, squaring a circle" (the ancient problem of constructing a square equal in size to a given circle).

The scientist and physician Ibn Sina (Avicenna) (c. 980–1037), who lived in Iran (Central Asia), developed the "Canon of Medicine" in the twenties of the 11th century, which served as a guide for physicians for five centuries. The scientist Abu Reyhan Muhammad ibn Ahmed al-Biruni (973 - ca. 1050), who lived in Khorezm (an ancient state of Central Asia), created the work "Collected Information on the Knowledge of Precious Metals." He also developed a device for determining the specific gravity of minerals.

The main conclusion about the period of the feudal mode of production can be as follows. The growth of technology was slow and was based mainly on the use of hand tools. Karl Marx (1818–1883) wrote about this period: "Feudal relations ceased to correspond to the developed forces of production. They slowed down production. Free competition has taken their place." At first, competition took place between artisans. Then, from among the most wealthy craftsmen, future capitalists grew up. The process of a new social stratification of society began. And the capitalist system requires, namely:

firstly, the presence of a large number of poor or low-income people, legally free, but deprived of the means of production;

secondly, the accumulation in a few hands of the monetary wealth necessary for the creation of capitalist enterprises.

There was a process of initial accumulation of capital, which K. Marx defined as the historical process of separation of the producer from the means of production. This initial period of capitalist production was called simple capitalist cooperation. In handicraft production, large workshops are formed. The need of production processes for a large number of people and a large expenditure of energy necessitated the creation of machines. There are two ways of development, or two forms of development of manufactories, namely:

an association of artisans of different specialties - heterogeneous manufacture (for example, carriage and saddle makers, coppersmiths);

bringing together artisans of the same specialty in one workshop (for example, the production of needles).

You can compare the productivity of different production methods. An ordinary artisan could produce about 20 needles per day. In an 18th-century needle manufacturing factory, 10 workers produced 48 thousand needles per day.

The main features of manufactories include the division of labor, the use of simple tools, improvement, specialization and differentiation of tools. For example, at the ironworks in England (18th century) over 500 types of hammers were used.

The main engine in industry (during this period) was the water wheel. Technical characteristics of such an engine: power up to tens of kilowatts, speed from 1 to 10 rpm, efficiency factor (efficiency) - 0.3–0.5. A comparison of the capabilities of humans, animals and water wheels is shown in Table 4.

Table 4. Performance Comparison

Energy source	Productivity kgf/sec
Human	5.5–9.6
Animals (donkey, bull, horse)	11.2–40
Wheel	131–175

A number of achievements in domestic technology are associated with this historical period. Russian mechanic and inventor A.K. Nartov (1694–1756), who worked in the Artillery Department, invented drilling machines, an optical sight and much more. Russian inventor Ivan Petrovich Kulibin (1735–1818) created a number of original mechanisms; in particular, a clock equal in size to a duck egg and consisting of 427 parts, as well as a tiny automatic theater with moving figures of people and the performance of various melodies. In November 1735, Russian masters father and son Motorina cast the Tsar Bell, installed in the Moscow Kremlin. Its characteristics: weight - 200 tons, height - 6.3 m, diameter 6.9 m, wall thickness from 27 to 40 cm. Cast iron cannonballs appeared in the 15th century, and wheeled carriages for cannons appeared in the 16th century. Smoothbore artillery existed for about 500 years (1350–1850). In 1586, Russian foundries cast the Tsar Cannon, which was also installed in the Moscow Kremlin. Its caliber is 900 mm, barrel length 5.5 m, barrel weight 4 tons, core weight 2 tons, charge weight 480 kg.

There was active development in other areas as well. The English student W. Lee invented the knitting machine in 1589. Clock designs were improved. Sundials have been known since the third millennium BC. e. Mechanical tower clocks appeared in the 13th century; spring portable clock - at the end of the 15th century. The Dutch mechanic, physicist, astronomer

Christiaan Huygens (1629–1695) wrote the book "Pendulum Clocks," which describes the use of an elastic spiral and a balancer. The origin of official invention is associated with the establishment of privileges for inventions. Table 5 shows the chronological sequence of introduction of relevant legislation in various countries.

Table 5. Introduction of privileges for inventions

A country	Year
England	1623
USA	1787
France	1791
Russia	1812
Holland Netherlands	1817
Spain	1820
Austria	1820

In the process of invention, authors encountered many difficulties and even open confrontation. For example, in Holland, the laws of 1623, 1639, 1648 prohibited the use and use of a tape machine (textile production). The inventor was sentenced to life imprisonment. Similar measures have often been used in other countries. And only in the middle of the 18th century these laws were repealed. It is impossible not to mention the most famous scientists and naturalists of this period, who had a tremendous influence on the development of science and technology. First of all, this is the Italian artist, scientist, engineer Leonardo da Vinci (1452–1519). His works are related to mathematics, physics, mechanics, astronomy, geology, botany, anatomy and physiology. He developed design diagrams for a parachute, a helicopter, a tank, lathes and weaving machines, and a printing machine. Leonardo da Vinci wrote: "Iron rusts without finding a use, and the human mind, without finding a use, withers."

Polish astronomer Nicolaus Copernicus (1473–1543), who developed the heliocentric system of the world - a doctrine proving that the Earth is one of the planets rotating around the Sun and its axis. In 1543 he published the book "On the Revolution of the Heavenly Spheres." Italian physicist and astronomer Galileo Galilei (1564–1642) is the founder of mechanics. He performed many practical works related to the study of simple machines, atmospheric pressure, motion in a resistive medium, etc. In 1609–1610, he designed the first microscope with a magnification of up to 300 times.

Many scientists worked fruitfully in the field of natural science. German astronomer Johannes Kepler (1571–1630) discovered the laws of planetary motion. The English mathematician, astronomer, and physicist Isaac Newton (1643–1727) formulated the basic laws of classical mechanics. The German physician and naturalist Philip Paracelsus (1493–1541) contributed to the rapprochement of chemistry and medicine. The naturalist Andreas Vesalius (1514–1564) wrote a book On the Structure of the Human Body. The English scientist William Harvey (1578–1657) discovered blood circulation. The Italian physicist and mathematician Evangelist Torricelli (1608–1647) invented the mercury barometer and discovered the phenomena of atmospheric pressure and vacuum. The German physicist Otto von Guerick (1602–1686) invented an air pump in 1650, created an electric machine, and in 1654 carried out the famous experiment with the Magdeburg hemispheres. The English physicist William Gilbert (1540–1603) in 1602 published the essay "On the Magnet, Magnetic Bodies, and the Great Magnet, the Earth." In fact, this is the first book about electricity. The American scientist Benjamin Franklin (1706–1790) produced electric sparks by flying kites during thunderstorms and thereby proved that lightning is an electrical phenomenon (1752). He also invented the lightning rod and flat capacitor. Mikhail Vasilyevich Lomonosov (1711–1765) is rightfully considered the first Russian natural scientist. He laid the foundations of physical chemistry, formulated the principle of conservation of matter and motion, created a number of optical instruments, and much more. Through the division of labor within production, manufacture simplified many operations, which were reduced to such simple movements that it became possible to replace the worker's hand with a machine. The main engine of manufactories becomes a hydraulic wheel (hydraulic water engine). Two social classes are formed: capitalists and workers. The main feature of this period is the invention and distribution of working machines in industry. This process determines the main signs of the transition from manufacturing to machine production. At the same time, a working machine is understood as the main part of the entire machine as a whole, which directly affects the object of labor and expediently changes its shape. The other two parts of the machine - the engine and the transmission mechanism - exist to power the working machine. The main feature of a capitalist factory, which distinguishes it from manufacture, is the use of machine cooperation. K. Marx distinguished between two types of cooperation of machines, namely:

simple cooperation (for example, a weaving factory includes a homogeneous class of machines);

cooperation of dissimilar machines (completing production with a system of machines).

The Industrial Revolution of this period is associated with the transition from manufacturing production and manufacturing organization to machine technology and the factory system. It is customary to divide the process of the industrial revolution into three stages: the appearance of working machines in textile production, the invention of a universal heat engine (steam engine) and the creation of working machines in mechanical engineering. The beginning of the development of fabric production in England is directly related to the passage by English industrialists (in 1719 through Parliament) of a special law prohibiting the import of Indian cotton fabrics. The chronology of inventions and events in this area, often of a dramatic nature, is as follows. In 1733, the English worker John Kay (1704–1774) invented a mechanical (aircraft) shuttle for a weaving machine. Weaving began to outstrip spinning. The spinners did not have time to serve the weavers. English mechanic James Watt (1736–1819) invented the first working spinning machine. In 1784, he took out a patent for it, and in the eighties of the 18th century, a revolt of weavers against machines arose. John Kay was forced to flee. He died in obscurity. In 1764, weaver James Hargreaves (1720–1778) invented the spinning jenny machine (patent 1770). In 1767, the spinners destroyed all the looms in Hargreaves' house. The inventor of the Jenny died in poverty. However, already in 1788, 20 thousand Hargreaves machines were working in industry. In 1769, a patent for a spinning machine was taken out by Richard Arkwright (1732–1792).

The introduction of steam-powered weaving machines led to the disappearance of a whole layer of workers who worked on handlooms. Of the 860 thousand weavers who worked in England at the beginning of the 19th century on handlooms, in 1834 about 200 thousand remained. Many died of starvation. Between 1780 and 1825, the Luddite movement arose in England (its organizer was the worker John Ludd). Workers destroyed factories and killed engineers and inventors. R. Arkwright was forced to defend factories from the Luddites with weapons in their hands. In 1769, a law was even introduced that made anti-machine speeches punishable by death. At the beginning of the 19th century, the gap between weaving and spinning was overcome. It required the development of other industries, such as bleaching, calico printing and dyeing. During the manufacturing period, the forces of animals, wind and water were widely used. But these energy sources, in addition to their advantages, also had a number of disadvantages. Animals could only be used for certain types of work; the wind is fickle and uncontrollable; Water is not available everywhere and its availability depends on the time of year and weather.

The factory method of production required the creation of a powerful engine, universal in technical application and under human control. Such an engine was supposed to free industry from dependence on natural energy sources, i.e. make it possible to concentrate production anywhere. The history (chronology) of inventions of the steam-atmospheric machine is given below.

The ancient Greek scientist and engineer Archimedes (c. 287–212 BC) invented the steam engine. The first to use steam for propulsion was the Greek Heron of Alexandria (1st century). The Italian Leonardo da Vinci left a description of the steam engine. The French physicist Denis Papin (1647–1714 (1712)) described the steam-atmospheric cycle in 1690 and invented the steam boiler and safety valve. The Englishman T. Savery (1650–1715) took out a patent for a steam pump in 1698, which he called “The Miners' Friend.” The pump could pump out water from a depth of up to 10 m. The Englishman Thomas Newcomen (1663–1729) created a new pump design in 1711. Its power reached 8 horsepower, and it could pump water from a depth of up to 80 m.

Interestingly, Newcomen was unable to obtain a patent for his pump, since Savery's patent was drafted in such a way that it reserved for the inventor any possibility of using water vapor. Therefore, Newcomen and his assistant were forced to make contact with Savery.

Russian inventor Ivan Ivanovich Polzunov (1729–1766) was the first to propose a universal heat engine with two cylinders. This is what he wrote in his report dated April 26, 1763: “In order to achieve this glory (if forces allow) for the Fatherland and for the benefit of the whole people, due to the great knowledge in the use of things that are still very familiar today (following the example of other sciences), to introduce into custom." However, Polzunov did not receive support. He had few funds. In May 1766, at the age of 37, he died of transient consumption. In August 1766, the machine was launched. In 43 days of operation, the machine brought in a profit of about 12 thousand rubles. In November 1766, the boiler leaked. The car was stopped and after a few years it was forgotten.

The Englishman James Watt (1736–1819) began work with Newcomen's atmospheric steam engine in 1764. His main reasoning boiled down to the following. To obtain a strong vacuum under the piston, complete condensation of the steam is necessary, i.e. strong cooling of the cylinder. To avoid loss of steam, it must be released into a hot cylinder. With the existing design, these two conditions cannot be met. In 1769 he took out a patent for a capacitor. Watt was invited to the position of chief mechanic in Soho (near Birmingham in the USA). The plant in Soho received letters from entrepreneurs from various industries with requests to produce machines not only for pumping water. The patent for a double-acting machine - a universal heat engine - was taken out in 1784. The main differences of such a machine were the following, namely:

double-action principle - steam acts on one side or the other of the piston;

a spool is used - steam is supplied to different cavities of the cylinder;

a flywheel is used to level out uneven rotational motion;

Watt's parallelogram was introduced.

The latter requires some explanation. Watt could not use a connecting rod-crank mechanism to obtain rotational motion, since a patent was taken for such a transmission by the Frenchman Picard. Therefore, in 1781 he took out a patent for a new method of converting a rocking motion into a continuous rotational one. K. Marx wrote: “...Watt’s great genius is revealed in the fact that the patent he took in April 1784, giving a description of the steam engine, is portrayed not as an invention only for special purposes, but as a universal engine for large-scale industry...” .

50 years later a steam hammer appeared, and 67 years later (1851) a steam engine for ocean-going steamships was presented at the London Industrial Exhibition. Over time, a contradiction arose between the manual technique of making machines and the need for their production. During the manufacturing period, mechanical engineering did not exist as a branch of industry. Only those inventions could have a revolutionary significance for mechanical engineering, as a result of which the tool would pass from the hands of the worker to the mechanism.

Russian inventor Andrei Konstantinovich Nartov (1693–1756) proposed the design of a lathe with a support. The English mechanic Henry Model (1771–1831) invented the cross slide for a lathe in 1794. With the introduction of the support, the machine began to operate with capabilities unattainable even by the most skillful human hand. With the use of supports, all metalworking machines begin to improve and turn into machines. Revolving, grinding, planing, and milling machines appear. In 1807, Model received a patent for an improved steam engine. At the beginning of the 19th century, he invented a hole-punching machine and designed a micrometric caliper, which he named “Lord Chancellor”. The unusually inventive Model did not bother much about obtaining patents. It happened that he was threatened with a lawsuit by people who stole his inventions and issued patents for themselves.

The precision of machine production began to improve. English machine tool builder Joseph Whitworth Whitworth (1803–1887) invented the first measuring machine in 1851. Measurements using his devices were accurate to 0.01 and 0.001 mm. He also introduced gauges and the very idea of thread standardization. It is no coincidence that England at that time was called the “workshop of the world.” Around 120 BC. e. The Greek poet Antinater of Sidon described the seven wonders of the world. All of them were located in the eastern Mediterranean and made up the following list:

Great Pyramid of Giza.

Hanging Gardens of Babylon.

Temple of Artemis at Ephesus.

Zeus statue in Olympia.

Mausoleum in Halicarnassus.

The Colossus of Rhodes.

Alexandrian lighthouse.

Let us analyze the above-mentioned wonders of antiquity, giving for each of them the corresponding temporal, geographical and technical and economic characteristics.

Great Pyramid of Giza (Pyramid of Cheops) Built for Pharaoh Khufu in 2580 BC. e. The construction site (Giza) is located opposite Cairo, the capital of Egypt. About 100 thousand people participated in the construction, which lasted 20 years. More than 2 million blocks were used, each of which weighed more than 2.5 tons. The side of the base of the pyramid is 230 m, the height is 147 m. The pyramid was built without the use of mortar, the outer blocks are polished white limestone.

Hanging Gardens of Babylon

Built around 600 BC. e. for the wife of Nebuchadnezzar II (605–562 BC) Amytis in the area of the ancient city of Babylon, located on the banks of the Euphrates River south of Baghdad, the capital of modern Iraq. The gardens consisted of rows of terraces with a total maximum height of 40 m and were equipped with an irrigation system.

Temple of Artemis at Ephesus

The last king of the ancient state of Lydia, Croesus (595–546 BC), decided to build a temple in honor of the Moon goddess. The city of Ephesus (currently the territory of Turkey) was chosen as the construction site. The temple was built in 560 BC. e. and consisted of about 120 marble columns up to 20 m high, installed on a foundation platform 131 m long and 79 m wide.

Zeus statue in Olympia

Citizens of the city of Olympia, located in southwestern Greece, decided to build a temple of Zeus, built in 466–456 BC. e., statues of Zeus. The 13 m high statue was erected in 435 BC. e. Ivory plates imitated leather, and gold sheets imitated the god's robe. The throne was inlaid with ebony and precious stones. Subsequently, the statue was transported to Constantinople and burned in Istanbul in 462.

mausoleum in Halicarnassus

The mausoleum was a tomb for King Mausolus (377 (376)–352 BC) and his wife Artemisia. Place of construction - the city of Halicarnassus (currently Bodrum) in Turkey. The mausoleum rose approximately 43 m above the ground. A chariot was installed on top. The time of construction is approximately 350 BC. e.

The Colossus of Rhodes

The decision to build the statue was made by the people of the island of Rhodes, located in the Aegean Sea, in honor of the victory in the battle. The Colossus took about 11 years to build and was completed around 280 BC. e. The material was bronze, the outer surface was covered with bronze plates. The statue was destroyed 50 years later by an earthquake.

Alexandrian lighthouse

In fact, it was the world's first real professional lighthouse. It was erected on the island of Pharos in the Mediterranean Sea, near Alexandria. The lighthouse took about 20 years to build and was completed around 280 BC. e. The total height of the lighthouse was 117 m; a spiral ramp for carts with fuel was built inside. In good weather, the lighthouse was visible at a distance of up to 50 km. The architect Sostratus decided to perpetuate his name. It was carved on a stone under cement with the name of King Ptolemy Philadelphus. In the 14th century, the lighthouse was destroyed by an earthquake.

Wonders of the Middle Ages

The list of structures classified as wonders of the world of the Middle Ages includes unique structures made in the period from 500 to 1500. By analogy with the previous list, we first give a general list of them, and then give a brief description:

Cave of Ten Thousand Buddhas.
Great Zimbabwe.
Angkor Wat.
Krak de Chevalier.
Salisbury Cathedral.
Alhambra.
Tenochtitlan.

Cave of Ten Thousand Buddhas (Wanfodang)

Religious building associated with Chinese Buddhism. Located on the banks of the Yellow River in Eastern China. It is a whole series of caves with a total of about 100 thousand Buddhas. In one of the largest, square-shaped caves, there is a sculpture of a sitting Buddha about 17 m high. In the same cave there are 10 thousand bas-relief figurines of Buddhas. Construction time: 680. Has survived to this day.

Great Zimbabwe

It is a fortress in the form of an ellipse with a wall 250 m long and up to 10 m high. Inside there is a conical tower 9 m high, built without mortar. The material was a mixture of clay and crushed stone - dagi. The fortress was built in Zimbabwe (Africa) around the 8th century and existed until the 17th century. It was discovered by Europeans in 1867.

Angkor Wat

Angkor Wat - the temple of God Vishnu (Hinduism) was built at the beginning of the 12th century in the city of Angkor Thom - the capital of the Khmer Empire, in the north-west of Cambodia. It was a three-story building with towers up to 60 m high. The temple was built by about 5 thousand artisans and 50 thousand workers. The city was destroyed in 1431 and discovered by a French missionary in 1850.

Krak des Chevaliers

The castle was built around 1142 for the crusader knights in Syria on the shores of the Mediterranean Sea at an altitude of 650 m above sea level. The castle has two walls with 13 towers and could accommodate a garrison of up to 2 thousand people with horses and a food supply of up to 5 years. Nevertheless, in 1271, the castle was captured through cunning. Has survived to this day.

Salisbury Cathedral

Located in the city of Salisbury in southern England. Construction time: 1225–1258. Built of stone on a foundation only one meter thick. Below is a natural layer of gravel. The length of the cathedral is 144 m, the height in the middle is 25 m. The height of the tower together with the spire is 123 m (built in 1285–1315). In 1386, a striking clock was installed on the tower, although without a dial. Has survived to this day.

Alhambra

A citadel fortress built by the Muslim Moors for defense in the 8th–9th centuries. Located near the city of Granada in Andalusia, southern Spain. In 1492, Spanish Christians expelled Muslims from the Alhambra. In the XIII-XIV centuries, the fortress was turned into a beautiful palace with 23 towers and 4 gates. The length is about 1 km, the maximum width is 300 m.

Tenochtitlan

The city of Tenochtitlan is the center of the Aztec Empire (Indian hunters). Located in the southern part of modern Mexico City in Mexico. It was built in 1415 and was the largest city of that time with a population of 100 thousand to 500 thousand people, stone houses, temples and palaces. In the center of the city there was a pyramid 30 m high. Tenochtitlan was destroyed by the Spaniards in 1521.

Wonders of the world of our time

In the second half of the 20th century, so many grandiose structures arose on land and on water that it is not possible to describe them even briefly within the framework of this publication. Therefore, from the entire variety of artificial structures, by analogy with previous periods, only seven were selected, the most characteristic of various areas of engineering activity:

Opera House in Sydney.
Channel Tunnel.
Kansai Airport.
Concorde plane.
Aswan Dam.
Sears Tower skyscraper.
Kennedy Space Center.

Opera House in Sydney

In 1950, a competition for the theater project was announced. Construction lasted from 1959 to 1973 in Sydney (Australia) on the bay. The main dimensions of the theater: length 185 m, width 100 m, maximum height 67 m. A distinctive feature is the roof of the theater in the shape of giant sails.

Channel Tunnel

The longest underwater tunnel. Connects the mainland (France) with the island (England). The first proposal to build a tunnel arose in 1802. The tunnel was built in 1987–1994. Its length is more than 50 km at a depth of 45 m below the seabed. The tunnel is divided into 3 sections. There are separate sections for rail and road transport. Traveling through the tunnel takes about 35 minutes, with a maximum speed of 160 km/h.

Kansai Airport

The first airport not built on land. The construction site was Osaka Bay, 5 km from the Japanese island of Honshu. The artificial island for the airport took 5 years to build and was completed in 1994. The island was built at a depth of twenty meters. The following materials were used for backfilling: sand, earth, crushed stone, reinforced with steel frames. Overall dimensions of the island: length 4 km, width 1.25 km. The 1,700 m long airport building is supported by 900 columns. The airport is connected to land by a bridge with roads and railways.

Concorde airplane

The Concorde supersonic high-speed transport aircraft was built in Britain (Filton) and France (Toulouse). The first aircraft was built in 1969. In 1997, there were 14 Concordes on the lines (a total of 16 were built). Technical characteristics of the aircraft: length 62.1 m, wingspan 25.5 m, maximum lift height 18,300 m, maximum speed 2 times the speed of sound (sound speed 1225 km/h), fuel volume about 960 thousand liters, landing 100 seats. Main flight routes: London - New York, Paris - New York.

Aswan Dam

Built on the world's longest river, the Nile, near Aswan (Egypt). The project belongs to Germany, construction was carried out with the help of the Soviet Union in the period from 1960 to 1971. The length of the dam is about 3.6 km, height 111 m, width at the top 40 m, at the bottom 925 m. After the construction of the dam, Lake Nasser was formed, about 50 km long.

Sears Tower skyscraper

Tallest building in the world (until 1998). Built in Chicago (USA) in 1973. It was built over three years by 2,400 workers. The total height is 540 m. The building has 104 high-speed elevators, divided into three lift zones. Six automatic machines constantly wash the building's 16 thousand windows. At an altitude of 412 m there is an observation deck, which offers views up to 80 km away.

Kennedy Space Center

The space center was built at Cape Canaveral (Florida, USA). In 1969, a man was launched to the Moon. The assembly of the devices was carried out in a building 160 m high. Transportation to the launch site, located 5 km from this building, was carried out using a special tractor with a crew of 26 people.

H. Emerson (1853–1931), in his book “The Twelve Principles of Productivity,” written in 1911–1914, notes that those ideas of faith, hope, love and beauty that were embedded in the seven wonders of the ancient world are practically absent in modern world. As an example, he cites seven American buildings of that time:

Panama Canal.

Train stations in New York.

New York Ship Canal.

Improving inland water communications.

American Navy.

Underground New York roads.

Skyscrapers with elevators.

All these structures “suffer” from a utilitarian, purely pragmatic approach with their corresponding perception and impact. It can be stated with regret that most modern engineering structures can also be attributed only to purely commercial, unspiritual “achievements” of humanity

In the world around us, four classes of objects can be distinguished: inanimate nature, living nature, technology, and thinking beings - people. Technology is the main means of human influence on inanimate and living nature, as well as a means of human interaction with nature. These connections and interactions are divided into four groups of systems:

technology is a subject of labor;

man - technology;

technology - nature;

technology - society (society).

The structure, functioning and development of technology are simultaneously subject to three groups of laws: the laws of nature, the laws of society and the laws (regularities) of technology. Technical laws are laws of goal implementation and are based on the realization of human needs. There are two groups of laws of technology: laws of structure and laws of development of technology. For a better understanding of the further material, we will introduce a number of definitions.

The technosphere is the totality of all operating, inactive and recycled technical objects, all material results and consequences of their activities for a certain space. By technical object (technical system) we mean a tool, machine, device, weapon, structure, etc. We will call everything that has a specific function an element of a technical object. We define a set of technical objects that have the same function as a class of technical objects, and we denote mass-produced technical objects that have the same function and design as a generation of technical objects.

When moving from the previous generation of technical objects to the next one, the function of a technical object usually remains unchanged, but its design changes and some criteria are improved. Below are tables with a list of groups of typical external and internal criteria for objects (Tables 6 and 7).

Table 6. Internal object criteria

No.	Groups and subgroups of criteria
1	Functional criteria a) performance: labor productivity; reliability; mechanization; automation: speed of movement or processing; physical parameters; continuity of the processing process; b) accuracy: manufacturing; measurements: hitting the target; management; c) durability
2	Technological criteria a) labor intensity of production; b) technological capabilities; c) use of materials; d) time and complexity of design; e) time and labor intensity of repairs
3	Economic criteria a) costs of materials; b) energy costs; c) costs of obtaining information
4	Anthropogenic criteria a) ergonomics; b) beauty; c) safety; d) environmental friendliness

Table 7. External object criteria

No.	Criteria (patterns) of development
1	The period of time between the great inventions that caused the technical revolution is monotonously decreasing (from hundreds and tens of thousands of years in the Stone Age to tens and several years at the present time)
2	The period of time from scientific discoveries to their implementation is monotonously decreasing (from hundreds and tens of years in the 18th–19th centuries to several years at present)
3	The period of time between two mass-produced technical objects that have the same function is monotonically decreasing (from tens of years in the 19th century to several years today)

Conclusion

The general principles of the main principles of engineering ethics are the support and development by engineers of the purity, honor and dignity of the engineering profession. To do this, engineers are obliged, namely:

Use your knowledge, skills and abilities to increase human well-being.

Serve the public, employers and customers fairly and impartially.

Respect the competence and prestige of the engineering profession.

Uphold the disciplinary standards of professional and technical communities.

Engineers, in the performance of their professional duties, must place the safety, health and welfare of the public above all else.

Engineers must carry out work only within the scope of their competence.

Engineers must respond objectively to public inquiries.

Engineers in their professional field act as loyal representatives, or fiduciaries, for each employer or customer and must avoid conflict.

Engineers should build their professional reputation on integrity and should not compete unfairly with others.

Engineers must support their own professional development and provide opportunities for professional development to engineers under their supervision.

Typical scenarios of conflict situations Situation “Paradox”

The formula of any invention is drawn up in such a way that it considers exclusively the positive aspect. However, each invention, in its internal essence, is based on the resolution (removal) of a technical or social contradiction in its dialectical interpretation and development (this thesis is developed in more detail in the “Theory of Solution of Inventive Problems”). Therefore, in every innovation there are inevitably and then always manifest negative consequences. This provision especially concerns environmental issues.

Such situations are observed in all typical technical innovations: an increase in engine power leads to increased environmental pollution; an increase in flight speed leads to the appearance of ozone holes; An increase in the carrying capacity of vehicles leads to the destruction of roads and soil, etc.

What should an engineer do? Where are the boundaries of ethical and unethical, moral and immoral technical solutions?

Situation "Good and Evil"

We are talking about military inventions. The engineer understands that the invention is aimed at destroying industrial facilities, natural resources, technical means, and enemy manpower. The engineer, as a performer and manager of work, is professionally prepared for this type of activity. However, he lives in the real world and understands that devoting his life to the direct or indirect destruction of other lives is clearly evil. What should a future engineer do during his training? During the period of designing military equipment? During the period of organizing work and managing other people?

Situation “Spiritless Automation” The issue of new technologies that make it possible to automate production is being discussed. Products put into production give birth to a world devoid of soul, a world that promotes the development of inertia, impersonality, and lack of spirituality. Panel and block construction of houses gave rise to dull neighborhoods and “gray” residents. Furniture made from particle boards consists of identical walls and tables with sharp, right angles, which respectively affect the human psyche: prickly, sharp angles appear in the behavior of the growing and already grown-up generation.

What should an engineer do? Should we cancel the automation of production processes? How to build both cheaply and beautifully? How can we make sure that things produced in continuous production bring joy to people?

Situation “Internal conflict”

The company has a large order, for example, for the production of an automatic line. However, individual units and components are not sufficiently developed and require improvement. The alternative is this: either a long but reliable way to debug individual units, or a relatively quick production of the entire line at once, for which the customer is already paying a lot of money, which has a beneficial effect on the financial situation of the engineer himself. What to do? Argue with management, whose prestige depends on the timing of the order? Give information to the customer without informing the management of your company? Silence?

Situation “Innovation is routine”

A typical problem when designing new technology. The device is designed the old fashioned way. Where electronics can be used, mechanics or hydraulics are used. The engineer understands that he needs to take a risk and give the new design a try to break into the market. But management is afraid of failures, inoperability and unreliability and therefore is “pursuing” an outdated, but already proven option.

What should an engineer do? Resign yourself? Conduct research yourself? Looking for sponsors?

Situation “Instant result”

The age-old debate about quality, quantity and cost. There are two options for completing any order. The first is to design and make things that are truly strong, reliable and durable. The second is to imitate strength, reliability and durability through the use of externally similar materials and design solutions (color, shape, weight, speed, etc.). At the same time, the main attention is paid not to the product itself, but to advertising and packaging. Many companies from the so-called developing countries took this path: the “yellow assembly” version of personal computers, toys from China, etc.

What should an engineer working in a company do according to the second option? Don't think about the consequences? Struggle to improve quality? Quit your job?

Situation “Domestic priority” A Russian company offers an organization (possibly state-owned) its own invention for use in the production of products. The invention promises high efficiency and low implementation costs. But the organization is going to negotiate the purchase of similar products in one of the Western countries, for which its representatives are going to travel to this country in the near future. The engineer, who must evaluate the proposal as an expert, is reminded of the priority of developing relations with this country (political aspect) and of the interest of the leaders in the trip (personal aspect).

How should an engineer behave if the effectiveness of a domestic invention is obvious to him?

Situation "Service invention"

An engineer works on an invention during office hours, using office equipment. When he is close to completing the work, he leaves the company and sells the product as his own invention. Perhaps the engineer received a low salary and, moreover, irregularly.

How to evaluate an engineer's behavior from an ethical point of view?

Situation "Choice"

The problem of fairness and reliability in engineering. An engineer works for a government organization that prepares reports on the environmental impacts of projects currently planned by the government. The engineer reports the results of his work to management, after which the manager asks him to change some of the conclusions presented in the report and/or remove some data from it.

What should an engineer do?

Situation "Personal Interest"

The engineer is expected to make an unbiased decision in the best interests of the client, but the engineer has his own interests (related to investment, family relationships, etc.) that may influence the decision. For example, an engineer is expected to help a company decide which product to purchase for the company's needs, and the engineer is the owner (or partner) of a company that offers those products.

Should an engineer remove himself from a situation in which he has a conflict of interest? Should the engineer tell the client that self-interest makes him biased?

Situation "Security"

The engineer is concerned about the safety of the project. Events can develop as follows. The engineer reports his concerns to his boss, but the boss is reluctant to take any action and advises him to remain calm. The engineer must decide whether to “sound the siren”, i.e. contact the authorities, the press, etc. At the same time, the employer can treat the engineer very well. How to combine a loyal attitude towards the employer with protecting the interests of society? When should an engineer “sound the siren”?

Situation "Risk"

(exacerbated version of the “security” situation)

An engineer must make difficult decisions regarding the degree of risk associated with the equipment he is designing.

How to decide on the acceptable level of risk?

Situation “Young specialist” (a specific version of the situation “Innovation - routine”)

The circumstances are such that you have to choose between a traditional and a new solution that promises increased efficiency and reduced costs. The choice, however, should be based only on preliminary testing. The young engineer's boss unexpectedly informs a group of colleagues that the recommendations must be substantiated within two days. At an engineering school, a young employee had the opportunity to research a new device, however, now, in production conditions, there is no time for thorough research. Nevertheless, the device is promising.

The engineering team agrees with the boss and recommends an old, proven device. The boss instructs a young employee on how to write a report praising an old device and recommending its use. The report should not contain a word about a new alternative.

What should an engineer do?

Summarizing the above, it should be noted that against the backdrop of an increase in the number of publications devoted to certain aspects of engineering work, the scarcity of studies in which it would be considered as a spiritual and practical activity becomes noticeable. The creativity of an engineer has not yet been studied deeply enough in the sociological and philosophical literature. Scientific, technical and engineering activities as a cumulative source of technological innovation in a number of important aspects are outside the field of research. Therefore, the need arose not so much to optimize the processes of scientific and technical creativity and scientific and technical activity, but to develop a general concept for the further development of a system for training specialists with higher technical education and a methodology for managing this system. The creation of a new paradigm for the educational process has become not only a pedagogical, technological or environmental problem, but also becomes a philosophical and socio-economic problem, on the successful solution of which scientific and technological progress throughout the country depends. It should be noted that until now the process of both theoretical and practical understanding of the categories “engineering activity”, “engineering thinking”, “scientific and technical creativity” has developed in such a way that its psychological, logical and epistemological aspects have received the greatest development, and in general - sociological, essentially, have been studied very little and, as a rule, are in the nature of general recommendations that are difficult to actually implement in the sociotechnical activities of an engineer. Therefore, it is natural that the public consciousness is dominated by the idea of scientific, technical and engineering activity as a special kind of spiritual activity, as if divorced from creativity in general and especially from art. Without accepting the limitations of such views, the author came to the conclusion that engineering activity should be considered as a dialectical unity of changes in the object and the subject of activity, as a constant divergent-convergent process of scientific and technical activity, including its subject, spiritual and organizational components. Engineering activity can be understood and revealed only through a specific historical study of socio-technical and socio-economic processes. Such an analysis makes it possible to understand the inextricable connection between the method of production and scientific and technological progress, scientific and technological progress and culture, the connection between engineering activity and art, with the moral values of a creative person. Modern highly industrialized and largely technocratic society is in dire need of such theoretical works that carry the potential of practicality and make it possible, with the help of technological innovation, to harmonize the processes of scientific and technical activity.

It should also be noted that there has been a sharply increased public need to unite representatives of different scientific disciplines in solving technical problems. This is confirmed by the material incentives Japanese and American firms provide for scientists and engineers to obtain second and third degrees, including the study of foreign languages and non-technical sciences. The real embodiment of this trend is the synector teams in manufacturing performance analysis consulting firms. An example indicating the negative impact of differentiation of sciences is the division of engineering departments of a higher educational institution into departments for equipment and technology in the same branch of production. Such a separation, formally convenient for organizing the educational process and for compiling a range of specialties, led to a deep and long-term mutual alienation of the style of engineering thinking of process engineers and mechanical engineers, as a result of which many unsuccessful and ineffective decisions arose in the design and manufacture of technical objects. To give universal recommendations for changing the entire system of higher technical education is an unrealistic task. This work is only an attempt to fill the “blank spots” that have arisen between the socio-philosophical and subject-technical areas of training in the education system, with the help of specific sociological and specific methodological research.

Solving the problems posed in the work is complicated by the fact that during times of crisis many social contradictions appear that are inherent in the existing social system. Therefore, this study does not claim to solve all problems associated with scientific, technical and engineering activities. Considering the multifaceted nature of engineering activity in the light of the onset of a new period in the education system, conditioned by the need to develop students' systems and computer styles of thinking, the author puts forward the following thesis as a basic one: the process of development of natural intelligence should not be identified with the development of increasingly universal artificial intelligence systems, including including computerization. The author also does not agree with the statements that engineering activity will become art only when, on the basis of fully automated and computerized labor, the techniques and methods of scientific and technical technology are combined with artistic creativity. The emergence of value-based approaches to human activity is a long-standing humanistic tradition. Mythology is actually considered the beginning of humanitarian culture. Religion divided the world into material and immaterial (mystical, otherworldly, supernatural), which led to an awareness of the importance of the spiritual in this world, which can also be attributed to humanistic cultural studies. Philosophy develops a rationalistic picture of existence, based on the human mind and scientific achievements. The humanistic orientation of philosophical concepts is expressed in value systems developed by philosophy. As shown in this article, art, including technical art (techne), originating in the springs of myth-making, religious teachings, and philosophy, ultimately led humanity to the development of rationalism, which degenerated in the 20th century into technicism and technocracy. There has been a shift in the value system towards greater satisfaction of human material needs. In the history of its development, humanity has moved further and further away from truly humanistic ideals, moving away from the social-humanistic direction of progress towards scientific and technological progress. Frightened by the results of such a movement, which led to an ecological and moral catastrophe, the world community, at least its leading part, is trying to change the course of human development towards humanization. This process is most important for the education system. In the education system itself - to humanize the process of technical education.

Using various sociocultural approaches (social, philosophical, systemic, structural-functional, general systems theory), we tried to formulate a technology paradigm for the formation of engineering thinking associated with the destruction of ideologies of utilitarian-pragmatic goals. We also tried to contribute to the work of streamlining the mass of recommendations, conglomerative in form and eclectic in content, by introducing a sociotechnical approach to solving technical problems using NTT and innovative technologies. In contrast to the descriptive (descriptive) method of constructing humanistic concepts adopted in socio-philosophical works, the study proposes a constructive definition of the methodology for moving the system of higher technical education along the path of humanization. To reveal this approach, the present study raised issues of dialectics, ethics and aesthetics as necessary.

Over the past decades, society's requirements for specialists have significantly transformed. In addition to being highly qualified in their field, workers in science, technology, and management must be capable of creative activity and self-improvement. Engineering activity began to have a planetary character, technogenesis became commensurate with natural scales, covering the entire territory of the earth.

The humanization of scientific and technological progress to mitigate technocratic blows should be directed primarily towards the humanization of the process of education of engineers. Nowadays, the disciplinary, narrow-subject paradigm of education continues to operate, fostering "chauvinism of special disciplines."

Those who call for a shift in the training of engineers to a paradigm shift, to the introduction of a problem-based method, and the like, are right, in fact. The difficulty of such a transition lies in the fact that there are no simple and quick solutions leading to successful results in education. It is obvious that the transition period requires not only time, but also special techniques. During this period, an understanding should come of how to move from technical knowledge, how to move from technocratic thinking to sociotechnical knowledge, to humanistic thinking.

First of all, the purpose of education must be changed; it is not knowledge itself that is important, but the development of personality with the help of knowledge. Such goal setting requires solving the problem of teaching students creativity and self-improvement. It is not enough to call for internalist activities focused on self-education. Tools for this activity need to be developed. If this is successful, then both the student and the graduate engineer will be able to take advantage of the content and scope of knowledge that is already available in existing educational programs, using this knowledge to humanize technical activities. The stated position is the main goal of this work. It is to achieve this goal that it is shown how, with the help of a sociotechnical approach, using the polyvariance of such concepts as "consumer properties" and "result quality", one can arrive at a full-fledged creative educational process.

Therefore, in this article, significant attention is paid to the consideration of the transcendental in engineering activities, i.e. such categories as faith, intuition, imagination, fantasy, creativity, "working" for the humanization of engineering thinking. The introduction of such conventional concepts as "efficiency coefficient" is associated with the need for an instrumental and constructive description of innovative processes in engineering activities. The ability to operate with these concepts will enable the engineer not only to adapt to innovation, but also to actively participate in the creative process and master the art of solving real life problems. The tools that the NTT methodology has in its arsenal will help the engineer make the transition from a system of conceptual knowledge to a system of instrumental knowledge, and move on to real creativity.

The search for effective criteria for optimizing engineering activities is a fundamental point to which considerable attention is paid in the study. The anthropological aspect of performance results can be realized with a sufficiently in-depth analysis of the concept of "result quality". This will help in teaching to move from explanatory and illustrative methods to problem-search methods.

A few words about the semiotic (linguistic) aspect of engineer training. The main operational means of engineering thinking is the ability to express one's thoughts using symbolic means and understand the meaning of regulatory texts, the form of which can take different forms: diagrams, drawings, specifications, etc. That is why it is necessary to use a large amount of illustrative material, which allows a methodical, step-by-step introduction to the subject of training, who has already learned the language of "technical graphics" from special courses (where, in addition to drawings and diagrams, various formulas can also be included, expressing graphical dependencies in a different symbolic form), to the social and philosophical categories revealed in our research using the language of the constructive and conceptual apparatus of the systems approach. For this reason, we considered it necessary to provide in the appendix a dictionary of concepts, which should form the basis of an engineer's thesaurus and reveal to the learner the main categories of an engineer's humanistic thinking.

As we part with the reader, let us draw his attention once again to the fact that in addition to knowledge acquired in a rational way, an engineer, relying on a system of moral values, in real life uses will, emotions, intuition, faith and other irrational components of human activity. Therefore, the strategy of higher technical education should be associated with the growth of the student's self-awareness, with training that performs the function of humanizing the individual.

The authors hope that the results of their research presented in the article will help Russian engineers develop creative abilities, develop a sense of confidence in their knowledge and realize their life goals with the help of their education and the art of engineering.

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Issue Article

Artur Aleksandrovich Blagorodov
Institute of Service Sector and Entrepreneurship(branch) DSTU
master's degree
Shakhty, Russia

Victoria Sergeevna Belysheva
Institute of Service Sector and Entrepreneurship(branch) DSTU
Ph.D., Associate Professor

Lyudmila Borisovna Tomilina
Institute of Service Sector and Entrepreneurship(branch) DSTU
senior teacher

Natalya Valerievna Volkova
LLC TsPOSN «Ortomoda»
PhD in Law, Director

Galina Yurievna Volkova
LLC TsPOSN «Ortomoda»
Doctor of Economics, Professor
Moscow, Russia

SOME RECOMMENDATIONS FOR MAINTAINING THE MOBILITY OF A CHILD WITH CEREBRAL PALSY IN EVERYDAY LIFE

Abstract*: in the article, the authors recommended information and practical features to parents and teachers of preschool children with cerebral palsy, without pretending to comprehensively cover the stated topic, reflecting the issues and problems that the specialists of the PPMS-Assistance Center worked on when accompanying families with children with cerebral palsy . The article presents the international classification of the functioning of people with cerebral palsy GMFCS, reveals the dynamics of the development of motor functions in children with cerebral palsy depending on the level according to GMFCS, tells what parents and support specialists should pay attention to when building a program for the development and maintenance of mobility of a child with cerebral palsy in their Everyday life. The section on verticalizers for children with cerebral palsy may be of interest, since information on this topic is not easy to find, and parents very often have difficulty choosing and using supports for children to stand, although this is especially important for the rehabilitation of children.*

Key words*: verticalizers, rehabilitation, postural management, skeleton, joints, internal organs, child comfort, fixators.*
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Introduction

A child's mobility refers to his mobility, ability to move and perform all kinds of actions. Mobility implies the development of the following abilities in a child:

1. change in body posture;
2. maintaining the body in the required position;
3. moving the body while sitting or lying down;
4. lifting and carrying objects;
5. moving objects with your feet;
6. use of precise hand movements (picking, grasping, manipulating, releasing);
7. use of hand and arm;
8. walking and moving in other ways;
9. movement using technical means.

Mobility is one of the most common problems associated with cerebral palsy. All parents of children with cerebral palsy (CP), upon learning about the diagnosis, begin to ask questions: Will my child move? Will he walk? How can I help him?

Are parents vaguely aware of what results they should expect? What can you do to improve your child's mobility? They grab every opportunity to show the child to another doctor, get advice and help, look for those who promise to put the child back on his feet, sometimes giving his last money for miracle procedures and magic medicines. Very often, the efforts of parents are spent on complex and not always effective activities, while on simple but vital things for the child there is not enough strength, time, or understanding that these actions are very necessary for the child, starting from a very early age.

Yes, mobility is a vital function of a child's rehabilitation. Course sessions with specialists and drug treatment of the child are important, but they will be ineffective if they are not reinforced every day. The task of specialists is to build, together with parents, a program for the rehabilitation and development of the child, based on his condition, to train parents to perform those tasks that they can implement themselves in everyday life.

A child with cerebral palsy should be assessed for limitations in mobility and walking, and parents should be offered options to improve the situation, including at home, in natural life situations. Although there is no cure for this condition, taking steps to make mobility easier can give your child a better chance at a normal life and independence.

The level of motor functions (degree of motor impairment) of people with cerebral palsy is assessed by specialists using the Global Motor Function Scale.

GMFCS is an international classification system for motor functions of patients with cerebral palsy over two years of age, which assesses the patient's overall functional activity in his or her usual environment and the degree of its limitation. It is fundamentally important that it is the everyday level of activity that is assessed, and not the maximum possible, demonstrated only during the study.

The GMFCS scale was proposed in 1997 by Canadian scientists from the Center for Childhood Disability Research at McMaster University R. Palisano, P. Rosenbaum and others based on data from a large-scale study of the development of motor skills in children with cerebral palsy. This scale, revised and expanded in 2007, is now widely used.

The scale is divided into five levels. For each level, its inherent motor capabilities are described in different age periods: from 2 to 4 years, from 4 to 6, from 6 to 12, over 12 years.

The GMFCS focuses on a child's ability to move, including with the use of assistive technology, and emphasizes the International Classification of Functioning concept of the importance of environmental influences on a person's functioning. It is noteworthy that the description of each level presents the child's capabilities, not limitations, even if these capabilities are minimal. The type of cerebral palsy is not taken into account. The authors emphasize that the scale was created to determine the current daily ability of a child (adolescent) to move, and not to assess the quality of movement or to make judgments about the prediction of improvement in movement. The general characteristics of the classification levels are presented in a diagram developed by specialists from the St. Petersburg Institute of Early Intervention (Figure 1).

The authoritative Russian pediatric neurologist Vera Anatolyevna Zmanovskaya, in the methodological manual "Observation Program for Children with Cerebral Palsy," provides the following description of the age-related development of motor skills characteristic of different levels of GMFCS:

I level - the child walks without limitation, but may have difficulty with more complex motor skills.

Up to 2 years - the beginning of independent walking.

From 2 to 4 years - independent walking without jumping or running.

From 4 to 6 years - independent walking over long distances and on uneven surfaces, climbing stairs, running and jumping.

From 6 to 12 years - walking without the use of assistive devices, going up and down stairs without holding handrails.

From 12 to 18 years old - independent walking over obstacles, running and jumping (speed and coordination may be impaired), participation in sports events.

Figure 1. Classification of functioning in cerebral palsy

II level - walks with restrictions.

Up to 2 years - children crawl on their stomachs and all fours, walk along a support.

From 2 to 4 years old - crawl on all fours, walk with support, with auxiliary devices.

From 4 to 6 years old - walking independently for short distances, climbing stairs, holding on to the railing, cannot run or jump.

From 6 to 12 years - walking without the use of assistive devices, going up and down stairs, holding handrails.

From 12 to 18 years - independent walking over long distances in a familiar environment, using equipment on the street, running and jumping poorly.

Differences between Level I and II: Level 2 children have limitations in long distance walking and balancing and require assistive devices to master walking. When going up or down stairs, they must use handrails. The quality of movement suffers: the child cannot run or jump.

Level III - walks with the use of assistive devices on a flat surface.

Up to 2 years - roll over and crawl on their stomach.

From 2 to 4 years old - crawl on their bellies or on all fours (reciprocally), sit without support, but do not sit down independently, walk with hand tools for short distances.

From 4 to 6 years old - they can get up from a chair without support, but walk only with assistive devices.

From 6 to 12 years old - stand independently; walk using assistive devices (walkers, crutches, cane, etc.).

From 12 to 18 years old - they can only walk with devices, they can go up and down stairs with railings, they can only move outside in a stroller.

Difference between Levels II and III. Level II children do not require walking aids after age 4. Level III children require hand-held devices for indoor mobility and wheeled devices for outdoor mobility.

Level IV - children can sit independently, but move using electrically driven assistive devices or are passively transported.

Up to 2 years - roll over, but cannot maintain a sitting position.

From 2 to 4 years old - sit, if placed, independently or in devices, crawl on their bellies.

From 4 to 6 years old - can sit independently, move with the support and supervision of an adult.

From 6 to 12 years old - can sit independently, but do not stand or walk without substantial support.

From 12 to 18 years old - they move around the room by rolling or crawling on their stomach, can move in a walker that supports the pelvic girdle and torso, and are able to control a motorized wheelchair.

Difference between III and IV levels. Level III children sit independently, move on the floor independently, and walk with the use of aids. Level IV children can sit, but independent movement is very limited.

Level V - children cannot move without assistance, independently control movements and maintain a posture against gravity (they cannot hold their head and body position). Independent movement is only possible with the use of advanced power chairs.

Under 2 years of age - need adult help to roll over.

From 2 to 4 years old it is impossible to move independently; some children can move using an electric wheelchair.

From 4 to 6 years old - they cannot move independently; some children, however, use an electric wheelchair.

From 6 to 12 years - the child in most positions experiences difficulties in controlling the position of the torso and head, since gravity prevents maintaining the position of the head and torso.

From 12 to 18 years old - limited control of the head and torso against the gravity gradient, as well as control of the arms and legs. Assistive technologies are used to improve head holding, sitting, standing, and ambulation, but limitations are not fully compensated for by devices. Some children achieve independent mobility using a high-tech electric wheelchair.

Difference between IV and V levels. Children with level V have significantly limited control of head and torso position. These children and adolescents need extensive physical assistance from others and technological support. Independent movement is only possible if a child or adolescent learns to operate a motorized wheelchair.

Figure 2 clearly shows the levels of functioning of a child with cerebral palsy on the GMFCS scale.

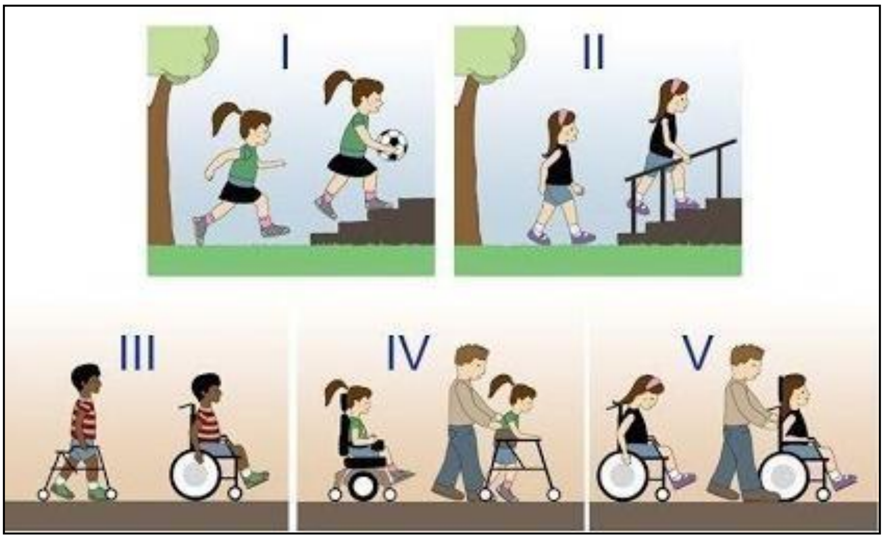

Figure 2. GMFCS levels of functioning

The level of development of a child’s motor functions on the GMFCS scale is determined by a medical professional, but both specialists and parents should have an idea about it. This is necessary in order to understand the child’s development prospects and set realistic, feasible tasks for him to function at different age periods. None of the GMFCS levels can or should be a reason for refusing to rehabilitate and educate a child. The scale helps set goals and objectives that are appropriate to the child’s condition. It is important that parents understand the maximum level of development of motor skills in their child, above which he “will not jump.” To do this, you can use the classification of age-related development of motor skills for different levels of GMFCS by V.A. Zmanovskaya. (shown above) and a graph of the growth of motor development of children with cerebral palsy (Figure 3), developed based on data from Canadian scientists.

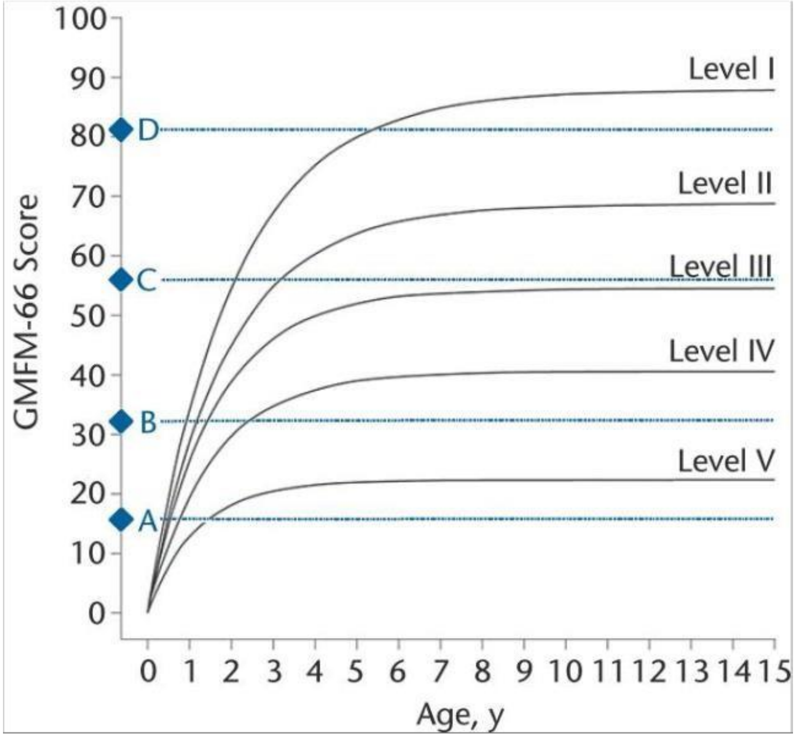

Figure 3. Graph of development of motor functions
Marks on the horizontal axis: child's age.
Marks on the vertical axis: child's ability levels:
A - the ability to raise and support your head in an upright position.
B - the ability to maintain a sitting position on the floor without support or hands for 3 seconds. D - ability to walk forward 10 steps without support. C - ability to descend 4 steps without support.

Conducted by a research group at McMaster University in the Canadian province of Ontario over four years (the study involved 650 children aged 1 to 13 years with various forms of cerebral palsy).

It is noteworthy that for every child with cerebral palsy, the level of motor skills according to GMFCS does not change; it is the same from two years old throughout life. It is indicated in the diagnosis following the indication of the form of cerebral palsy. For this reason, the GMFCS level cannot be used to assess the dynamics of motor development. But it can be used when building a program for the rehabilitation and development of a child, taking into account the child's age. However, with age, natural changes occur within the same level, and the child's progressive development occurs.

Cerebral palsy itself does not progress, but secondary orthopedic complications can lead to a worsening of the condition. To reduce the likelihood of such a development of events, it is necessary to focus on the prevention of orthopedic complications and train muscle strength. You just need to engage in rehabilitation and prevention both in childhood and in adulthood on the recommendation of a specialist, since improper loads can also lead to deterioration.

If a child, while at home, is left to his own devices, sits or lies in the wrong position all day, does not stand periodically, after some time he will develop contractures that will not allow him to stand even in a verticalizer, although initially the body there were opportunities for this. If you don't maintain your muscles every day, they will stop working even in a healthy person. It is important to provide quality assistance to a child with cerebral palsy in a timely manner.

The task of specialists is to identify the child's available capabilities and help develop them. But sometimes difficulties arise. For example, it is currently important for a child to learn to walk with a walker or holding handrails. And it is necessary that he can train this skill at home. But at home everything is filled with furniture so that walkers cannot fit, and there is no possibility or desire to make handrails. But the child can only walk with support; holding on to walls and furniture is uncomfortable for him. If you do not adapt the environment and do not select the right technical devices, the opportunities for developing the child's functionality will be missed. In this case, using diagnostic data and advice from specialists, you can not spend a huge amount of time and effort on getting the child to take three steps in a walker, but teach him to use a stroller and direct his activity in a different direction.

For all levels of cerebral palsy, there are accessible ways to be active. It is necessary to switch attention from the limitations that cerebral palsy gives to the opportunities that the child has, then he will learn to live with them and enjoy them. Even a motionless child can be left sitting so that his head dangles and he will not see anything around, or he can be fixed in a position where he can see the world around him and be interested in it. There are electric chairs and strollers, the movement of which brings a lot of positive emotions to children with varying severity of disabilities.

A child must be verticalized every year. This is necessary for a variety of purposes, including the formation of hip joints. Because children at levels 2-5 have a high risk of hip dislocation. Children in the first level of motion have zero risk of hip dislocation because they started before age two. Children of the second level of movement have a 15% risk, the third level - 40%, the fourth - 70%, the fifth level - 90%. If the child is not exposed to gravitational loads at an early age (that is, verticalized), then the prerequisites for the development of a normal hip joint will not be created, which means there is a risk of hip dislocation. The scale of gross motor functions, defining the boundaries of a child’s capabilities, does not so much close, but rather opens up great, and most importantly, real prospects for him.

Main part

Studies have shown that a child masters motor skills in everyday life much better if these skills are taught to him by solving functional motor tasks in everyday life, and not just by training in artificially created conditions. Table 1 shows the main directions of movement training for children with varying severity of cerebral palsy.

Table 1. Teaching movement to children with different levels of GMFCS

GMFCS Level	Movement training: directions and tasks
I	Improve the quality of movements, especially movements associated with shifting weight to the side, rotation, and reducing the area of support in vertical poses. Train balance while standing and standing with a reduced support area. Learn to use a variety of means of transportation: bicycles, roller skates, skates, skis, etc.
II	Maximize the quality of walking: reduce the risk of falls, increase speed, endurance and coordination of movements. Learn to the highest possible level the skills for which Walking is enough: skis, balance bikes, snowshoes, trekking, etc. Master climbing skills, including rock climbing. Avoid dangerous movement patterns and pathological body postures.
III	Maximize your balance while sitting, transferring weight to your legs while sitting and standing. Introduce standing posture, supported walking, and assisted walking as early as possible. To the maximum extent possible, train hand functions, including hand support (weight bearing) during motor transitions. Train motor transitions: from the floor to a chair, from a sitting position to a standing position, into a technical rehabilitation device (chair, walker), from a technical rehabilitation device. Give the maximum amount of active independent movement. Avoid dangerous movement patterns and pathological body postures.
IV	Maximize the development of motor transitions in the horizontal plane, sitting balance, skills of independent movement in a wheelchair, a verticalizer with large wheels and using any other technical means for movement. Make maximum use of crawling, motor transitions to sitting, standing, and assisted transfers. To develop and maintain support (weight bearing) on the legs and arms as much as possible. Develop hand functions associated with fine motor skills. Be sure to use a 24-hour program for the prevention of secondary complications!
V	To the maximum extent possible, develop the ability to adapt to certain postures, tolerate sensations associated with weight distribution, posture maintenance, passive motor transitions and movement.

	Train and support the ability to lift the head in a prone position, partially rely on the forearms and on the legs as important components of partial weight bearing during passive transfer. Maintain controlled or partially controlled rotations, frequent transfers with assistance. Learn to give signals to change body position when tired. Develop awareness of the body, perception of one's own posture. Train hand functions - for communication, play, control electric wheelchair, other technical means of rehabilitation. Be sure to use a 24-hour program for the prevention of secondary complications!

Postural management is a program aimed at maintaining correct body position throughout the day and preventing the development of secondary complications.

If rehabilitation activities are carried out at best a few hours a week through a specialist, then postural management is a program applied 24 hours a day every day, it is associated with the performance of normal daily activities. The child and the people caring for and raising him become active participants in the postural management program.

The importance of postural management cannot be overestimated. If rehabilitation sessions with a child with severe motor impairments are carried out for one hour a day, and the rest of the time he is in the wrong position, then there will be no benefit from such "rehabilitation". The child will still develop secondary complications - contractures, deformities, problems of the hip joints. The postural management program as a program for the development and maintenance of mobility of a child with cerebral palsy in everyday life includes the following components, namely:

1. The correct posture of the child during the day (positioning).
2. Ensuring adequate load on the skeleton (use of technical means of rehabilitation).
3. Changing body position throughout the day.
4. Eating and drinking only while sitting or lying on a high headboard.
5. Use of orthopedic devices (tights, orthoses, corsets, shoes,...).
6. Supports the child's full range of motion and stretching.
7. The highest possible level of physical activity. - Organization of assistance to a child in real conditions.

Correct positioning of the child must be ensured throughout the day. In lying, sitting, standing poses, it is necessary to provide the child's body with:

1. Adequate support.
2. Symmetry.
3. Alignment.
4. Load on the skeleton.

To ensure the correct position during the day, you can and should use various devices: supports for sitting and standing, pillows for positioning, a verticalizer, a headrest, walkers, railings. Ensuring correct body position when sitting on the floor.

Often children with cerebral palsy take the "W" position when sitting. This is a pathological position and should be avoided. When staying in the "W" position for a long time:

1. The child runs the risk of acquiring a specific hip deformity: with internal rotation of the hips and their adduction, the relationship of the femoral head and neck with the axis of the femoral body is disrupted.
2. The child will not develop balance reactions and rotation (alternate change of position) of the torso, since in the "W" pose the pelvis is tilted back, the torso is "turned off" from maintaining balance and rotation is impossible.
3. There is a risk of perpetuating a backward pelvic tilt, which will prevent the child from sitting in the correct position, while sitting with a "round" back, in turn, will limit the use of hands and the development of reaching and fine motor skills.
4. The "W" pose will promote plantar flexion in the ankle joint; in a vertical position, this will lead to support on the forefoot. When resting on the forefoot and moving the center of gravity forward, a biomechanically natural hyperextension occurs in the knee joints. All this can significantly affect the child's gait in the future.

Figure 4. Pose W

To limit the child's presence in the "W" position, it is recommended:

1. Teaching your child to sit on the floor correctly(in the poses "legs to the side", "under oneself", "legs forward", "Turkish style", "one leg forward, bend the other").

2. Use various devices for sitting the child on the floor: a low stool or bench, an inflatable circle-seat, bolsters. At the same time, you need to pay attention to your back and, if necessary, consider additional support.

Figure 5. Correct sitting positioning

Figure 6. For correct use of baby positioning devices

For example, the position “Riding on a bolster” is convenient to use if the game is organized on the floor.

If necessary, you can raise the back end of the bolster, this will help the child keep his back vertical. A helping adult can sit in the back. Instead of a roller, you can use a small wedge-shaped block of polyurethane foam. It can be attached to the body using straps, then the child can crawl freely on the floor, dragging the seat behind him.

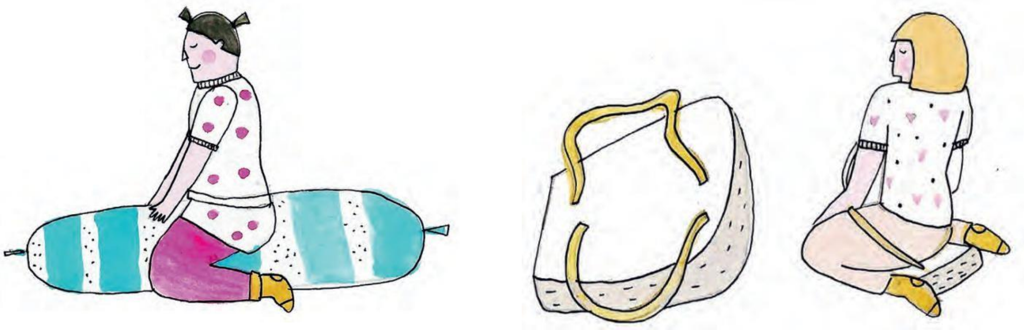

Figure 7. Using devices to correctly position the child

Ensuring the correct position of the child’s body when sitting in a support, stroller or chair.

While sitting in a stroller, in a seat support, in a chair, the child’s pelvis should be positioned evenly and symmetrically, the child should not fall to the sides, forward or backward. To do this, the width of the seat must correspond to the width of the pelvis. If you have to use a stroller (seat) that is not suitable in size, the space between the armrest and the side surface of the thigh must be filled; for example, a rolled up towel can be used as a material. The seat and back should not sag; such a design defect can be corrected using a board appropriate to the size of the seat (in this case there should be a fairly soft cushion on top) or several layers of polyurethane foam mat. To fix the position of the pelvis, it is necessary to use a pelvic belt.

The body must be level. If the child does not hold the body in an upright position, the back of the chair should reach shoulder level. If body control is insufficient, it is necessary to use lateral supports and a vest-type restraint. It is necessary to choose the angle between the seat and backrest. If there are no obstacles, the angle between the seat and the back should be 90. If it is difficult for a child to sit with a vertical or almost vertical back, or he is tired of being in this position and needs to lean back, it is better to change the angle of the entire seat. If only the backrest is selectively reclined, this position becomes unstable - the child begins to slide forward. To control the position of the head, additional support is needed (headrest or special head holder).

The hips should be positioned symmetrically, parallel to each other or with a slight separation, not tilted to one side, not crossed. To avoid this, the width of the seat should correspond to the width of the pelvis; for spreading, you can use a soft cushion between the knees or a butterfly belt. The seat depth should be equal to the length of the thigh minus 2 cm.

The feet should be on the footrest. The position of the footrest and its angle of inclination are selected individually for the child. The height of the armrests should be comfortable: the arms rest freely on the armrests, the elbows do not hang in the air, the shoulders are in a natural position, not raised to the ears.

In a stroller, the child should always be fastened with a pelvic belt, otherwise there is a high risk of falling. When the stroller is not in motion, especially when moving a child from or to the stroller, it is necessary to put the stroller on the brake. Failure to comply with this rule most often leads to injuries to children and caring adults.

For children associated with cerebral palsy, it is important to pay attention to verticalization: why it is important, how to choose the right verticalizer. Is verticalization rehabilitation?

Verticalization is not a rehabilitation method. That is, this is not a rehabilitation intervention that in itself can teach a child to stand or walk. This is part of postural management - a program aimed at maintaining correct body position throughout the day and preventing the development of secondary complications.

If rehabilitation activities are carried out at best a few hours a week through a specialist, then postural management is a program applied 24 hours a day every day, it is associated with the performance of ordinary daily activities. The patient himself and the people caring for him become active participants in the postural management program.

The importance of postural management cannot be overestimated. If rehabilitation sessions with a child with severe motor impairments are carried out for one hour a day, and the rest of the time he is in the wrong position, then there will be no benefit from such “rehabilitation”. The child will still develop secondary complications - contractures, deformities, problems of the hip joints. It is correct positioning and regular changes in body position that help avoid complications. Verticalization is an important part of this program. Why is vertical position so important for a person? Man is an upright creature; his vertical position distinguishes him from all animals. To assume a vertical position, it overcomes the force of gravity. Normally, a child already at the age of 6-8 months comes to a sitting position, and at the age of 8-10 months - to a standing position. In the period from 1 year to 1 year 3 months, he masters walking. This amazing mechanism (less than a year passes from the moment of birth - and the child independently verticalizes) allows the skeleton, joints, and internal organs to form correctly, namely:

Standing pose:

1. gives a good load on the skeleton and stimulates the formation of bone tissue,
2. promotes the correct formation of the hip joints (due to the correct load on the acetabulum),
3. stimulates the maintenance of symmetry of the spine and the formation of its bends,
4. has a positive effect on the function of the cardiovascular and respiratory systems,
5. improves blood circulation,
6. improves the functioning of the gastrointestinal and urinary systems.

An upright posture is no less important for the child’s psychological comfort. After all, this is an opportunity to communicate “on the same level.” Whereas lying on the floor, for example, you always look up. While standing, it is easier to establish eye contact, move your hands in any dimension, and therefore play actively and variedly. A standing position allows a child with motor impairments to look not only at the ceiling or wall, but to expand their visibility area and generally explore the world from a new angle. The vertical position stimulates activity and social interaction, and therefore provokes self-confidence in the child. Complications in the absence of verticalization. If the child does not reach an upright position in time - does not begin to stand by 10-12 months, it will be difficult for him to form the chest correctly. It will not be able to expand, as it should, in three dimensions - vertical, horizontal and sagittal - and will not take on a cone shape.

And an incorrectly formed chest is an incorrectly formed tidal volume. The infant type of breathing - through the diaphragm (tummy) - will continue to accompany the growing baby. But this volume is clearly not enough for a growing organism.

The time of natural verticalization is the time of formation of internal organs.

When eating solid food in an upright position, the fundus of the stomach is formed (stretched). In the absence of verticalization, the convexity of the bottom does not develop, and there is no place for food to linger. Regurgitation (involuntary reflux of stomach contents into the mouth), aspiration (penetration into the respiratory tract when inhaling liquid or solid substances), dyspepsia (difficulty in digestion) appear.

In the absence of verticalization, the removal processes are also complicated. Human organs are located in such a way that it comes out and flows out of them best in a vertical position - gravity helps. With a constant horizontal position, both constipation and urinary tract infections (associated with stagnation of urine) appear. Spend at least five hours sitting still on the plane. And you, a healthy person, will probably experience problems, at least with gas formation.

No verticalization - no muscle tension. To stand, a person strains his legs, which means he stimulates good venous flow. In a lying position, blood circulation becomes difficult. Due to the lack of axial load on the skeleton, the risk of developing osteoporosis increases. One of the formidable secondary complications associated with incorrect body position during the day is contractures (limited mobility in the joints). Deformations are no less dangerous. The human body, like the filling in an English sandwich, is under the influence of two forces - gravity and ground reaction force. If the posture is asymmetrical and his ability to align is limited, then these forces will deform the skeletal system. Skeletal deformities will occur. Most often, scoliotic deformity of the spine, flattening of the chest, and pelvic deformities occur. Symmetrical, competent verticalization will help avoid this. Due to insufficient vertical load on the joints, dislocations or dislocations and subluxations develop. The most painful are dislocation and subluxation of the hip.

It would seem like such a simple thing to stand. But our body is so intelligent, it is adapted precisely to this position, it behaves so wisely and manages all processes independently. And how difficult it can be for those children who are deprived of the ability to support themselves in an upright position.

But understanding the importance and necessity of verticalization, it is possible to at least partially correct and slow down the deformation processes with the help of verticalizers. Timing of verticalization.

Currently, it is believed that it is necessary to start placing a child with motor disorders at approximately the same age as a child with normal development, that is, about a year.

At the reception, specialists immediately identify those children who were not verticalized on time - before 12-14 months. Their arms are bent and pressed to the body, their head is thrown back, their hips are adducted and are often asymmetrical. In the supine position, the legs are bent and “knocked down” to the side. In English-language literature, a similar situation is described by the term “wind-blown legs syndrome.” Constantly staying in this position is guaranteed to lead to the formation of paralytic hip dislocation.

To prevent this from happening, you need to use a verticalizer, give the child the opportunity to stand with fixed legs for sufficient time and train muscle strength through physical exercises. There are two myths that prevent you from starting to use a verticalizer on time.

Myth 1.The child can be verticalized without using any devices, simply supporting him with his hands.

"We hold him by the hands," some parents answer when asked about verticalization. But we can almost guarantee that the child's position in this position will not be correct, and the time will not be sufficient. It is too difficult to hold a child motionless for several hours a day. That is, we will not achieve the desired effect.

Myth 2.If you place a child in a standing position, this will slow down his development, and he will not be able to walk independently in the future.

We have already said that after a year it is extremely necessary for a child to be in an upright position. If the level of his physical activity allows him to do this, then, of course, he can do without a verticalizer. Most likely, for children with cerebral palsy of levels I-II according to the GMFCS system, this task can be solved with the help of a simple support that the child can hold on to by himself.

Children with more severe motor impairments need a separate technical device - a verticalizer. In this case, it's more likely the opposite - the absence of a verticalizer will hinder the child's development.

But even with mild paralysis, in a situation where the child gets to his feet on his own, be sure to pay attention to exactly how he holds his torso. If he has poor weight distribution (standing on tiptoes, on the lateral (outer) surface of the foot), if his hips are brought together, if he strongly bends his torso (lays on a support), a short stay in the verticalizer will not slow him down, but will help him learn correctly distribute the load, save hip joints from problems.

Contraindications to the selection of a standing posture and means that help maintain a standing posture are:

- severe atrophy of the bones and muscles of the trunk;
- serious problems with respiratory function;
- severe contractures that do not allow a person to be "straightened" and placed in a standing position;
- severe osteoporosis;
- dislocations of the hip joints - some congenital malformations (for example, under development of the chest).

The right verticalizer. So, we said that a verticalizer, in contrast to "holding with hands," can fix the child in the correct position for a long time. Let me explain.

The correct position can be called one in which: – the child is symmetrical: the head is on the midline, not tilted forward or backward, neither to the right nor to the left, shoulders are at the same level, the chest is neither depressed nor arched, the pelvis is not turned to the right , neither to the left, legs rest equally on the stand; - the child does not hang on the clamps - they firmly hold him in the desired position - the child's functions are noticeably improved (for example, it is easier for him to control his hands - he plays and eats better); the child generally looks more cheerful and does not waste energy maintaining the desired posture.

What if a child does not tolerate the verticalizer well? Is he capricious or even screaming?

If such behavior is associated with familiarization with a new device, getting used to it, parents should be creative. "I would, of course, stock up on something amazingly interesting for my first acquaintance with the verticalizer. For example, a piece of chain link (which you can buy at a hardware store), or a huge metal funnel through which you can pour beans into a plastic bottle, or some kind of iron bowl that rattles so much. It is important to quickly and deftly place the child in the restraints, quickly draw him in and take him out about five minutes before he gets tired," explains Ekaterina Klochkova. "If you succeed, the child will quickly calm down and will have a positive attitude towards him in the future. If, despite all your tricks, the baby screams and turns blue while standing in it, most likely the device has inconvenient fastenings or another defect."

What does it mean to spend a long time in a verticalizer? Experts say that it is necessary to spend at least an hour and a half a day in the verticalizer. The more, the better: after all, an ordinary child spends almost the entire day in a standing position. However, it is better to break this stay into intervals of 30-40 minutes: a continuous one and a half hour stay in the verticalizer can greatly tire the child and cause rejection.

What to look for when choosing a verticalizer? Pay attention to the upholstery. The surface with which the child will come into contact should not be slippery. Otherwise, the child will slip out and spend extra effort to maintain the desired position.

Check the fasteners. Tight fastenings will hold the child firmly and safely. Belts that are too tight and narrow can twist and cut into the body. No braces should put pressure on your knees. It is better to fix your legs above or below your knees. The abductor, which prevents the hips from connecting, should not be located too high and should not put pressure on the perineum. The tips of the toes and knees should not be pressed against the same plane: this causes the axis of the limb to bend.

If we are talking about a verticalizer for a child with cerebral palsy of level IV according to GMFCS, then the fixation should be at the level of the feet, knees (approximately), pelvis, chest, and, if necessary, lateral support of the torso. If we are talking about a verticalizer for a child with cerebral palsy of level V according to GMFCS, then head support must be added to these clamps.

How to use a verticalizer and how much time to spend in it

Since the child with disabilities has an obvious activity deficit, use the time spent in the verticalizer (Figure 8) as a moment of activity.

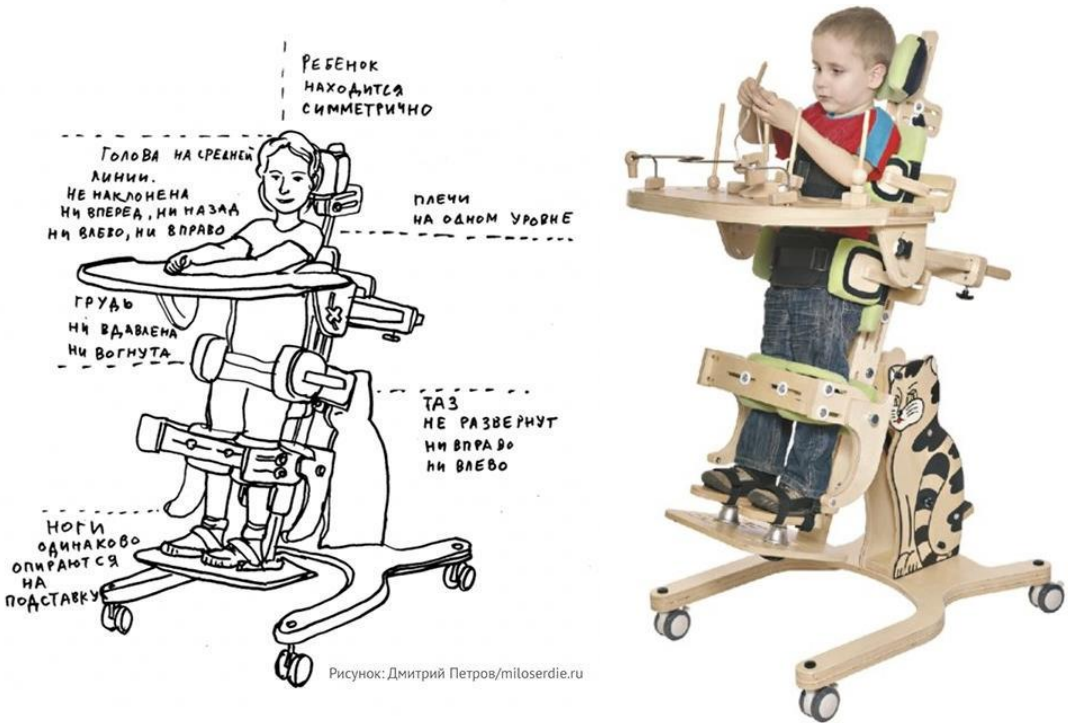

Figure 8. Position of the child in the verticalizer

Give your child the opportunity to move as much as possible - raise his arms, stretch, look in different directions, turn his head - this way he will shift his weight slightly, and he will not become overtired from immobility.

It's not the best option to put your child in the device and play him a cartoon on the tablet. Firstly, his gaze will be directed downwards and his head tilted forward. And this pose will be fixed for a long time - it's difficult to tear yourself away from the cartoon. We have already said that a vertical position helps free up your hands, make them more mobile, it is important to take advantage of this and initiate active play.

It is equally important to use the time spent in the verticalizer to eat. For a child who has the potential to hold a spoon independently, vertical eating will become a training in self-service skills. And for any child, vertical rather than horizontal eating is the prevention of gastrointestinal disorders.

If the child spent each feeding in the verticalizer, and then played for another 30-40 minutes, the total verticalization time per day would be quite sufficient.

Let us remind you once again that the verticalizer is part of postural (or physical) management. And as physical therapist Pauline Pope said: "If you only have one hour a day to help a child with severe motor impairment, then spend it on organizing a physical management program, as no amount of exercise or training can prevent the development of secondary complications." .

When writing the article, materials from the book "Rehabilitation of Children with Cerebral Palsy: A Review of Modern Approaches to Help Rehabilitation Centers" were used.

Nowadays, the question of the importance of verticalization of children with cerebral palsy is no longer raised. All experts agree that the use of a standing support for children with musculoskeletal disorders is a necessity. Cerebral palsy is not as scary as secondary complications caused by the child's incorrect position. Timely start of using a verticalizer for children with cerebral palsy is the prevention of osteoporosis, disruption of the functioning of internal organs and systems. Man is an upright creature, vertical position and the action of gravity are the basis for the construction of all vital functions of the body.

If the question of the need to verticalize children with musculoskeletal disorders is no longer raised, then another equally important question arises: when should this process begin? From what age? From the age when a normally developing child begins to walk. About a year ago.

Next, an important question arises: which verticalizer (standing support) should I use? The market offers a wide range of verticalizer supports for children with cerebral palsy, but not all can help a particular child. It all depends on their functionality.

Verticalizers are divided into 2 main types: rear-support and front-support. There are also those that combine both types.

The selection of verticalizers is carried out based on the child's motor impairments.

Table 2. Selection of a verticalizer based on the child's motor impairments

Supports (verticalizers): main types	Purpose	Support functions
Rear support verticalizer 	• Used for children with poor control over the position of the torso and head. • Used for children with severe contractures of the hips and knee joints. • It is most often used for older children, since moving to a standing position with support on the back is easier to perform. • Improves psycho-emotional state.	• Must be able to move from horizontal to vertical position. • It should be possible to install additional accessories taking into account the functionality and anatomical features of the child. • Must provide safety and comfort. • Must provide correct symmetrical standing posture (see standing rules)
Front-support verticalizer 	• Promotes muscle stretching when bending forward. • Provides extension of the hip and knee joints. • Gives the child a feeling of security. • Provides the child with a good field of view. • Provides maximum activity in a standing position. • Children who have difficulty controlling their head can often move their head more freely. • A good workout for the head, hands and arms. • Improves psycho-emotional state	• Must be able to tilt forward up to 35 degrees. • It should be possible to install additional accessories taking into account the functionality and anatomical features of the child. • Must provide safety and comfort • Must provide correct symmetrical standing posture (see standing rules)

In addition to the fact that verticalizers are divided into rear-support and front-support, they also have many models:

- Single-level models are budget models. They allow the child to stand, but do not allow the child to change body position if necessary. Therefore, in order for the child to sit or lie down, he will have to be unhooked from the device. But most single-level models can still change the angle of inclination by 20-40 degrees.
- Multi-level models are already quite expensiveexpensive.
- But the overpayment is compensated by the presence of several modes, due to which children can not only stand in the verticalizer, but also be in other positions (half-standing, sitting and lying down). This is very convenient as it allows the child to take a short rest at any time.
- The static verticalizer is designed to passively assume a vertical position. In this situation, the body adapts to the new state. The verticalizer has wheels, so the child can be transported without difficulty.
- Mobile devices have large rear wheels, allowing the child to move around while standing in the device. They can change the angle of the central pillar, which allows you to increase the load on the lower girdle of the limbs.
- Active verticalizers make it possible to train the leg muscles while performing arm movements.

Many models have additional accessories and fixtures.

Table 3. List of additional accessories

Accessories	Accessories Purpose, functions
Step	• ensures uniform distribution of the load on the pelvis/hips/feet, • can take into account different leg lengths, contractures and deformities.
Knee supports	• can be of different configurations to ensure the correct position of the joints while standing.
Pelvic support	• can be of different configurations with and without separator, • ensure stability of the pelvis and keep it in a symmetrical neutral position.
Breast support	• used to stabilize the body in a symmetrical position, • correct and prevent the development and aggravation of secondary deformities.
Headrest	• provides orientation along the midline, • prevents the head from tilting back.
Belts	• are used to further stabilize the torso while maintaining the maximum possible activity and comfort of the child.
Table	• Stabilizes the upper body. • Provides additional support. • Provides stabilization of the body in a symmetrical position. • Allows you to install additional accessories.

The choice of the type of verticalizer is made, first of all, by the doctor. But parents should also understand their diversity.

If the task is to rehabilitate a child with musculoskeletal disorders, who cannot even sit, let alone stand, on his own, then it is necessary to provide him with conditions that are similar in mechanism to the natural biomechanics of a normotypical child. And this is where problems arise, since not all standing supports for children with cerebral palsy meet the necessary functional requirements. Will such a child be of great benefit if the support provides him with only a vertical position?

Of course, the body will be ensured the correct position of the internal organs and the normalization of the vital functions of the body. Without a doubt, this is important, but the task is larger! It is necessary to use all the child's systems, including muscles and joints.

How to do it? Use the correct support - a verticalizer, which functionally contains all the laws of biomechanics (Figure 9). Such a standing support - a verticalizer - not only ensures the vertical position of the child, but is also capable of providing a gradual, step-by-step increase in the load on the muscles of the back, legs and joints.

Figure 9. Standers

A correct standing support, from a biomechanical point of view, should have the following functions, namely:

❖ Headrest adjustable in different planes. If a child has problems holding his head up on his own, a headrest will help fix his head in the correct position. For some complex cases, you may need an anatomical headrest with an emphasis on one side, or with greater coverage than a standard headrest.

❖ Thoracic fixator. The thoracic vertical support for children with cerebral palsy should ensure the correct vertical position of the back, which corresponds to the position of the back of a healthy person. The correct position of the spine is the prevention of curvature and scoliosis. Correct posture is the basis for the proper functioning of internal organs.

❖ Pelvic support adjustable in height and depth. The child's pelvic area must be clearly and rigidly fixed to ensure uniform and correct load on the hip joints.

❖ Height and depth adjustable knee supports. Knee supports ensure correct leg positioning and help distribute the load evenly.

❖ The standing support must be equipped with a function of smooth vertical tilt adjustment. At any stage of rehabilitation with the help of support, it is very important to dose the load on the body. Start with a smaller one and gradually increase it. Load adjustment can only be achieved by changing the angle of inclination of the vertical axis. You cannot place it in a full vertical position at the initial stage of verticalization; you must start with a tilt of 45 degrees. As certain progress is achieved, the angle must be changed to ensure an increase in load.

❖ The standing support must have the function of isolated leg extension (each leg separately). Also, as in the case of adjusting the vertical inclination, providing a gradual load, from less to more, adjusting the load on the legs is of great importance. Often, when there are already secondary complications caused by a lack of load on the legs, and, as a result, joint dislocations that have arisen, it is important not only to create a load, but also to return the joint to its place. The gradual load, which is provided by spreading the legs, returns the joint to the acetabulum.

❖ Standing device for children with cerebral palsy, must have the function of adjusting the height of the footrest (each leg separately). One of the most common phenomena caused by a secondary complication is different leg lengths. This is due to the fact that the joints of the legs can come out of the joint capsule at different speeds, under the influence of a number of reasons. As a result, we get legs of different lengths. If you place such a child in a support without the function of adjusting the height of the footrest for each leg separately, it will turn out that one leg will stand, experiencing excessive load, taking the weight of the whole body, and the second will hang freely in the air, not experiencing any load at all. It is worth considering the need to distribute the load on both legs.

Figure 10. Design features of verticalizers, namely: they have the function of adjusting the height of the footrest (each leg separately)

It is imperative to place a child with cerebral palsy in a standing support and verticalize it, and the sooner you start verticalization, the better. The only thing worse than the fact of having the disease is the secondary complications it causes. Standing supports that do not have the function of changing the tilt along the vertical axis and the function of isolated leg extension are not able to provide a complete range of rehabilitation measures.

Conclusion

Doctors recommend that all children with musculoskeletal disorders, including children with cerebral palsy, use various orthopedic products (splints, shoes, insoles, etc.). But not all parents put doctors' recommendations into practice, and this is very important.

For example, if a child is recommended to sleep at night in splints for the ankle joints, then in order to effectively prevent complications - the development of contractures and deformities - they should be used every night for at least 8 hours. If you wear night splints several times a week (two to three times for two hours), this will not be enough to prevent complications.

Wearing orthopedic shoes or orthoses is necessary for proper development of the foot. Shoes prevent the development of deformities and contractures. Therefore, it must be used not only when going outside, but also indoors.

For proper development of the foot and correction of deformities of the feet and leg joints, orthopedic shoes must be used constantly during the day. Shoes must be selected according to size and individual measurements

It is necessary to promptly replace orthopedic products as the child grows. A child with communication difficulties or intellectual disabilities often cannot communicate that shoes are too small or cause other discomfort; adults must take care of this. If necessary, contact ITU to make changes and additions to the IPR.

To reduce muscle tone at home, a simple massage is recommended, namely:

- ❖ Hand massage. First, lightly shake the child's hand to relax it. Then stroking from top to bottom, gentle rubbing and patting. Try placing your thumb in your child's palm. When he squeezes your finger, lift the handle and massage the other side.
- ❖ Leg and foot massage. First, stroking and gently rubbing the legs from top to bottom. Afterwards, we start massaging the foot, first you need to massage it thoroughly, and then draw a figure eight from your toes to the heel with your index finger, repeat the drawing several times.
- ❖ Back massage. It must be done in order to strengthen the child's back muscles. You need to massage the back from the neck to the buttocks, using stroking, rubbing, and patting. Do not massage your spine under any circumstances!
- ❖ Tummy massage. Very important! The belly can only be stroked and only clockwise. Your hands should be warm. After the massage, there is no need to immediately dress the child. Let it lie there for a few more minutes under a light sheet.

Such a massage will not harm your child, and if you give him at least 10 minutes a day, it will be beneficial.

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Issue Article

Artur Aleksandrovich Blagorodov
Institute of Service Sector and Entrepreneurship(branch) DSTU
master's degree
Shakhty, Russia

Victoria Sergeevna Belysheva
Institute of Service Sector and Entrepreneurship(branch) DSTU
Ph.D., Associate Professor

Lyudmila Borisovna Tomilina
Institute of Service Sector and Entrepreneurship(branch) DSTU
senior teacher

Natalya Valerievna Volkova
LLC TsPOSN «Ortomoda»
PhD in Law, Director

Galina Yurievna Volkova
LLC TsPOSN «Ortomoda»
Doctor of Economics, Professor
Moscow, Russia

DISADVANTAGES OF A SYSTEMATIC APPROACH TO PROVIDING ASSISTANCE TO CHILDREN WITH CEREBRAL PALSY IN RUSSIA

Abstract*: in the article, the authors talk about the radical transformation of economic and social life taking place in countries, which has led to the extreme actualization of the problem of social protection of children with disabilities. Total denationalization, market transformations, on the one hand, and, on the other, the deterioration of the social ecology and, above all, the multiple increase in the birth rate of children with disabilities, contributed to the formation of an entire social group - disabled children, for whom it is necessary to create a special social protection system in in general and specific state social assistance in particular.*

Key words*: Russia, cerebral palsy, orthopedic shoes, orthoses, children with disabilities.*

Language*: English*

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Introduction

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Statistics show that the number of disabled people on earth is a constant value and amounts to five percent of the total population, which means that every person, regardless of age, health, nationality, religion, social and financial status, has a 5 percent chance of becoming parent of a disabled child. The World Health Organization states that those born with disabilities account for almost 11%, that is, every tenth child is born with psychophysical disabilities, the rest acquire disabilities at the time of birth and throughout life. According to UNESCO, among almost seven billion people on earth today there are over 600 million people with disabilities, of which 100 million are children, more than 30 percent of them do not attend school. Persons with disabilities remain currently marginalized in education systems.

In each state, to solve the problems of people with disabilities, there is a priority area of social policy - social protection of people with disabilities, including children with disabilities.

Over the past thirty years, stable trends and mechanisms have emerged in the world for formulating policies regarding people with disabilities, supporting governments of various countries in developing approaches to solving the problems of this social group and assisting state and public institutions in defining and implementing policies addressed to people with disabilities.

Social policy is a set of principles, methods and ways of influencing the state on the social sphere of society. States have priority areas of social policy, one of which is social protection of people with disabilities.

Social protection systems for children with disabilities in each country have developed historically and, despite the similarity and uniformity of the tasks being solved, they have fundamental differences in approaches, organization, and principles.

Main part

In this regard, three models of social protection of children with disabilities abroad can be distinguished, depending on the role of the state and/or non-state sector in this area.

The first model is maximum participation of the public sector. This model prevails in Austria, Belgium, Germany, Ireland, Italy, Finland, France, and Japan. The basis of the state policy for the protection of children with disabilities is caring for a disabled child through the redistribution of income in favor of those families who have such children. Health and education systems are generally accessible and free.

The second model is minimal state participation in the social protection of children with disabilities. In Latin American countries (Argentina, Brazil, Peru, Uruguay, Chile), the denationalization of the social sphere has led to the fact that it is practically privatized and is in the hands of private individuals, there is almost no state social security, free education and affordable medical care.

The third model is a mixed system of social protection for children with disabilities. This model is typical for Great Britain, Holland, Denmark, Norway, Poland, Sweden, USA, CIS countries and Russia. It combines public and private forms of protection for children with disabilities. Social protection of children with disabilities is carried out mainly through developed social insurance systems, the financial basis of which is taxation. Non-governmental organizations that implement various programs to help children with disabilities play a significant role in protecting children with disabilities.

The following are involved in the social protection of children with disabilities:

state organizations for the social protection of children with disabilities.

These organizations are sponsored by the federal government, state, and county. They are financed by state tax, that is, a specialist working in them receives a salary from the state budget. State and local authorities are responsible for developing a national social policy in the field of social protection of children with disabilities and its implementation throughout the country, as well as at the regional and local levels.

They coordinate activities to implement social protection programs for children with disabilities with other official institutions, as well as with non-profit organizations and businesses. Within the budgetary capabilities of each state, these organizations implement programs to provide various types of social assistance to children with disabilities and their families.

The Children with Disabilities Service provides social, medical, legal and guardianship services to children with disabilities.

Local government organizations have different structures in different countries, but their role is the same - to carry out social policy in the field of social protection of children with disabilities at the local level.

Private social organizations for the social protection of children with disabilities.

These organizations are also called entrepreneurial or commercial. They are financed in a mixed way: through charitable contributions, gifts from individuals, fees from persons to whom services are provided, and government appropriations.

The main link in this structure is the social agency. This is a standard form of organizing assistance to the population, including children with disabilities. This organization is led by a Board of Directors. The agency is usually staffed by professional social workers, representatives of other specialties, and technical personnel (assistants). These organizations have clear bylaws that determine which clients to serve, what problems to solve, and what methods to use.

Voluntary organizations for the social protection of children with disabilities.

They are usually called non-profit. However, according to foreign authors, talking about them as non-profit organizations is not entirely accurate, since many of them have a very large income. The most important thing is that all profits received are used to expand charitable activities.

According to American authors, the term “voluntary organization” does not quite correspond to the modern situation of these organizations. Currently, bureaucratization and professionalization have penetrated into this area. The term “non-profit” better expresses the essence of these organizations than “voluntary”.

And yet, with all their state and commercial elements that have appeared recently, voluntary organizations have guidelines that are different from those of other organizations and, in general, form the third organizational sector in the social protection of children with disabilities. Volunteer organizations can operate at the local, state, and national levels.

Thus, in every state, in order to solve the problems of people with disabilities, there is a priority area of social policy - social protection of people with disabilities, including disabled children. It consists in preventing social foundations that contribute to the dynamics of growth of disability among the child population, creating conditions for a full life for such children; promoting the process of adaptation, rehabilitation, and integration of children into the system of social relations. Abroad, the implementation of this area of social policy can be carried out by government agencies, private organizations, and volunteer associations.

Based on the influence of which organizations predominate in the country, there are three models of social protection of children with disabilities: maximum participation of the public sector, minimal participation of the public sector, mixed system of social protection of children with disabilities.

For the purpose of social protection of disabled children, laws are adopted, funds are allocated for the organization of treatment, rehabilitation, education and leisure, measures are taken to provide barrier-free access to various structures and to provide information. Additional meals, summer holidays, etc. are provided for children with disabilities.

The lack of adequate rehabilitation is the cause of persistent disability of children, leading to the loss of the opportunity to study in a comprehensive school, which means living in a wheelchair within one’s apartment and a sharp narrowing of the circle of people in contact with the child.

Let us give examples of the organization of care for patients with cerebral palsy in some countries and in Russia.

In many countries, a network of rehabilitation centers for disabled children has become widespread. In such centers, the so-called team method is usually used: a group of specialists of different profiles works with the child (physical therapy methodologist, physiotherapist, psychologist, teacher, etc.), who implement an individual comprehensive rehabilitation program developed in accordance with the capabilities and psychophysical characteristics of the child. Due to cerebral palsy, they visit these centers along with children who have other developmental problems.

In Germany there is a system similar to the Russian one. Special schools have been opened for children with cerebral palsy, where, along with education, children receive treatment, exercise therapy, speech therapy assistance, and job training. The schools employ teachers with defectological education. But there are also significant differences, namely:

firstly, children are at school only during the daytime, since it is considered inappropriate to separate a child from his family for the entire working week. At the same time, children are transported to and from school by school employees using specially equipped transport;

secondly, and this is an undoubted advantage, children are admitted to school regardless of the severity of their motor and intellectual disabilities.

Work with them is carried out differentially, taking into account the severity of motor pathology and the level of mental development. Of course, with such a diverse and difficult contingent, the problem of personnel arises. In Germany, this problem is solved by involving conscripts undergoing alternative service to work in schools for children with cerebral palsy. This not only helps solve the problem of personnel to work with the most difficult children, but also has great social significance. Conscripts become acquainted with the problems of disabled people with impairments in physical and mental development. Young people develop a positive attitude towards them. Some conscripts consciously choose medical or teaching professions after finishing their service.

In Hungary, over the last decade, another model of correctional pedagogical work with children with cerebral palsy, called conductive pedagogy, has gained the greatest fame and popularity. This trend originated in Hungary in the late 40s and became widespread throughout the world. The method of conductive pedagogy was developed by Peto in 1945-1967, and later developed by the school of M. Hari (1971). Conductive pedagogy is currently considered one of the most effective methods for overcoming motor disorders in children with cerebral palsy without pronounced deviations in mental development. The widespread use of this system in our country is hampered by the fact that only the Association of Conductive Teachers has the right to train specialists in conductive pedagogy. Training is provided on a paid basis only for member countries of the Association.

The term "conductive pedagogy" means "learning organized by a conductor." The method is based on a systematic pedagogical approach to; education of functions, in which the main attention is paid to medical and pedagogical correction aimed at; to develop the child’s independent activity and independence. A conductor is a specialist who knows the problems of medicine, pedagogy, physical therapy, speech therapy, and psychology. He is the only specialist working with the child. The teacher-conductor, working with children throughout the day, pays attention to training movements, speech, psyche, and emotional reactions. The conductor, together with the doctor, evaluates the child's motor abilities and determines ways to correct them. Its main goal is to overcome motor, speech and mental disabilities through education, development of detainees and correction of impaired functions. To do this, the child, starting from the moment he opens his eyes in the morning, must constantly be aware of and purposefully make every movement necessary to get out of bed, wash, go to the toilet, have breakfast, move around the room, etc. The conductor suggests the child, with the help of a kind of auto-training, relax, take the starting position necessary for each motor complex. At this moment, the child hums melodies that help him relax. Then, moving on to active movement and as he masters this movement, he pronounces it, for example: "I am standing", "I am walking", "I have gone", "I am taking a spoon", etc. This is an active awareness of the movement being performed, permanently reinforced by a strong stimulus - in a word, it is extremely effective for stimulating motor activity and motor capabilities.

The very performance of self-service movements is a method of development and correction of impaired motor functions. Thus, in the process of getting out of bed, raising the head, turning the body, sitting down, and vertical positioning of the body are mastered. The conductor's task is to help the child perform these motor complexes through verbal instructions, imitative movements, and correction of incorrect positions of the child's body and limbs and his movements through passive movements. The conductor focuses the children's attention on the most successful self-correction techniques that help them master one or another motor complex, reinforcing it with repetition if necessary. Stimulation of the development of movements occurs with maximum awareness by the child of the need for each motor complex.

A constant positive emotional background is extremely important. The conductor helps the child master the movement, points out his achievements and further opportunities for the development of the mastered motor complex, and rewards him for what he has done. So, if a child begins to stand, the conductor praises him for this, tells him how well, beautifully he is standing, now he can see much more, look at what is happening in the room and at what is happening outside the window. Now he needs to learn to move his legs, and he will walk, run, and play. When performing a particular task, the conductor strives to evoke the maximum emotional reaction of the child, talks to him in a calm tone, encourages him for the minimum success achieved, encourages him to repeat, setting his results as an example for other children. The conductor never makes comments to a specific child, but addresses the entire group. He tries not to give instructions or orders to perform a particular movement. There are no strict instructions - "do this", "do this" in the conduction system. The conductor strives to awaken activity and motivation in the child, relying on indicative cognitive motor reactions, the development of which, although delayed, is not completely lost. For example, the conductor invites children who cannot take their first steps with the help of crutches to look out the window at how beautiful the snow is falling and whether there is enough of it for sledding. Incorporating a positive emotional response encourages the desire to start moving around like other children.

An important point in stimulating physical activity is the participation of all children, regardless of their condition, in acts of self-care (cleaning shoes, washing dishes, clearing the table after meals, sweeping the room, etc.), and what is especially significant is the child's awareness of the usefulness of his life activities .

The pedagogical approach to the development of functions involves group classes. The group includes children with different motor abilities. This gives rise to a desire to improve one's motor skills and imitate those children whose skills are more developed. Learning voluntary motor activity occurs in the process of everyday life, i.e. it forms part of the life of the child himself. The group, under the guidance of a teacher-conductor, masters various types of activities throughout the day - getting out of bed, washing, going to the toilet, eating, cleaning the room, etc. Children naturally become involved in a set of movements aimed at achieving a goal. The conductor strives to immediately develop complex functions in the child, which in one way or another include more primitive ones, while at the beginning he does not focus on the quality of movements. Gradually, in the process of special exercises and daily activities, movements are improved. In some cases, the fundamental task can be broken down into a number of simple actions that are integrated during the activity. The conductor selects his own individual lesson program for each child. He monitors the execution of all movements, helps to complete them if the child is not able to do this at this stage. Thus, children do not experience a feeling of dissatisfaction, which can suppress the incentive to act. Achieving positive results creates a positive emotional background and the need to repeat the task. Repetition of motor patterns in the process of daily activities gradually improves the child's motor skills, speech and mental development.

The United States has a different system of assistance to children and adults with disabilities. Rehabilitation is carried out both in centers specially equipped for this purpose, and in a variety of private and public agencies, where they mainly provide vocational training. Now in the United States there are about 300 rehabilitation centers for people with disabilities due to cerebral palsy; this is one of the most developed networks in the country. Such a large number is explained by the fact that after the victory over polio, cerebral palsy is the most common group of neuromuscular disorders. In addition, where services for people with other disabilities (muscular dystrophy, multiple sclerosis, mentally retarded or patients with comorbidities) are lacking or ineffective, these centers offer their services to them.

The rehabilitation programs offered by the centers vary somewhat in detail depending on material security, relationships with nearby hospitals, government services, and the needs of people with disabilities living specifically in a given region. The central headquarters of the Association of Cerebral Palsy in New York, which oversees these centers, only draws a general line and provides information. But, despite the differences, the general principles of the centers' activities are the same. They are established by a Board of Directors, consisting of prominent and respected citizens of the city, and are supported financially by funds from government organizations, as well as through fundraising campaigns. They have an active corps of volunteers who participate in fundraising, clerical and other support work. The centers liaise with rehabilitation agencies, as well as with local educational authorities, camps for the disabled, nearby hospitals, colleges and universities, whose students often work as voluntary helpers. Collaborators at the center are convinced that rehabilitation is a global process that includes every aspect of life: physical, social, emotional, recreational, educational and professional.

Most experts in the world reasonably consider cerebral palsy to be a collective concept that unites a group of syndromes that arise as a result of underdevelopment and/or damage to the brain in the prenatal, intranatal and/or early postnatal periods and subsequently manifest themselves, first of all, by the inability to maintain a posture and perform voluntary movements. Cerebral palsy (CP) is a disease of the central nervous system characterized by pathological motor activity and abnormal postural disturbances. It is also recognized in the scientific and medical community that the term cerebral palsy cannot include all the variety of pathological changes that occur with this disease.

Children who do not have or have lost the function of support and movement since birth are patients with a sharp limitation of vital activity criteria. Lack of movement and load for a long time leads to the formation of joint contractures, deformation of the limbs and spine, disruption of statics and movement, up to a complete loss of the ability to move and self-care. Long-term physical inactivity causes inflammatory diseases of the digestive system, disorders of mineral metabolism, the development of osteoporosis, the progression of skeletal deformities leading to complete immobility, the formation of cardiopulmonary failure, which is an obstacle to communication, leads to stress, depression and further aggravates the above-mentioned disorders.

Since cerebral palsy is a congenital disease and its typical symptoms do not disappear permanently, appropriate types of assistance must be provided from the beginning of life and throughout its entire life. Therefore, a full-fledged center usually includes the following services: a school, various training programs for children and adolescents, pre-vocational training programs for youth (mastering general skills necessary for further professional training), vocational training for adults in workshops. Since the multiplicity and combination of disorders is the rule rather than the exception in cerebral palsy, the centers have services for physical therapy, household adaptations, social and psychotherapy, and vocational guidance. Full-fledged centers must also provide full medical examination and treatment by pediatricians, orthopedists, ophthalmologists, neurologists, psychiatrists, etc. In addition, the center must maintain contact with the family of the disabled person.

A typical rehabilitation program has the following components, namely:

The physical therapy program includes assessment of sitting, crawling, walking and standing abilities; exercises for the development of motor skills and functional activity (the patient learns to move from bed to chair, climb stairs, etc.). The goal of the program is to develop muscle strength, coordination of movements, the ability to maintain balance, and teach how to use auxiliary orthopedic devices - crutches, canes and other means.

The home adaptation program focuses on activities of daily living—eating, dressing, and maintaining hygiene. This activity requires preparation and training in the use of special non-spill cups or cutlery with special handles, and other devices designed for the disabled. The program includes mastering some activities necessary in everyday life (cooking, handicrafts). The goal of the program is to achieve maximum independence in everyday life.

The recreational program includes indoor games (checkers, chess) and outdoor games using appropriate equipment, summer camps, participation in scout organizations, organization of various clubs, etc. The goal of the program is to give children the opportunity for meaningful entertainment, improve social skills, and fill the life of a disabled person with new ones, sensations, new experiences.

The vocational training program includes pre-vocational training to perform basic labor skills, vocational guidance, vocational training and placement in the open labor market. The goal of the program is to prepare a disabled person to perform useful, socially significant and decently paid work.

The speech and hearing correction program includes a developmental assessment! these functions, speech therapy work, development of verbal and non-verbal communication abilities, ear training. The goal of the program is the treatment of speech and hearing defects and the development of communication abilities.

The psychological program includes an assessment of the level of intelligence, personal development and general abilities; counseling on personal, emotional problems and psychotherapy; diagnosis of learning disabilities; participation in the planning and implementation of compulsory and professional programs; parent counseling. The goal of the program is to determine abilities and needs, and help in solving individual psychological problems.

The social assistance program includes studying the home environment of a disabled person, his family relationships; periodic conversations with parents with the aim of closer cooperation in meeting the patient's needs; organizing discussion groups for parents where they could share their experiences; organizing the use of local resources (various rehabilitation agencies, summer camps, domestic help services, etc.). The goal of the program is to strengthen the involvement of the family of a disabled person in the rehabilitation process, to help solve the practical and personal problems of a disabled person.

The educational and training program consists of a developmental program starting from infancy, a school preparation program, and special education for the mentally retarded. The goal of the program is to minimize learning disabilities and develop intellectual and social skills. But they, with regret, do not provide rehabilitation for a child with cerebral palsy.

Rehabilitation centers for patients with cerebral palsy often have other services and programs that directly or indirectly affect the rehabilitation process. These could range from home economics courses to consumer rights courses to those that involve patients in research related to diagnosis and treatment.

In Russia, according to official data, there are about 1.5 million children with serious disabilities of the musculoskeletal system, including at least 300 thousand disabled children. The number of children with severe forms of cerebral palsy, clubfoot, etc. is constantly growing. Enormous amounts of money are spent on supporting the livelihoods of disabled children. At the same time, every year thousands of disabled children sit in wheelchairs for the rest of their lives.

Children with cerebral palsy are often limited in their daily activities due to the occurrence of primary and secondary disorders. A valid and reliable assessment of functional limitations in children with cerebral palsy at the clinical level can be made using the Effective Motor Function Classification System (GMFCS) for children under 12 years of age. The GMFCS allows clinicians to formalize the severity of a child's functional limitations into one of five levels. Children of level 1, having only mild restrictions in everyday life, are slightly different from their healthy peers. Conversely, children at level 5 are the most limited in their daily life activities due to severe impairment of control of head and torso position.

Of the most common forms, the spastic form of cerebral palsy is the most common and is observed in approximately 80% of all children with cerebral palsy. According to the International Society of Prosthetics and Orthotics (ISPO), the goals of lower extremity orthotics in this population should be to correct and/or prevent deformities, provide support, facilitate skill learning, and improve ambulation efficiency.

In this case, it is necessary to achieve, namely:

- increasing range of motion;
- maintaining or increasing the level of functionality and stability;
- maintaining constant control of muscle length during skeletal growth.

Cerebral palsy is the most common cause of childhood disability, and each child with cerebral palsy has a unique motor control pattern that affects posture and balance while walking and standing.

In addition to technical means of rehabilitation (strollers, walkers, canes, etc.), which are absolutely necessary for every patient with cerebral palsy at various stages of rehabilitation, orthopedists and neurologists in the treatment of such children use a sufficient number of orthopedic products, primarily orthopedic shoes. Orthopedic shoes improve the ability of patients to move and delay the moment of complete dependence on a wheelchair. Today, the effectiveness of some has been clinically proven and they are widely used in practice, while the positive qualities of other groups of used structures are questionable.

In Russia today, unfortunately, there are no effective methods for the rehabilitation of disabled children, namely children with cerebral palsy, and there are no national standards or procedures for medical care. Therefore, it is necessary at the state level to approve a standard for the rehabilitation of children with cerebral palsy and, first of all, for children with a spastic form of cerebral palsy of the lower extremities.

To do this, it is necessary to intensify the role of orthotics in the complex treatment of children with cerebral palsy, as it forms the relationship of all key aspects, and ensures their relationship with all means and forms of treatment, namely:

- neurological;
- orthopedic;
- pediatric;
- physiotherapy;
- multidisciplinary;
- social.

Orthotics is the process of using special devices (orthoses) to support, stabilize or correct parts of the body, usually used for medical purposes. Orthoses can be designed for different parts of the body such as joints, spine, limbs, etc. and help improve functionality or provide protection from further damage.

In Russia, orthosis, as part of the prosthetic and orthopedic provision, for children with cerebral palsy syndromes is a very long, labor-intensive and, as it seems to us, extremely ineffective process. Despite the postulates of rehabilitation of this category of children, accepted by the world medical community (comprehensive multidisciplinary rehabilitation), in Russia there is no talk of such “complexity” yet.

Unfortunately, the current socio-economic situation in the country has led to the collapse of the existing system of providing assistance to these children. The regional centers that have been created and are being created suffer from the lack of specially trained medical personnel and paramedical personnel (especially in the field of exercise therapy, orthopedics and rehabilitation) and a systematic approach to treatment. According to prof. V.G. Barefoot, ill-conceived use of known, including modern, rehabilitation methods and techniques sharply reduces the effectiveness of treatment measures, and sometimes is even harmful. Information deficiency does not help improve the situation either. Today, there is a big problem of ignorance among the medical community involved in the examination and treatment of children with cerebral palsy in Russian medium and small cities, and even more so in rural areas. And only large federal medical centers and leading industry research institutes in Russia have information about the specifics of orthotics for this category of patients, which must be extended to all identical rehabilitation centers in Russia.

Also, one of the main reasons for the ineffectiveness of existing domestic treatments for children with cerebral palsy is the lack of systematic medical control over the prescription and use of orthoses in this category of patients. Despite this, in combination with other medical, conservative and surgical methods, orthosis and orthosis therapy play an important role in facilitating the rehabilitation of children with cerebral palsy.

A thorough and objective assessment of the child's present and future needs will ensure effective rehabilitation. Naturally, the need of each child depends on the severity of his condition and his functional limitations.

Orthopedic care and orthotics are intended for various functional levels of the child’s condition, namely:

- a child unable to stand (given that this may be the highest level of activity for some children);
- child able to stand;
- a child capable of walking.

Comparison and assessment of the data necessary to determine the direction of rehabilitation and, consequently, the need and/or benefit of orthotics in a given rehabilitation plan is an interdisciplinary task. The required amount of data typically includes accurate diagnosis using SCPE classification; functional status of functions using GMFCS; measuring the volume of passive and active movements in joints; local study of muscle strength and spasticity, as well as x-ray diagnostics of large joints. In addition, postural pattern assessment, standing balance, and gait analysis are performed. Other factors that influence the formation of a rehabilitation plan should also be taken into account: the environment in which the child is located, his behavioral characteristics, concomitant disorders such as epilepsy, gastroesophageal reflux, or the need for tube feeding.

After determining the direction of rehabilitation, various methods of therapy (including oral, intramuscular or subcutaneous drugs), orthopedic and neurological surgery, physical therapy and occupational therapy, technical means of rehabilitation (wheelchairs, crutches, etc.), staged plaster casting or splinting are prescribed. These methods may be prescribed as more effective or in addition to orthotics.

However, for children with cerebral palsy, doctors in Russia everywhere either do not prescribe prosthetic and orthopedic products at all, or, often mechanically, prescribe devices with the beautiful term “orthoses”, without understanding what they are talking about and without monitoring the use of these means of rehabilitation. In order to analyze Russian research and published scientific data, we searched for publications, the main of which: RSCI (http://elibrary.ru) and SCIENCE INDEX.

It was found that there are very few scientific and popular science publications in Russian publications, and those that exist often do not provide statistical data on the effective use of orthotics in the rehabilitation of children with cerebral palsy. Some directly advertise orthoses of their own design or production, without justifying their effectiveness.

In our opinion, in the direction of rehabilitation of children with spastic syndromes, in every major federal medical institution and regional medical center that provides medical care to patients with cerebral palsy and its consequences, it is necessary to organize a structural unit involved in orthotics for this category of citizens. In medium-sized and small cities, this work should be entrusted to a large medical institution at the central (regional, republican) level, which would advise and provide orthoses to small healthcare facilities of various levels of subordination.

The institution must have a Technical and Orthopedic Department, whose tasks include determining the type of orthosis, manufacturing the orthosis during the treatment process, and developing an orthotic therapy plan together with the doctors involved and the child's parents.

The technical and orthopedic department includes an orthopedic doctor's office, an impression making room, and an orthotic workshop. Products made from polymer materials are manufactured in the institution itself, and more complex devices are manufactured in leading orthopedic production centers in Russia. This model of work will enable the child to receive an orthosis immediately in a health care facility, the parent to learn the principle of working with this product, and the doctor to have clinical control over the effectiveness of the prescribed orthosis and correction of the rehabilitation plan with its use.

Conclusion

In Russian medical institutions there is no single agreed methodology for the rehabilitation of children with cerebral palsy, there are no national standards and procedures for medical care. In Moscow and St. Petersburg, local health authorities have approved methodological recommendations for the treatment of children with cerebral palsy. However, in order to determine the advantages or disadvantages of a particular type of orthosis and rehabilitation, reliable and reliable research and classification methods are needed, such as in the leading countries of the world. Of course, the results of orthopedic intervention to prevent deformities should be assessed taking into account the improvements in activity that have occurred. But the role of orthotics in the rehabilitation of children with cerebral palsy should not be underestimated. Therefore, it is necessary at the state level to determine the general canons of rehabilitation of children with cerebral palsy and, first of all, orthotics. To do this, it is simply necessary to continue to study the role of orthotics in the complex treatment of children with cerebral palsy, the relationship of all key aspects, and to include this area in all scientific and practical forums in Russia and the regions: neurological, orthopedic, pediatric, physiotherapeutic, multidisciplinary, social.

Today, it is accepted as an axiom all over the world that only a united medical team, including the child's parents, an orthotist-doctor, an orthopedist-doctor, a physiotherapist and a neurologist, can ensure results and ensure progress in the rehabilitation of a child with cerebral palsy throughout his development. Whatever the treatment goals and orthosis design, in an outcome-oriented family, the approach will promote appropriate use of the orthosis throughout the rehabilitation period. Therefore, the medical team, including the prosthetist, must be well coordinated, work in partnership with the family, provide adequate information support about the role of orthotics, participate in the correct use of the prescribed orthosis by the family, and public medical institutions guarantee the family effective financial assistance.

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Issue Article

Oksana Igorevna Korotkova
Institute of Nano Technologies, Electronics and Instrumentation Southern Federal University
Ph.D., Associate Professor,
Taganrog, Russia

Artur Aleksandrovich Blagorodov
Institute of Service Sector and Entrepreneurship(branch) DSTU
master's degree

Vladimir Timofeevich Prokhorov
Institute of Service Sector and Entrepreneurship(branch) DSTU
Doctor of Technical Sciences, Professor
Shakhty, Russia

Natalya Valerievna Volkova
LLC TsPOSN «Ortomoda»
PhD in Law, Director

Galina Yurievna Volkova
LLC TsPOSN «Ortomoda»
Doctor of Economics, Professor
Moscow, Russia

FEATURES OF ENGINEERING ACTIVITY IN MODERN REALITY

Abstract*: In the article, the authors for the first time made an attempt to combine the material necessary for students to prepare them into a single complex called "Fundamentals of Engineering." With such an organization of training, one can count on the emergence of graduates of higher educational institutions who master the basics of engineering and are capable of independent innovative activities. Just as in the 19th century blocks of academic disciplines were formed related to the targeted training of specialists in engineering specialties, so now there is a need to form a new block of academic subjects that reflect the needs of innovative development of society. A new block, reflecting the level of development of modern civilization and focused on the humanistic path of its development, is the following group of disciplines: fundamentals of engineering, history of science and technology, philosophy of science and technology, methodology of scientific and technical creativity, protection of intellectual property, technical aesthetics, fundamentals of scientific research.*

Key words*: artistic creativity, works of art, ideas, individual, consumer properties, fundamentals of engineering, innovation, engineering, regions of Russia.*

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Introduction

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In the early nineties of this century in Russia there was a demand from society for specialists capable not of routinely following established social and technical canons, but of active creative innovative activity, of adapting their professional qualities to the operating conditions of new technology and market relations developing in Russia. The relevance of the task, in addition, is dictated by the need to eliminate and prevent in the future the current significant lack of demand by society for specialists receiving higher technical education according to outdated social, scientific and technical principles, which has led and still leads to obvious and hidden unemployment, to the loss of only work in their specialty, but also the meaning of life for an entire social stratum - engineers and scientific and technical workers in Russia.

This particular situation is clearly reflected in the system of higher technical education, where it became especially aggravated during the period of so-called perestroika and then the denationalization of enterprises. Today it has become obvious that even a “good engineer”, filled with precise technical knowledge acquired at a university, is just a good performer of a given algorithm and, least of all, a creator. Life requires that an engineer be both a qualified expert in modern production and a creator of new scientific and technical projects, such as the Russian engineers I.P. Bardin, A.N. Tupolev, V.G. Shukhov and others. To solve this problem, there is only one way - to form a creative engineer, or an innovative engineer, already at a university, for which it is necessary to mobilize all the means that reveal the factors and driving forces of scientific and technical creativity. They are discussed in the monograph as very specific ways of forming a new type of engineer. These factors include psychological, philosophical, economic, sociological; in the monograph they are considered comprehensively and systematically. The leading one, in our opinion, is the factor of humanization of education. Social and philosophical problems of innovative, scientific, technical and engineering activities have now emerged as a relatively independent field of epistemology. Knowledge about scientific and technological progress, scientific and technological revolution, scientific and technical creativity, obtained only within the framework of historical, sociological, philosophical, psychological, pedagogical, economic and technical sciences, cannot fully reveal the inner essence of socio-technical innovations in scientific and technical areas of activity of modern society. Therefore, there is a need not only to improve, but also to develop a general concept for the further development of the system for training specialists with higher technical education and the methodology for its management. The creation of a new paradigm for the educational process becomes not only a pedagogical, technological or environmental problem, but also a socio-economic task, the successful solution of which determines the success of the development of the entire society. An analysis of the literature devoted to engineering activity indicates significant interest among the world community in issues related to the formation of an innovative engineer. There are many works that explore various aspects of engineering and innovation activities. These include, first of all, the works of V.V. Alekhina, L.V. Yatsenko and others.

Main part

Consideration of engineering activities and scientific and technical activities in general cannot be carried out in isolation from such a concept as “engineering art”. The definition of this concept with fairly detailed argumentation is given in the article. Here we will present, at least briefly, a view of art as a special kind of activity of representatives of various sciences.

The work of M.E. Markov can be considered fundamental in this direction. Markov, which provides the foundations of the functional theory of the arts. As the author rightly points out, “... if the essence of an object is its function, then clarifying the essence of art requires a functional approach to it.” His works provide the structure of the process of social cognition, in which the subject of analysis is the function of the implementation of the cognition process by each individual, the result of which becomes the property of all members of society. The structure is based on the procedure of transition from the primary creative process, which involves artistic creation or scientific research, to the product of creativity, which includes works of art or a scientific treatise; then to the interpretative creative process, which includes not only artistic performance, but also teaching and scientific popularization, and, finally, to the final (addressed) process with its direct perception of paintings, performances, films, books, lectures, lessons. As the final result of this process, M.E. Markov takes “changes in personality and behavior.” The functional approach to the analysis of art discussed above, although different in form from those used in science and technology, is in essence completely identical to them. What is important is not so much the coincidence of the analysis procedure as the inclusion of the entirety of scientific activity in the logic of the process of cognition at the level of art. Here the features of the sociologization of scientific creativity are clearly visible. Probably the first to notice this characteristic feature of the process under consideration was the French philosopher and sociologist Jean Marie Guyot. Alfred Fouillet writes: “According to Guyot, the peculiarity of the nineteenth century, and mainly of the centuries to come, in all likelihood, will be the creation of a social science that will dominate all other sciences that previously seemed independent of it: religious, metaphysical, moral, the science of education and, finally, aesthetic.”

Guyot, of course, could not, more than 100 years ago, talk about sociotechnical systems in the modern understanding of this term and analyze relationships in human-machine systems, justifying the primacy of the social in relation to the technical. But he very accurately noted the main function of art: “The most important task of art is to produce an aesthetic emotion of a social nature." And indeed, technical achievements have no less, and perhaps even greater, impact on society in comparison with "pure art." Moreover, in real, everyday life they come to the fore, since all members of society, without exception, are forced (and, perhaps, coerced) to use various technical devices.

The history of the development of engineering activity goes back more than one millennium. Legends and traditions quite convincingly indicate that long before our era, humanity was capable of constructing such artificial and skillful structures that cannot be accomplished without special (engineering) theoretical work. Let's take the famous "wonders of the world" as an example. According to most historical sources that have reached us, the seven wonders of the world are usually considered to be:

1. Pyramids in Egypt (3–2 thousand BC). The most grandiose - the pyramid of Cheops (146.6 m high) - according to Herodotus, was built by 100,000 thousand people over 20 years.

2. "The Hanging Gardens of Babylon" in Babylon - terraces (VII century BC).

3. Temple of Artemis in Ephesus (~550 BC).

4. Statue of Zeus at Olympia by Phidias (~430 BC).

5. Halicarnassus Mausoleum (mid-IV century BC).

6. "Colossus of Rhodes" - a statue of the sun god Helios on the island of Rhodes (~292–280 BC).

7. Lighthouse of Alexandria (~280 BC).

No one will deny that these "miracles" are works of art. However, almost all of them were not so much miraculous as engineering creations. At least six of the above miracles were primarily technical structures, i.e. requiring design and calculation from their creators. Therefore, it is legitimate to talk about engineering art from the very beginning of engineering activity. And further achievements, which the world community is especially proud of, are primarily engineering structures: the Eiffel and Ostankino towers, spaceships, etc., etc. Any miracles created by the mind and hands of man are united not only by the amazing grandeur of the plans and the majesty of execution, but also by two main features characteristic of any engineering activity: the processes of design and calculation. The presence of these very signs determines the legitimacy of the opinion that such acts are impossible without appropriate engineering work. There is another aspect of scientific and technical activity, which M. Guyot was also one of the first to highlight. He writes: "A sociologist, remarkable for the originality of his points of view and the subtlety of his mind, Gabriel Tarde, has admirably demonstrated that the social world, and even the whole world, is entirely subject to two types of forces, namely, imitation and innovation. And further: "Individualization is a task that is included in the general laws of innovation: and everything that is individual, personal, original, ingenious, is subject to the same laws... Hence, in the private world of art, as in the entire social world, one can consider two classes of people: innovators and repeaters, that is, geniuses and the public." Taking into account the above, we can safely say that the works of M. Guyot are the starting point for modern works related to the new science of innovation. An example is the study of A.I. Prigogine "Innovation: incentives and obstacles", dedicated to the analysis of innovative and routine processes. Emphasizing the sociality of any type of activity, M. Guyot writes: "The highest task of the nineteenth century was, apparently, the desire to highlight the social side of the human individual and the animate being in general, to which too little attention was paid by the egoistic materialism of the previous century." Directly concerns M. Guyot and scientific activity, speaking about scientific analysis and artistic synthesis: "Synthesizing, creating is always a matter of art, and in this regard, the creative genius of the sciences is always connected with art; inventions of applied mechanics, chemical synthesis are an art... true genius is recognized by the fact that it is broad enough to rise above the real, and logical enough to never wander away from the possible." This thesis of M. Guyot wonderfully expresses the meaning and deep essence of the entire methodology of scientific and technical creativity. The question of what role art plays in the system of training an engineer and in his activities,raised by almost all major figures in science and technology. One of the most famous organizers and founders of the Russian engineering school is Viktor Lvovich Kirpichev, whose works represent an example of an interdisciplinary and humanistic approach to the organization of training engineers. At the grand opening of the Kyiv Polytechnic Institute on August 31, 1898, he said: "The Polytechnic Institute is a higher educational institution designated for training engineers, that is, as the name itself shows, people of genius, capable of inventing and organizing new things. The concept of an engineer's activity is necessarily connected with the requirement of creative ability and constructive activity, the ability to do something new. If someone intends only to routinely copy antiquity, he does not need to graduate from a higher educational institution; his work will be that of a craftsman, not an engineer." Already at that time, during the formation of engineering activity, the need for a synthesis of humanitarian, natural scientific and technical knowledge was understood. Therefore, it is no coincidence that V.L. himself Kirpichev and other scientists refer to the example of Leonardo da Vinci as an example of an engineer: "At the dawn of the Renaissance, we meet a man who should be looked at as the founder of engineers, preparing the ideal type of the engineering profession. This is Leonardo da Vinci. He combines a scientist, a practitioner and an artist; all three of these sides must be developed in a real engineer." And, continuing, V.L. Kirpichev directly points out the need for compulsory artistic education of the future engineer: "Engineers are obliged to take care of the beauty of their structures, and, therefore, they must receive an artistic education. The essence of the requirements for an engineer was well expressed symbolically during the construction of the Zurich Polytechnic School. There, the department of general sciences - the university one - is connected with the department of applied sciences - the technical one - in a hall that is an art museum. This indicates the composition of engineering education: you need to start with pure science and build applied knowledge on it; but at the same time, do not ignore art. Those who think that works of technology are necessarily ugly and that industry is becoming more and more incompatible with art are very mistaken." At the same time L.V. Kirpichev proposes to introduce into teaching such provisions that can form the humanistic basis of any human activity. Noting that "in the technical field, fantasy is called invention," he said: "... there are numerous similarities between the three categories of brilliant people - scientists, poets, inventors." It is also logical that, like modern developers of the methodology of scientific and technical creativity, L.V. Kirpichev emphasizes the importance and possibility of developing imagination: "For young children, reading fairy tales is very important in this regard."The result of proposals in the direction of a humanistic approach to the education system can be the parting words of L.V. Kirpichev to all present and future generations of engineers working in Russia: "All sorts of templates, establishing samples, and ready-made designs are also harmful for the development of engineering. They kill imagination, take away our field of activity, and create deadness. Would it be good if we covered all of Russia with the same buildings: all churches, stations, bridges would be of the same type!" There is another Russian, purely national aspect of the issue under consideration. So, for example, in the old days in Rus', the builders of cities, bridges, dams - all those whom we now call engineers - were called "rozmysli". Thus, the Russian name "rozmysl" essentially anticipated the understanding that was established in Europe only in the 19th century. It was the Russian thoughts that personified what, combined with their natural intelligence and practical art, cemented by high spirituality and responsibility in relation to the projects being implemented, can be designated as a humanistic approach to technical work. Therefore, when approaching the analysis of engineering activity, it would be necessary, first of all, to show a retrospective of the emergence of all engineering "miracles" from the Ancient World to the present day. However, the purpose of this study is not to demonstrate the technical achievements of mankind, but to clarify those methodological aspects of engineering activity that are directly related to the humanization of engineering education. In connection with the above, it is useful to compare the views of V.L. Kirpichev and modern authors on the origin of engineering activity. On the origins of the emergence of engineering as a profession, Professor V.L. Kirpichev said in his speech at the opening of the Congress of Workers on Mining, Metallurgy and Mechanical Engineering on April 17, 1913: "Engineering has greatly advanced, received much greater importance than before, and this happened for two reasons: first, a period of intensive industrial growth began ... the second reason: industry has changed its character... Automata have replaced the former slaves, and the engineer plays the role of a commander, a genius, a leader of a crowd of slaves" (by a crowd of slaves we mean machines and mechanisms). The origins of engineering activity in the modern interpretation are analyzed in detail in the works of V.G. Gorokhov and V.M. Rosina. The prehistory of engineering activity is associated with the fact that "in the Middle Ages there was no engineering activity in the modern sense, but rather a technical activity organically connected with the craft organization of production." The origin of engineering activity and its specific features from a methodological point of view are, according to the same authors, as follows: "For an engineer, every object in relation to which there is a technical task, on the one hand, acts as a natural phenomenon, subject to natural laws, and on the other - as a tool, mechanism, a machine, a structure that must be built artificially. The combination of "natural" and "artificial" orientations in engineering forces the engineer to rely both on science, from which he draws knowledge about natural processes, and on existing technology, where he borrows knowledge about materials, structures, their technical properties, manufacturing methods, etc..d. But the object of modern activity is also the connections between man and machine, economic, organizational and even social connections. The complex differentiated structure of modern engineering activity necessitates its management and the organization of its constituent activities into a single whole." It is in such approaches that the transition from technocratic to humanistic engineering activity lies, which was accurately noted by V.L. Kirpichev: "The construction of devices for saving labor, for making it easier, for its safety, for the hygiene of work - this is a worthy field for the occupation of active minds, and I think you will agree with me that technology represents a vast field for humane and educational activities." The close connection of engineering activities with humanitarian and artistic activities is confirmed by attempts at conscious and often intuitive preservation of art in relation to scientific and technical activities, considered in various modern domestic and foreign works. Of interest is the assessment of R. Shannon's work “System Simulation Modeling - Art and Science” by the editor of the translation, who writes: “The book is entirely devoted to precisely that part of the simulation experiment, which is art, since processes such as the selection of essential factors for building a model, introduction simplifying assumptions and making correct decisions based on models of limited accuracy rely largely on the engineering intuition of the researcher and the practical experience of a particular manager.” An analysis of the previously discussed socio-technical and historical-philosophical processes allows us to conclude that the new social, economic and environmental problems that arose before humanity at the beginning of the 21st century require a reorientation of the engineer training system. In society and in the system of higher technical education, a clearly defined demand arose for the study of “the history of science and technology,” “philosophy of technology,” and “methodology of scientific creativity.” Consequently, there is a need to move from methods and techniques of inventive creativity, from setting purely engineering and technical problems to solving social and sociotechnical problems. And such a transition is possible only through the humanization of education. Regardless of a specific academic discipline or even an entire scientific field, future engineers have to study various laws and theories as part of each training course. This is explained by the fact that even in the natural sciences, not to mention the technical ones, there is hardly an examplewhen one theory or law would cover and explain the entire set of phenomena in a given field of knowledge. Therefore, it will be fair, albeit categorical, to state that there are no single, universal laws and theories suitable for all areas of knowledge. Examples confirming this statement can be given as many as you like: from general philosophical laws, of which there is a whole group even within the framework of dialectical theories, to very different theories of the origin of the Earth and such purely applied areas as, for example, the theory of gluing. All theories and laws are based on axioms, i.e. “the initial provisions of a scientific theory, accepted as true without logical evidence and underlying other provisions of this theory.” These axioms are that real, that fundamental basis, those postulates - “positions, judgments, statements accepted within the framework of any scientific theory as true due to evidence”, on the basis of which the knowledge base of each specific subject is subsequently built - theorems, patterns, dependencies, etc. In interdisciplinary research, especially when using a systems approach, demands inevitably arise for the development of more universal theories, since theories and patterns operating in a single subject area can never, even by definition, “satisfy” another area of knowledge; thereby creating the prerequisites for the development of more universal theories. Examples illustrating interdisciplinary breakthroughs include such sciences as physical chemistry, social psychology, etc.“satisfy” another area of knowledge; thereby creating the prerequisites for the development of more universal theories. Examples illustrating interdisciplinary breakthroughs include such sciences as physical chemistry, social psychology, etc.“satisfy” another area of knowledge; thereby creating the prerequisites for the development of more universal theories. Examples illustrating interdisciplinary breakthroughs include such sciences as physical chemistry, social psychology, etc.

Combining new poly directions into single complexes allows us to reach the level of metatheories similar to the theory of the noosphere by Vladimir Ivanovich Vernadsky. He was also one of the creators of anthropocosmism - a system in which the natural historical natural (cosmic in general) and social and humanitarian trends in the development of science harmoniously merge into one whole. Thus, V.I. Vernadsky combined into a real scientific paradigm the idea of humanization of scientific knowledge from the side of the natural scientific picture of the world. The “counter” paradigm for explaining the universe from the side of scientific, artistic and theological knowledge was the philosophy of unity of Vladimir Sergeevich Solovyov and his concept of “integral knowledge”, based on an intuitive comprehension of the world based on the moral efforts of the individual. Ignorance or misunderstanding of complex processes, which were largely explained in his teachings by V.I. Vernadsky and V.S. Soloviev, led a large army of scientists and technicians to a situation of internal and external discord, which, in turn, resulted, as a rule, in technocratic, purely pragmatic solutions to any problems. Edouard Shuret, a French writer, philosopher, musicologist, spoke wonderfully about this confrontation, the process of internal split personality: “As long as Christianity affirmed the Christian faith among European peoples - still semi-barbaric, as they were in the Middle Ages - it was the greatest of moral forces, it shaped the soul of modern man. As long as experimental science sought to restore the legitimate rights of reason and protected its boundless freedom, so long it remained the greatest of intellectual forces: it renewed the world, freed man from age-old chains and gave his mind indestructible foundations. But since the church, unable to defend its fundamental dogmas from the objections of science, has locked itself in them, as if in a windowless dwelling, opposing faith to reason as an indisputable absolute commandment; since science, intoxicated by its discoveries in the physical world, turning the world of soul and mind into an abstraction, became agnostic in its methods and materialistic in its principles and in its goals; Since philosophy, confused and helplessly stuck between religion and science, is ready to renounce its rights in favor of skepticism, a deep discord has appeared in the soul of society and in the soul of the individual. Religion responds to the needs of the heart - hence its magical power; science responds to the demands of reason - hence its irresistible power. But a lot of time has passed since these two forces stopped understanding each other. Religion without evidence and science without hope stand against each other, powerless to defeat each other. Hence, deep division and hidden hostility - and not only between the state and the church, but also within science itself, in the bosom of all churches, as well as in the depths of the conscience of all thinking people.

For no matter what we are, no matter what philosophical or social school we belong to, we carry in our souls these two hostile worlds, seemingly irreconcilable, although they arose from the equally inherent, never-dying needs of man: the needs of his mind and the needs of his hearts." If you follow the theories of V.I. Vernadsky and V.S. Solovyov, then with such a movement it becomes inevitable to reach those eternal truths from time immemorial, and from the point of view of science - axioms on which any religious teachings are based. These axioms are nothing more than commandments, or, in modern language, a system of values, the only, unique and universal basis of human spiritual and material existence that humanity has created over the long history of its development. These fundamental commandments are the sources of any truly humanistic movement. Without a corresponding value orientation, no positive, personal human development and the development of society, science and technology as a whole is possible. Here lies the true meaning of the humanization of education, including, and perhaps primarily, higher technical education. All educational subjects should be imbued with the spirit of humanism, not only the humanities, natural sciences, but also special ones. Textbooks and teaching aids must be humanized. How to achieve this? Indeed, religious courses should not be placed within special disciplines! Well, of course not - it's both unrealistic and funny. But the principles of humanization themselves must be laid as the basis of any academic subject, any academic discipline. These principles are the universal methodology with which you can humanize any area of engineering activity. The methodological basis of humanization should be, as follows from the analysis of the development processes of the philosophy of technology and engineering as an art, the principles of historicization, sociologization and streamlining of science. The principle of historicization should be based on the history of science and technology, including the history of discoveries and inventions. The principle of sociologization is a comparative analysis of the development of scientific and technical achievements of mankind in accordance with the social needs of society. The principle of ordering or logization presupposes the substantiation of the development of science as a single, integral system, i.e. "technologization" of the presentation of material within each training course. So, the humanization of education should mean more than just the expansion of university curricula by including individual humanities disciplines. By humanization of higher technical education we mean exactly:

firstly, the humanization of all educational material, mainly textbooks and teaching aids, which today are almost completely faceless and contain a description of only ready-made knowledge intended for memorization;

secondly, the logical systematization of educational material so that the science taught appears not as a set of knowledge, but as a logically coherent developing system.

Ready-made knowledge, as D.I. said. Mendeleev is not yet science; ready-made knowledge separated from the methods of obtaining it is "slavery to what is being studied." Science is not ready-made knowledge, but a creative activity for the production of knowledge. Creativity can only be taught by studying the experience of the history of science and technology. At the same time, humanizing educational material presupposes the formation of cognitive activity in students, and logical systematization is a way of systematically consolidating information. If the above principles are taken into account when constructing a training course, then engineering activity, both at the level of setting problems, and during their solution, and in the process of implementation, will never act to the detriment, but only to the benefit and benefit of all humanity.

Speaking about the socio-philosophical aspects of innovation and engineering activity, it is necessary, first of all, to turn to the general definitions on which further reasoning is based. First of all, these are the concepts, namely:

"activity";
"innovation";
"innovation process";
"creation";
"structure";
"innovation" and some others.

The concept of "activity" could be defined using a Russian language dictionary. This is an occupation, labor, work. But this concept also has a deep philosophical meaning, which can be revealed as a form of active attitude towards the surrounding world, the content of which is its purposeful change and transformation. The concept of activity includes the goal, means, result and the process of activity itself. Within the framework of the topic under consideration, it is important to note the variant of classification of activity that divides it into reproductive, i.e. aimed at obtaining an already known result using known means, and productive activity or creativity associated with the development of new goals and corresponding means, or with the achievement of known goals with the help of new means. It follows from this that the concept of “creativity” can be defined as the creation of spiritual and material values that are new in design, as an activity that generates something qualitatively new, something that has never existed before. The concept of “structure” could also be defined according to the Russian language dictionary as “structure, internal structure.” But the structure of what? What object? Obviously, the concept of structure cannot be applied to such an object as a pile of sand or a pile of stones. Therefore, the concept of structure is used only in relation to a systemic set of elements, and not to a summative set. At the same time, by system we mean such a multitude of elements or components that represent a single integrity and in which all elements are so interconnected that they influence each other and transform each other. One or more elements cannot be removed from a system without changing its quality. Based on this, the concept of structure can most briefly be defined as “stable orderliness of a qualitatively unchanged system.” Taking into account the above, we can define the concept of structure somewhat differently as “a set of stable connections of an object that ensure its integrity and identity with itself, i.e. preservation of basic properties under various external and internal changes.” The concept of “organization” can be considered related to the concept of “structure”. This is a stable orderliness of a qualitatively changing system, i.e. process. Another form of definition of the concept of “organization”, which has a social connotation, is as follows: an organization is an association of people who jointly implement a certain program or goal and act on the basis of certain procedures and rules. For us, this form of definition is interesting because it is comparable to the basic concepts of system analysis. A few words about other, less general, but no less important concepts related to innovation.

The concept of “innovation” is usually revealed as “the science of innovation”, and the creation, development and dissemination of various types of innovations is considered as the subject of innovation. Various authors, depending on the direction of their specialization, provide very diverse definitions of the concepts of “innovation”, “innovation”, “innovation process”. Let us present those that best correspond to the solution of the problems posed in this study. Innovation can be defined as a purposeful change that introduces new, relatively stable elements (both material and social) into the implementation environment (organization, settlement, society, etc.). Innovation is considered as a new order, custom, method. The most successful definition of the main innovative contradiction inherent in any system is given by A.I. Prigogine: “If a norm as a social standard preserves the existing, then innovative activity and innovations “knock down” the functioning of the system, changing the existing.” He also introduces the “golden rule” of innovation: the system will only be open to innovations when their development becomes a condition for its preservation. Taking into account the above, new variants of definitions are introduced that are necessary for the semantic linking of the transition of concepts from innovation to engineering activity. Such definitions primarily include:

innovative structure of the enterprise - the relationship between the divisions of the enterprise, the main function of which is to ensure the development and implementation of innovations (innovations);

creative activity - the development of something new, related to the change and development of a given object, as well as the development of fundamentally new objects that include the same or a new function;

creative activity in the innovative structure of an enterprise is the functioning of enterprise divisions, which allows obtaining new developments and ideas that ensure greater efficiency of the organization (enterprise) according to specified criteria.

The stages of the innovation process that determine any scientific and technical activity can also include movement along the traditional chain from fundamental discovery to production, namely:

1) fundamental discoveries;
2) applied research;
3) introduction of new technology into production.

Of course, the main basic factor influencing the concept of training programs is the social status of the specialist: researcher, designer, student, etc. At the same time, the experience of preparing students for innovative activities has shown that the presence or absence of one’s own task should be recognized as the main criterion of the learning process. Both situations are very specific. The absence of a specific task (as a rule, these are students or young professionals) requires the training system to develop artificial motivation among students to solve problems directly in the process of presenting the training course. Moreover, the complexity of this situation can be compensated by increased curiosity, ambition and the spirit of competition characteristic of young audiences. The presence of a specific task arouses deep interest in the audience, but at the same time requires an individual approach, since the listener is naturally interested in the method of approach to solving his own problem (graduate students, inventors, designers). The basic concepts of this study include: “technology”, “engineering activity”, “engineering thinking” and “engineering art”. There are an extremely large number of publications that use these concepts. Their number amounts to not tens, but hundreds of works in various fields. But still, these categories are most deeply and consistently revealed in dissertation research related to the analysis of philosophical and social problems of science and technology. The concept of "technology" is adequately defined in the works of V.I. Belozertsev as a social material system that serves as a conductor of transformative human activity, a means of knowledge, use and subordination of forces, properties, laws of development of nature, man and society in satisfying natural and social needs. It is interesting to note in this regard that in the study by L.G. Titarenko proposed a generalizing definition of technocratic consciousness. Technocratic consciousness is considered as a specific ideological orientation of public consciousness as a whole (or individual social strata and groups), aimed at absolutizing the scientific and technical factor in the development of human civilization and the role of scientific and technical specialists (or their individual groups). Already in these definitions two trends are clearly visible, namely:

the first of them is the orientation of technical activity to meet social needs;

the second is the recognition among specialists involved in technical activities of a special, specific worldview.

We will also find confirmation of these trends in other studies. If we turn to the concept of "engineering activity" itself, then according to the dictionary "Scientific and Technological Progress", engineering activity can be defined as an activity aimed at applying scientific knowledge to create technical objects - structures, mechanisms, devices, machines, etc. — and management of their manufacturing process. This definition seems unjustifiably narrowed. Considering the quality of engineering training as a social problem, A.B. Kurlov in his work defines engineering activity as a creative process, the purpose of which is the creation of means, methods and technologies for material transformation of the environment and the professional socialization of the subject of these transformations. At the same time, it is noted that the creative intensity of engineering work presupposes the formation and development of appropriate abilities in the subject in preparation for engineering activity. Moreover, the main function of the engineering personnel training system is the development of creativity.

IN AND. Martinkus, classifying engineering activities by intellectual functions, proposes the following classification of types of engineering activities, namely:

managerial (organizational),
design,
technological,
inventive,
scientific

For us, it is also important to consider the social function of engineering activity. IN AND. Martinkus, in our opinion, was able to come closest to understanding the essence of engineering activity, considering "creativity" as a subsystem included in a more general philosophical system - "labor activity" with the subsequent inclusion of this system in the supersystem "cognition". Having linked knowledge, work and creativity into one structure, V.I. Martinkus analyzes the change in the world as a result of purposeful cognitive, creative labor activity. The social function of engineering and creative activity, in his opinion, is to develop the spiritual and practical activity of people, to change the boundaries of possibilities in technical and social relations, and to update the structure of such relations. Subsequently, D.O. Gusev supplemented and developed this approach. He gave a philosophical and methodological analysis of the dialectics of the formation and development of the social functions of engineering activity. Engineering activity, at the same time, is considered as a developing social phenomenon. In version D.O. Gusev's engineering activity is presented as a system of the following social functions: the function of applying natural scientific, technical, social and humanitarian knowledge for technological organization and development of material production; functions of producing technological knowledge, i.e. knowledge of the operating principles and methods of creating technical devices; functions of producing technical knowledge, i.e. knowledge of what a given technical device is, what principles underlie its functioning.

V.V. Alekhine approached the consideration of engineering activity through an analysis of the characteristics of engineering and technical work, the content of which he includes: the scientific and cognitive work of an engineer, engineering and technological work, engineering and design work, engineering and operational and engineering organizational work. An attempt to generalize such studies was made by A.I. Rakitov. He comes to the conclusion that engineering thinking by its nature is systemic and activity-based. Introducing the division of types of knowledge into scientific, technical, engineering and everyday, A.I. Rakitov considers the process of creating artifacts and the direct activities of managing them as a subject of engineering knowledge. He considers the goal towards which engineering thinking should be directed to be the creation of effective means of activity and conditions for human life, the creation of an artificial habitat.

The leading concept in this monograph is "engineering art". The actual history and logic of the development of this concept will be given below in subsequent sections. We note here that, despite the long-standing traditions of using the concept of "engineering art," it was not possible to find its specific and clear definition in publications, despite a thorough bibliographic search. Most works devoted to the study of such topics or using this concept are, at best, limited to an eclectic-descriptive version of the presentation of its semantic content. The following definition is proposed. Engineering art is an expedient activity aimed at studying, creating and managing artificial objects, the result of which is an original solution of a high functional and aesthetic level. This definition reflects the categories of philosophy, sociology, economics, engineering psychology, history of technology, technical aesthetics, and ergonomics. In fact, expediency is based on knowledge of the laws of technological development and is based on a systematic approach to the problem. Originality includes a logical-intuitive way of thinking, formed with the help of various methods and techniques of scientific and technical creativity. The functional and aesthetic level is the result of optimization of solutions, the embodiment in the object of activity of the principles of design and economic sciences with the help of the professional knowledge of an engineer. The inclusion of scientific and technical creativity (STT) in innovation activity as one of the main structural elements is beyond doubt. However, the role and place of NTT in innovation activity is not clearly defined. In addition, it is extremely important to understand the origins of the emergence and development of NTT to consider the "root system" of such processes. Below, an attempt is made to introduce a new conceptual category that determines the need to involve the NTT apparatus and the degree of its use. A huge number of articles, a large number of book publications and dissertations are devoted to the processes of development and research of new things. The classification of such works is associated with the consideration of various aspects of innovative activity: psychological, social, pedagogical, scientific, technical, historical, philosophical and even fantastic.

What is important for us is the fact that, regardless of the specific topic, all authors directly or indirectly have to touch on various aspects of the activities associated with the STT process. And this is no coincidence. Without defining the goal, the means to achieve it and the characteristics of the performer, talking about NTT is simply pointless. Since one of the main goals of this article is to establish relationships between the social and technical aspects of STT, and the result is the development of methodological material for the academic discipline "Scientific and Technical Creativity", it is first necessary to determine the basis of STT. The history of inventions and discoveries, which is directly related to engineering activities, is, in essence, the history of technology as the main component of social production or the history of the socio-technical development of mankind. We have already talked about the role and place of the engineer in innovation. It is obvious that NTT is a natural part of engineering. But what is primary, what is secondary and what is the source that determines the direction of development of scientific and technical technology, and therefore engineering activity as a type of labor activity, remains not clear enough to this day. If we consider the sequence of development of ideas about the world from the point of view of the technocratic approach, we will come to the following chain: primitive mythology - art - philosophy - natural science - exact sciences - technology. If we imagine as the basis of innovative processes mental activity, connected by the above-mentioned categories, we get a chain of activity processes: thinking in images - entry into scientific thinking - thinking in concepts - practical transformation of the world. At the same time, any social changes are determined by the general type of culture - the spirit of the era. It is obvious that the practical transformation of the material culture of mankind is based on technique and technology. What is the basis, motive, driving force for the development of technology and engineering? These are two sources: social and scientific-technical. This thesis must be understood as follows. The social factor is determined by the needs of social production; scientific and technical factor - potential opportunities associated with the level of development of science and technology. As they say, this is the internal logic of the development of science. Both of these sources, when combined, form a certain common basis for the development of technology, which, in turn, is humanity's tool for the practical transformation of the world. In works on the history of science and technology, as well as in philosophical and sociological works, external and internal factors in the development of science and technology are considered, as a rule, in a certain opposition. At the same time, some researchers consider external factors to be leading, and internal factors to be subordinate, secondary, or even not playing a significant role at all. This direction of the sociology of science is called externalism.In contrast, a movement arose called internalism. Researchers who support this direction highlight the factors of the internal logic of the development of science. The externalist and internalist positions of scientists of various specialties (sociologists, economists, historians of science) are sufficiently discussed in detail in the essay by S.R. Mikulinsky "Methodological issues of historical and scientific research." Although at present, in essence, there are no longer extreme externalists and internalists, the opposition between external and internal factors in the development of science has been preserved. For us, this question is important because in the aspect of the problems of scientific and technical creativity, considered in this work, there is an urgent need to study not only the relationships between external and internal factors, but also their deep integration into something unified, synthetic. There is a need to talk about the integrative factor. The fact is that, unlike scientific creativity, the result of which is fundamental science, scientific and technical creativity leads to integrative results, to the organic unity of a scientific discovery and its technical implementation. External and internal factors of the

NTT process are inseparable from each other. They cannot act in isolation even over a very short period of time, since they are implemented at strictly defined and modern discrete levels of development of science, technology, and production. An example is the emergence of synthetic rubber (SR) production. Despite the birth of this idea back in the 19th century, the production of SC itself could not have arisen either earlier or later than the 1920s–1930s. It was by this time that a phased social order for rubber rubber appeared from the auto and aircraft industries, which until then, due to the small scale of these industries, had made do with natural rubber. At this point, chemistry had just discovered methods for polymerizing SA monomers. And, finally, by this time, the industry had just created the technical prerequisites for the production of monomeric raw materials SA from alcohol and petroleum hydrocarbons. If these prerequisites did not exist, there would be no innovation itself - SC, despite the presence of a social order and a solution to a scientific problem with the help of chemistry. There is an urgent need to study not only the relationships between external and internal factors, but also their deep integration into something single, synthetic. There is a need to talk about the integrative factor. The fact is that, unlike scientific creativity, the result of which is fundamental science, scientific and technical creativity leads to integrative results, to the organic unity of a scientific discovery and its technical implementation. External and internal factors of the NTT process are inseparable from each other. They cannot act in isolation even over a very short period of time, since they are implemented at strictly defined and modern discrete levels of development of science, technology, and production. An example is the emergence of synthetic rubber (SR) production. Despite the birth of this idea back in the 19th century, the production of SC itself could not have arisen either earlier or later than the 1920s–1930s. It was by this time that a phased social order for rubber rubber appeared from the auto and aircraft industries, which until then, due to the small scale of these industries, had made do with natural rubber. At this point, chemistry had just discovered methods for polymerizing SA monomers. And, finally, by this time, the industry had just created the technical prerequisites for the production of monomeric raw materials SA from alcohol and petroleum hydrocarbons. If these prerequisites did not exist, there would be no innovation itself - SC, despite the presence of a social order and a solution to a scientific problem with the help of chemistry. There is an urgent need to study not only the relationships between external and internal factors, but also their deep integration into something single, synthetic. There is a need to talk about the integrative factor. The fact is that, unlike scientific creativity, the result of which is fundamental science, scientific and technical creativity leads to integrative results, to the organic unity of a scientific discovery and its technical implementation. External and internal factors of the NTT process are inseparable from each other. They cannot act in isolation even over a very short period of time, since they are implemented at strictly defined and modern discrete levels of development of science, technology, and production. An example is the emergence of synthetic rubber (SR) production. Despite the birth of this idea back in the 19th century, the production of SC itself could not have arisen either earlier or later than the 1920s–1930s. It was by this time that a phased social order for rubber rubber appeared from the auto and aircraft industries, which until then, due to the small scale of these industries, had made do with natural rubber. At this point, chemistry had just discovered methods for polymerizing SA monomers. And, finally, by this time, the industry had just created the technical prerequisites for the production of monomeric raw materials SA from alcohol and petroleum hydrocarbons. If these prerequisites did not exist, there would be no innovation itself - SC, despite the presence of a social order and a solution to a scientific problem with the help of chemistry.

The theoretical prerequisites for something new in science also appear as a result of not only the requirements of production (the action of social order), but also what has already been achieved in production, and this can serve as a condition for setting up new experiments (the action of social security), i.e. production (as an external factor in the development of science) both stimulates the emergence of something new (social order), and acts as a limiting factor (social restrictions) or creates technical conditions (social security). The history of science knows many examples of premature discoveries that were not accepted by either science or industry due to the fact that they appeared either away from the main path of development of science and technology, or at the wrong level of scientific and technological progress.

All this makes us talk not so much about external and internal factors in the development of science and technology, but rather about a single integrative factor. When using a problem-based approach both in the learning process and in the process of solving creative problems, we are often faced with ambiguity in the interpretation of the procedure for its implementation. In fact, to successfully resolve any problem, both universal and specialized knowledge are required. By introducing two levels of problem analysis - horizontal and vertical - we will get a clear idea of the need to combine both levels. At the same time, multiple solutions are allowed. Each of them can be designated by a point, the position of which in a rectangular coordinate system is determined by the relationship between the degrees of specialization and universality of the approach applied to solving the problem. There is an analogy here with how the search for necessary information is usually presented. This technique is often used when planning the time expenditure of graduate students and researchers. The abscissa axis represents time, and the ordinate axis represents the amount of information. Over time, the graduate student, having selected the necessary information to conduct specific research, concentrates his efforts in a fairly narrow range. NTT techniques and methods can connect special and universal knowledge with each other. To review the entire search field, it is useful to use brainstorming, synectics, morphological analysis, and to go deeper into the problem - FSA, ARIZ (TRIZ). At the same time, the choice of search field is largely determined by social order, and the search path is determined by the algorithms of NTT methods. Analysis of various factors allows us to divide all activities related to engineering in the field of scientific and technical technology into two types: socio-technical and educational and methodological. The need for such a division is due to the fact that both the NTT methodologist, who helps find a solution, and the decision maker (decision maker) are forced, before developing practical recommendations or forecasting the direction of development, to go through a stage of work, the purpose of which is to define the problem associated with explaining the socio-technical aspects Problems. This activity is naturally woven into the system analysis, following the preparatory stage, the main content of which is to clarify the situation and then formulate the problem (Table 1). As for educational and methodological activities, it can also be divided into preparatory and main stages. Training in NTT methods is associated with acquiring knowledge about optimal options for solving problems; The independent work of a methodologist includes the selection of techniques and methods of scientific and technological progress for a specific socio-technical task.

Table 1. Stages and activities when using NTT

Activities	The first stage is preparatory		Second stage main		The third stage is final
	Clarifying situations		The work of a methodologist		Practical activities
	Target	Function	Target	Function	
Socio-technical	Practice support	Problem Statement	Definition of the task	Clarifying the socio-technical aspects of the problem	Forecast of development direction
Educational and methodological	Training in NTT methods	Solution Process Training	The solution of the problem	Selection of techniques and methods of NTT	Practical recommendations

It should be noted that the introduction of social factors may be conditional. However, like other methodological techniques, the use of these factors makes it possible to clarify and formulate the content of such concepts as “innovation”, “engineering”, “STT”. Just as in mathematics, techniques such as reducing fractions to a common denominator, artificially introducing a system of equations with the appropriate number of unknowns help solve a problem, so social factors can help make the unclear clear, the controversial - resolved, and the incomprehensible - explained. By causing the NTT process, social factors, interacting with each other, not only form the boundary conditions of engineering problems, transforming into innovative activity, but, ultimately, can determine both the direction of development and the methods of implementing innovation.

The next main property of social factors is their dual role. These factors are both the source and the driver of NTT. The development of social factors means both an increase in requirements for the development of production and an intensification of the requirements of the internal logic of the development of science and technology. Figuratively speaking, the processes occurring in scientific and technical technology, in engineering, in innovation, are derived from social factors. Comparison of the process of development of society with the concept of the structural-functional approach makes it possible to reveal the internal meaning of transitions in the multi-level model “elements - subsystem - system - supersystem”. An example is the transition from the evolutionary phase of the development of science and technology to the scientific and technological revolution. Thus, although the introduction of social factors is an artificial device, it helps to clarify the relationship between real factors operating in STT and innovation. A systematic approach to activities related to STT is reflected in the works of authors from different countries. Didactically successful is the option of a systematic approach to the presentation of material using graphic classifications - the coordinates of the existence of technology were outlined in the work by V.E. Steinberg. By developing this direction, we can represent the chains of areas of activity that interest us in space using a single structure: science - technology - technology. We should also agree with A.S. Tsesnek that, by developing such structures, one can move on to constructing matrices based on differentiated characteristics corresponding to a specific practical problem. And, indeed, such matrices contain significant heuristic potential, which makes it possible to increase the efficiency of engineering activities. However, no pedological developments can be successfully implemented without restructuring the learning process itself. Thoughts about the need to change the system of training students worried not only teachers, but also people of art. Here are a few quotes. F. Schiller: “Society makes position the measure of a person, it honors in one of its citizens only memory, in another only reason capable of counting, in a third only mechanical dexterity... Is it surprising that all other abilities are launched in order to educate the only that ability that gives honors and rewards? Antoine de Saint-Exupéry: “The theorist believes in logic. It seems to him that he despises dreams, intuition and poetry. He does not notice that they, these three fairies, simply disguised themselves to seduce him, like an amorous boy. He does not know that he owes his wonderful finds to these fairies. They appear to him under the names of “working hypotheses”, “arbitrary assumptions”, “analogies”, but can the theorist suspect that, listening to them, he is betraying “severe logic” and listening to the melodies of the muses? A.P. Chekhov: “I thought that the intuition of an artist is sometimes worth the brains of a scientist, that both have the same goals, the same nature, and that, perhaps, over time, with the perfection of methods, they are destined to merge together into a gigantic,monstrous power." These statements can be summed up using the thesis expressed by G.N. Volkov: “An intuitively discerned image of the whole can unfold into a theoretical whole when it is built in accordance with the aesthetic and philosophical idea of the world, when it is recreated not arbitrarily, but according to certain laws that express the inner essence of this whole, its harmony, its nature, structure, its correspondence to the totality of experience and experimental data.” These ideas are especially relevant for teachers involved in training specialists in various fields of science and technology. It is no coincidence that almost all countries of the world are concerned about the education crisis. This phenomenon is universal. Therefore, in a number of articles in the collection “Philosophy of Education for the 21st Century,” the question is naturally raised that before moving on to campaigns for “humanization, technocratization, or educationalization,” it is necessary to develop an education paradigm—a common denominator. A new scientific direction is proposed - philosophy of education. This term is understood as “a certain system of ideas about the world and a person’s place in it, from which we can further identify the goals of education, its content structure, basic organizational principles, relationships between teacher and student, etc.” Comparing the above with the activities of a scientist, we can draw the following analogy. By setting up an experiment, we accept working hypotheses. Having received the results of the experiment, we process them and present them taking into account certain assumptions, drawing conclusions. At all stages of this activity, regardless of their sequence, artistic, logical, and philosophical levels of thinking are involved (Figure 1).

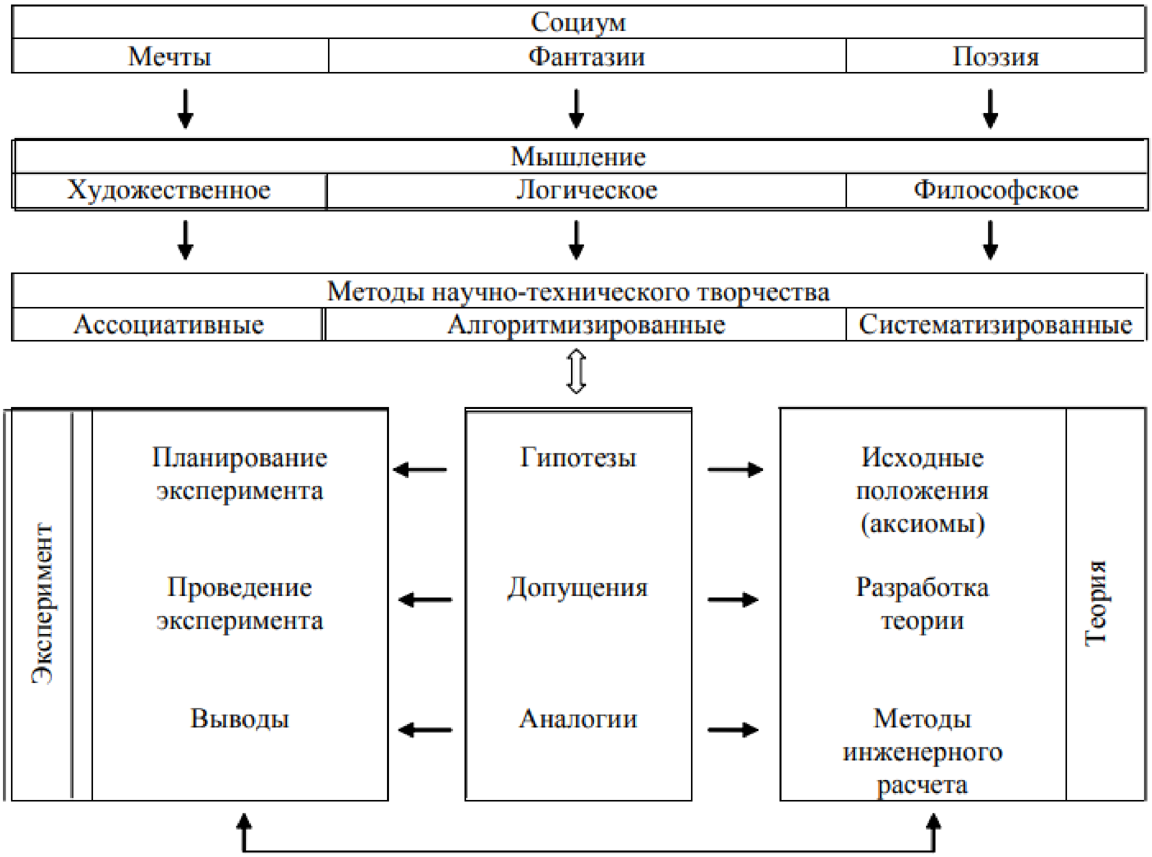


Figure 1. The relationship between scientific and technical creativity and innovation activities

NTT uses associative, algorithmic and systematized techniques and methods, which are, in fact, derivatives of various types of thinking. Society and nature determine the emergence and development of innovative processes. Using the NTT methodology, they not only systematize existing knowledge, helping to optimize the experiment and navigate theoretical work, but also develop a person’s intellectual abilities. At the same time, it should be taken into account that the use of a socio-technical approach to solving problems is associated with some propaedeutic preparation, namely:

firstly, the learning process should be aimed at nurturing universal personality traits, including an orientation toward imaginative thinking. Art, as Balzac put it, is "concentrated nature". Here the image is directly excited from the image, association from association, bypassing long logical transitions and rational orderings. If the mind pedantically climbs the endless ladder of concepts and categories, then imaginative thinking immediately grasps the essence of the problem, all the richness of the concrete. Therefore, intuition can be considered a “tool” of imaginative thinking;

secondly, the student should develop the skills of analysis (both structural and functional) and synthesis. In this case, one cannot do without mastering philosophical and methodological categories and the apparatus of formal logic.

Let us summarize what has been said in the form of the principles of engineering activity that should be embedded in the scientific and technological process, namely:

Identification of a social problem as a stimulus for NTT. A good technique is to “search” for a problem between opposing opinions.

Identification of scientific and technical opportunities. Here it is appropriate to use the full power of the forecasting apparatus associated with information technology.

Using social factors and heuristic techniques as a source of NTT.

The processes of teaching NTT (the activity of a teacher-methodologist) and using NTT (the activity of an innovator: scientist, engineer, manager) are inextricably linked with the questions of what NTT is and how to teach an NTT course. From a formal point of view, these are two different questions. Most of the literature on NTT is devoted to answering them. We tried, with the help of research data, to answer the question: what should be the foundation, the foundation on which a building of engineering art is built? And in this case, the process of cognition of NTT (formation of engineering thinking) and the process of NTT itself (as fundamental in engineering activity) constitute a single, harmonious in nature, whole. Without such an approach, the large arsenal of available NTT techniques and methods is simply a beautiful palette from which one can choose one or another color, either based on random information about NTT, or focusing on the (always limited due to objective reasons) amount of knowledge which the teacher managed to give during class. In order to move away from the usual structure of a training course, which is traditional when teaching certain technical disciplines, a radical rethinking of the perception of scientific and technical technology is required. Here we are faced with a situation that is specific to Russia, and is often not taken into account by both domestic and foreign experts. Until recently, we did not take irrational factors into account at all. Even representatives of such sciences as philosophy and psychology were forced in their publications (at best) to pass over in silence issues of the transcendental, mystical, etc. What can we say about the art of engineering? Those fundamental works on creativity that were published specifically in Russia (the period 1900–1930) are, in fact, simply forgotten, since the training of engineers has been pursuing a strict course towards narrow professionalization for more than one decade. Based on the above, the author considers it necessary (in preparation for innovative activities) to introduce special topics into the educational material to explain concepts such as “faith,” “intuition,” “knowledge” and their relationships. Only in this case can we count on the formation of a Russian engineering corps, the level of which will be determined not only by the ability to copy foreign developments, but by a very capacious and original Russian qualification characteristic - “an engineer from God.” Persons working in the field of inventions and discoveries contribute to the development of culture. Culture is an improvement in the economic coefficient of transformation of life according to W. Ostwald.

Attempts to qualitatively and quantitatively assess various types of human activity have been made repeatedly. It is no coincidence that entire subdivisions such as laboratories and institutes of SOT (scientific organization of labor) arose, in which various criteria for labor efficiency were developed and then applied in practice. The division of labor activity processes into mental and physical led to the development of a whole set of relevant indicators. However, if the situation with the assessment of physical labor was quite clear, then in the assessment of mental labor specific difficulties always arose. Therefore, despite the actual practical implementation of various methods and norms, life itself, over time, “buried” various proposals for assessing the effectiveness of mental work. This, for example, was the case with the standardization of the activities of one of the largest engineering departments - the design department. An assessment based on the number of formats submitted by the designer, of course, could be a criterion for labor productivity, but what about the quality of what is drawn on a piece of whatman paper? We are not talking about the number of errors in dimensional chains, although this also matters. We are talking about the level of design elaboration. An analogy with a writer’s payment for an author’s sheet is quite appropriate here. Whether he is Leo Tolstoy at least three times or, on the contrary, a pathetic compiler, with the above approach they will receive the same material reward. Below we will consider various options for criteria, starting with assessing the performance of technical devices and ending with an attempt to formulate a criterion for the effectiveness of innovative activities. For us, it seems extremely important that regardless of the type of mental work, including in the process of scientific and technical creativity (STT), the teacher and the student must be imbued with an understanding of the dualistic - rational-irrational nature of this kind of activity. Therefore, the presented material first provides a brief retrospective overview of assessments of various activities, and then reveals the role of the rational and irrational in NTT. The first option for assessing labor efficiency, which found the greatest application, was the efficiency factor (EC), defined as a dimensionless quantity showing “what part of the total input energy W is useful. (Wuseful) is used in the device under consideration.” Efficiency is a purely technical indicator. By analogy, in economics they use the indicator of production profitability. For example, if we take the indicator of the level of profitability to current costs, then it is defined as “the ratio of profit to the cost of commercial or sold products.” Or more generally, “profitability P is defined as the percentage of the amount of profit to the total cost of goods sold.”

where O is the volume of products sold in wholesale prices of the enterprise; Cp - full cost of products sold; Wp - profit from product sales.

There is a whole group of economic indicators similar (in structure) to profitability: capital productivity, turnover ratio, etc.

It is also impossible not to mention a very common way of assessing an individual by IQ. One of the options for defining it is as follows where IQ is intelligence quotient; UM - mental age; IV - true age.

It is easy to see that all variants of this kind of assessment can be conditionally attributed to the “human efficiency factor”, considered as an intelligent system.

An interesting transition is from purely economic indicators to indicators that take into account the employee’s motivation—his interest. L. Zhdanov proposed the following formula for this:

where X is the correction factor for working conditions; KR - amount of work; B - material well-being of the employee.

At the same time, the amount of work, according to the author of the formula, depends on the intensity of labor, duration of work, qualifications of the worker, perfection of technology and organization of the business. The concept of a productivity coefficient is also introduced, which makes it possible to compare work results:

where KP is the performance coefficient; ND - the number of units of work actually completed; NT is the theoretical number of units of work that can be done in the same time.

The most generalized option for determining the effectiveness of activities can be considered the option proposed by V. Gasparsky. Having introduced the definition of praxeology as the science of the effectiveness of actions, the author proposes to evaluate effectiveness by the quality of the result:

where is the quality of the result; W—result (positively assessed effect); C - goal (maximum possible effect).

Graphically, the quality of the result is proposed to be assessed using the usual linear relationship.

While recognizing the unconditional usefulness of this approach, it should be taken into account that there is still a long way to go from general discussions about the development of rational and effective actions to the possibility of their application in a specific situation. There are a number of studies devoted to the need to represent by a single dependence both the results of economic calculations - relations of type (1) and (2), and general methodological approaches - relations of type (6). In particular, V. Hubka gives the following definition of economic efficiency: “The ratio of beneficial effect/operating costs is called economic efficiency.” This definition comes closest to the terms used in functional cost analysis (FCA). Note that FSA is one of the few methods that have found international recognition and effective practical application in various fields of activity. The FSA method is based on a combination of purely economic calculations (for example, the cost of manufacturing products) and the determination of consumer properties (usually by calculating the level of product quality through the functions it performs). The relationship between these criteria can be written in symbolic form as follows:

where E is production efficiency; UPS - level of consumer properties; 3 - costs.

By analyzing and generalizing the concepts included in dependencies (1)–(7), we can come to the conclusion about the identity of these expressions, which essentially contain, regardless of the form of recording, the categories of “part” and “whole” in different interpretations. Using the concept of integrity as one of the main components of the systems approach, D. Michie and R. Johnson introduced in their work a generalized version of assessing the effectiveness of activities. It is proposed to evaluate a person’s ability to manage the world around him using a relationship that is a fraction, the numerator of which is the power of the means of cognition and control, and the denominator is the complexity of the environment in which these means are used.

where SU is the degree of control; P - cognition; C - complexity.

And here, as well as in dependence (7), a positive assessment criterion is the rapid growth of the numerator compared to the denominator. Otherwise, the complexity of the surrounding world will completely exclude the possibility of understanding it. It would probably be possible to continue the presented series of dependencies, but, in our opinion, the main methods and approaches to assessing the effectiveness of activities have already been covered. Table 2 shows the performance objective function and related concepts discussed in previous sections. Depending on the object being assessed, stages of development and generalization of the target function can be distinguished (Figure 2).

Table 2. Objective Function Evaluation Parameters

No.	Objective function	Parameter relationship	Object being assessed
1	Degree of intelligence	Mental age True age	Man as a system
2	Degree of harmony (I am a concept)	Scientific + Intuitive	Individual
3	Degree of usefulness	Energy used Energy input	Technical system
4	Profitability level	Profit Cost	Economic system
5	Degree of achievement of results	Result Goal	Sociotechnical system
6	Efficiency level	Quality Costs	Technical and economic system
7	Control degree	Cognition Complexity	Socio-technical-economic system

Consideration of options for assessing the effectiveness of activity is inevitably associated with the use of a group of concepts, the semantic content of which determines not only the choice of efficiency criterion, but also establishes the level, capabilities and nature of the activity process itself, in particular scientific and technical creativity. Turning in this regard to such concepts as "thinking", "cognition", "creativity", we can come to the conclusion that in the process of scientific and technical creativity, concepts work and function that are interconnected in two semantic "chains" (Figure 2).

Considering these chains, one can clearly see that in fact both of them contain two elements as indispensable components, reflecting the rational and irrational principles in the process of cognition. Therefore, within each chain one can identify its main lines of connections that determine the productive (creative) or reproductive (routine) type of activity.

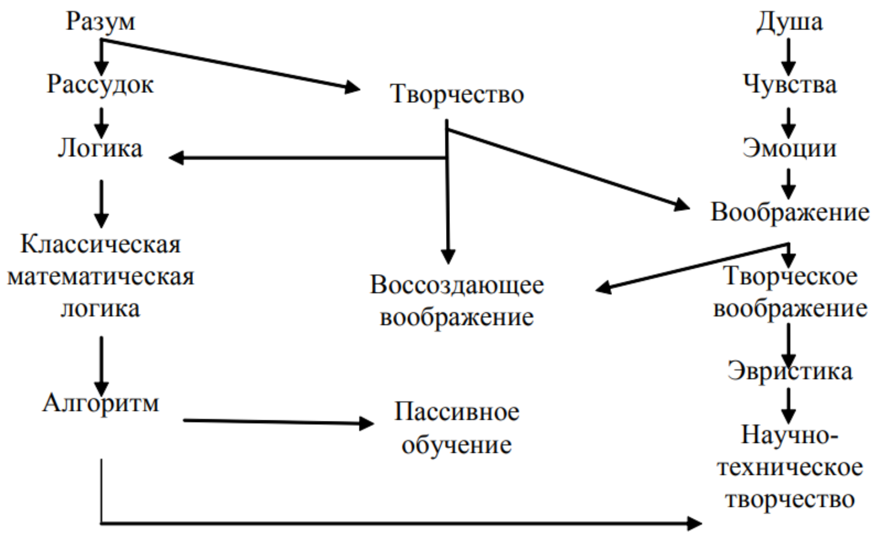


Figure 2. Two "chains" of concepts

The use of classical mathematical logic leads to the possibility of algorithmic problem solving; using creative imagination to develop heuristics. By introducing the ratio of the logical (algorithm) and the illogical (fantasy), you can try to find out which class of tasks a specific objective activity belongs to. And here we cannot do without mentioning the relationship between two procedures of scientific creativity: observation of facts and faith. Even such a major scientist, an enemy of positivism and spiritualism, as D.I. Mendeleev, recognized the role of faith, intuition and insight in the knowledge of natural and social phenomena in the study of material substances. This role is especially significant, according to D.I. Mendeleev, occurs at the stage of generalizing facts, putting forward hypotheses, theories and scientific forecasts. Mendeleev did not at all deny the role of the "religious frame of mind" in comprehending the secrets of nature, adhering to a rationalistic attitude towards religion rather than opposing religion to science. He likened the persecution of religious beliefs to burning for witchcraft. Science here will be understood for now only as the scientific meaning or body of knowledge about facts and laws brought into a system, where these facts and laws are interconnected by certain relationships and mutually determine each other. In other words, scientific knowledge is by definition that which can be proven using formal logic. Approaching the definition of the concept "religion" with caution, we can state that in any definition the key concept is faith. At the same time, we cannot agree with the definition of faith as the antipode of knowledge. It seems that with good reason theology can be defined not only as a form of social consciousness, but also as one of the forms of abstract-intuitive knowledge. If, taking into account the above considerations, we introduce P as the degree of rational (logical), and I (irrational) as the degree of spiritual, then the degree of harmony (SG) in a person's knowledge of the surrounding world is equal to:

$$SG = R + I. \qquad (1)$$

In essence, expression (1) confirms the semantic content of the concept of "conscience," which "manifests itself both in the form of rational awareness of the moral significance of the actions performed, and in the form of emotional experiences." The content of the rational and irrational can be seen more clearly if we imagine a three-dimensional figure made up of two planes P and I. The angle of rotation of these planes and the integrity of the circles can help determine the degree of harmonious development of a person. The incompleteness of the filling of the resulting spherical structure is similar to the shape of the human aura, when gaps and voids indicate an unhealthy body. Let's try to introduce a relationship between the rational and the irrational to determine the degree of innovation:

Of course, this relationship should be treated with a certain degree of convention, considering its components as parameters of fuzzy, vague sets. At the same time, with its help it is easier to understand the features of innovative activity.

Thus, in the case of using the laws of only formal logic, we are dealing with ordinary thinking (I = 0 and SI = 0). If only imagination is involved in thinking, not based on knowledge (laws), then a case of pure fantasy (utopia) arises (Figure 4).

Developing Figure 4, we can identify zones of inventions related to the development of devices, methods and fundamentally new technologies (Figure 5). Returning to Table 2, in particular to target function No. 5 - the degree of achievement of the result and No. 6 - the degree of efficiency, we introduce the concept of efficiency of innovation activity (EID), defined as the ratio of the degree of innovation (SI) to the costs invested in the innovation process (CI):

Analyzing assessments of the effectiveness of activities and taking into account the influence of both the rational and the irrational on the result and on the process of activity, let us summarize the possible use of the above reasoning in specific, in particular engineering activity.

As A.V. points out. Kudryavtsev, depending on the type of problem, a different strategy for finding a solution can be chosen. At the same time, the choice of a particular strategy, and therefore the corresponding solution method, depends primarily on the amount of available information. When there is a small amount of information, an intuitive search strategy is used; when the solution is completely clear, a strict calculation is used. A specialist in a given subject area, setting a specific task and understanding the degree of innovation of the problem that needs to be solved (10), can determine in advance the area and nature of future activity (Figure 3–5).

Figure 3. Zones of degree of innovation

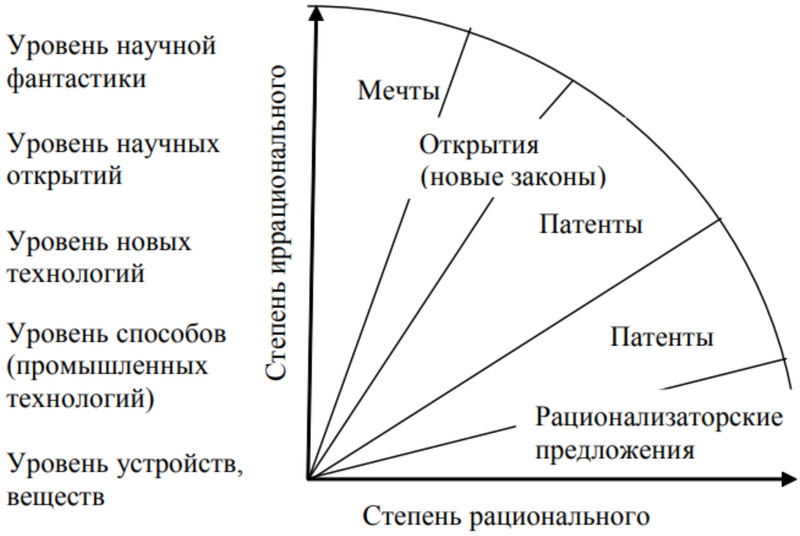


Figure 4. Development level zones

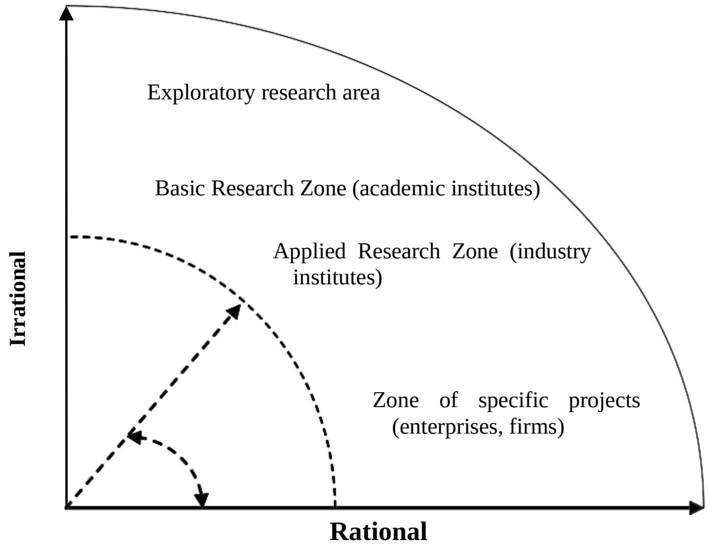


Figure 5. Definition of the area of activity

The degree of innovation beam (Figure 5) shows the direction of activity and helps to choose the appropriate strategy and methodological support as tools for solving this problem. Understanding the level of the task, the engineer will be able to navigate the choice of criteria for assessing the effectiveness of activities. Using the appropriate criteria, it is easier to select methods for their calculation, then moving on to the solution process itself. Using system analysis in research work and teaching practice is both simple and difficult. Attempts to teach systems thinking, at least at the level of a systems approach, are associated with two phases that are opposite in perception. Initially, the vast majority of students develop a sincere interest in the methods used in systems analysis. A clear formulation of the problem, structural and functional analysis, scientific methods of thinking - all this impresses the students. At the same time, in the higher education system, and more specifically, in textbooks intended for higher education, as a rule, there is no analysis of problems in subject areas. Genetic-functional analysis is even less common. Therefore, any information on a systematic approach literally “cleanses the brains” of a specialist, which are clogged with a mass of reference and subject sources. Successfully solved practical problems, analyzed together with the teacher in class, also evoke admiration. Students lively and joyfully discuss the possibilities that open up through the use of systems thinking. But after the learning process (phase 1), the process of independent attempts to formulate problems and solve problems begins (phase 2). And here a specialist (technological engineer, mechanical engineer, software engineer, economic engineer, etc.) encounters obstacles that most cannot overcome. Allegorically, the situation can be presented as follows. A student who has received a higher education diploma is introduced to systems analysis. Depending on the place and time of training, there are three options for obtaining knowledge about systems analysis, namely:

a) while studying at a university;

b) in the process of advanced training;

c) independent study.

But at the very first real task, two very significant obstacles arise:

1) a wall of misunderstanding, made of individual bricks filled with scattered information on various subjects and cemented by the psychology of traditional thinking;

2) the lack of clear and truly “working” tools with which to overcome this wall.

The first obstacle is due to the fact that the specialist does not know how to practically link his existing “database” with the principles of the systems approach; the second obstacle is essentially a consequence of the first. Therefore, we called these obstacles the wall of misunderstanding or inability, since in order to use subject knowledge, you need to know how to overcome this wall and with what tools. For these reasons, problems arise: how should an engineer be taught, at what stage of training can the ability to overcome obstacles appear, is it necessary to rebuild existing courses or introduce completely new ones, what recommendations are needed for a research engineer, and which ones for a production engineer? It is impossible not to mention the numerous publications devoted to these problems. The engineer's work is reviewed and constantly improved. But the fact remains real that, despite the abundance of material covering the above problems from different angles, it is very difficult to work with it on a specific task. Each specialist has to rethink and adapt existing teaching materials to their problems. Therefore, one of the most pressing tasks is to develop not only the technology of engineering thinking, but also tools for such technology. The originality of the style of engineering thinking is determined by the essence of the engineering approach to solving scientific and production problems. It is impossible to develop universal solutions suitable for all technical problems, but the basic principles of the solution methodology can be given. What are these principles based on? Whatever activity an engineer prepares for and whatever activity he engages in practice, it is always related to the production of products or preparation for this. Where should I start this activity? Of course, from an assessment of the goal, i.e. from an assessment of socio-technical needs. It is as a result of such activity that the engineer, acting as a subject, will be able to study and use the principles of engineering thinking in relation to the production of products, which in this case is the object of activity. Therefore, the author proposes a methodology for a systematic approach to assessing the consumer properties of products, based on the most successful, from his point of view, developments of domestic and foreign authors.

Speaking about the specific tasks facing the person making innovative decisions, the assessment of the quality of the finished product that is the result of his innovative efforts should be recognized as the main and even fundamental one. After all, in the end, the entire set of means and methods developed by humanity over its history and designated by such key concepts as science, technology and technology comes down to meeting the various needs of people. Without dwelling on the degree of actual need to realize these needs, let us consider the technical side of this issue. Usually, when assessing quality, we are talking about the performance characteristics or consumer properties of products. Before moving on to analyzing methods for assessing them, let’s try to identify the relationship between such concepts as “quality” and “system approach”. As already mentioned, there are many attempts to use systems analysis or a systems approach to solve a wide variety of problems. There is also general methodological literature such as textbooks for universities and general technical literature intended for self-education of engineers, textbooks that implement a systems approach and system analysis in relation to a specific task. The level of presentation and volume of information in such publications differ significantly. And this is understandable. After all, they have different purposes: from purely informational messages about system analysis in a newspaper or magazine essay to detailed analysis taking into account the specifics of the enterprise’s work in a certain area. Our goal comes down to seeing the place and role of such a concept as “quality” both in the system analysis itself and in assessing consumer properties. A unique tool for forming such a vision is the laws of dialectics. The foundations of the chain of connections between the concepts of systems approach - systems analysis - quality are already included in the definitions. In fact, one of the main stages of system analysis is the consideration of the elementary composition, structure or organization of an object, i.e. its quality. In turn, quality and quantity, composition and structure belong to philosophical categories, the dialectical unity between which is established using the category “measure”. Thus, if we talk about a systematic approach in relation to our task, then, in essence, we are talking about the “philosophy of engineering,” “philosophy of technology,” and ultimately, about the art of engineering. Without pretending to develop a new concept, we will try to carefully analyze the well-known philosophical categories in relation to the task at hand. It is generally accepted that the law of unity and struggle of opposites reveals the source of development, the law of the transition of quantitative changes into qualitative ones is the mechanism of development, and the law of the negation of negation expresses development in its direction, form and result. In essence, there is a fairly clear connection here with innovation processes and the range of concepts included in them: innovation, novelty, etc. This connection is even more obvious when using categories such as measure and norm. In fact, based on the well-known provisions on the relationship of dialectical laws, one can use the following graphical meta in relation to engineering: handicap: the source of development, the knowledge of which is oriented towards the law of the transition of quantitative changes into qualitative ones, can be seen in sociotechnical factors; the development mechanism, determined by the law of the transition of quantitative changes into qualitative ones, can be revealed through the quality/quantity relationship, in turn, directly related to the categories “measure” and “leap” (Figure 6). As for the use of the law of negation of negation, which essentially reflects the cyclical, or spiral, development, an analysis of this possibility is given in the extremely interesting work of A.F. Esaulov, where the methodological and psychological foundations of engineering creativity are considered on the basis of a polycyclic movement dictated by the law of negation of negation.

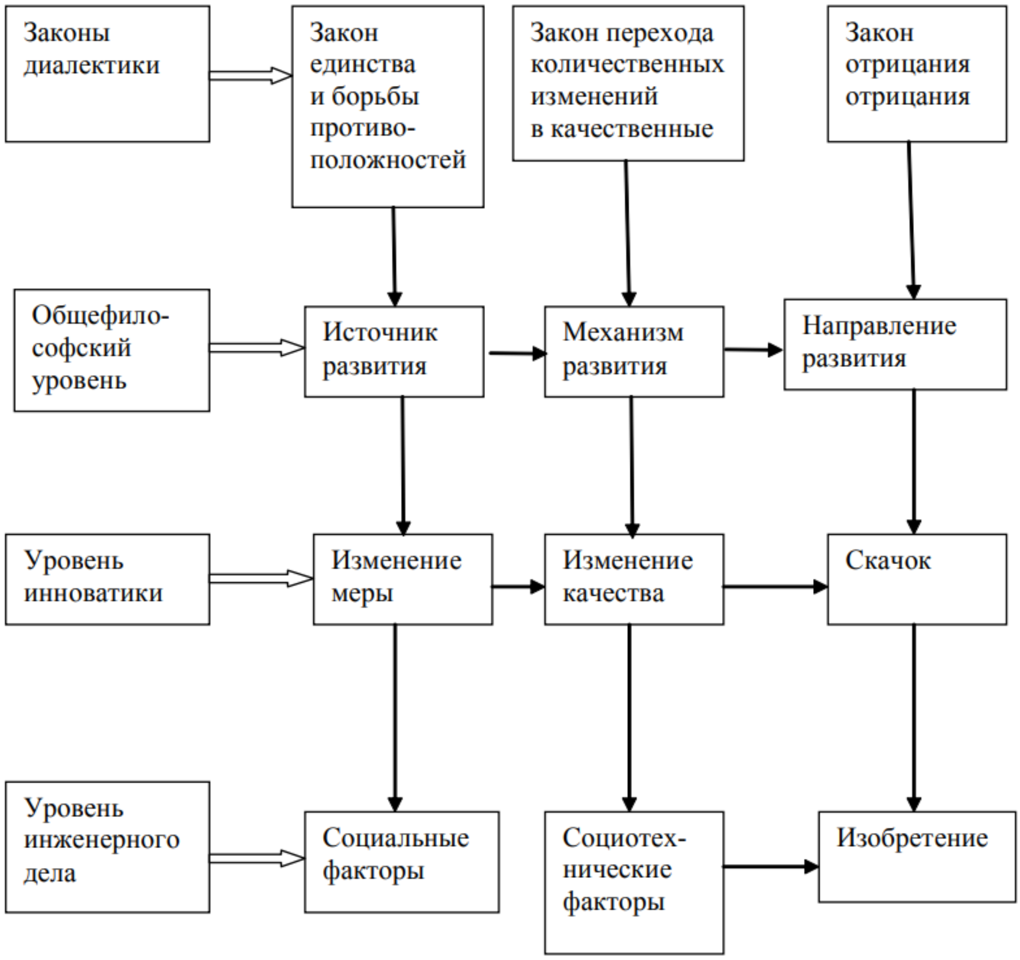


Figure 6. Engineering, innovation processes and the laws of dialectics

It should be noted that the dialectical approach to the analysis of technical sciences is being developed by both domestic and foreign philosophers. Moreover, all works emphasize that “a truly systematic approach to solving technical problems has not yet become a reality...” At the same time, even in specialized literature aimed at a narrow circle of professionals, social-innovative processes are touched upon, which inevitably bring the authors to the level of dialectical thinking. Returning to Figure 7, which shows three levels of the epistemological approach - general philosophical, innovation and engineering - it is necessary to clarify the following positions more clearly:

about the epistemological and ontological approach. In contrast to the level of general philosophical knowledge and the level of categories of innovation, the level of philosophy of technology is determined by the subject of activity itself - scientific and technical thinking. Since the end result of the activity is the development of material, technical objects or knowledge about them, even if this happens at the level of abstraction, the engineer is faced with the concepts and realities of a purely concrete, material world. Developing and mastering the possibilities of most fully satisfying the requirements requested by society for the consumer properties of products, he is forced to rely on concepts considered at the ontological level. Of course, we can take a position of scientific snobbery (at the heights of epistemological truths), but in this case we will not be able to solve a single issue related to substantive practical activity. Figure 8 shows the "circulation" of concepts, designated as a single conceptual cycle "concrete - abstract - concrete". The content of the figure consists of terms, without mastering which it is difficult to understand the relationships and interdependence of the processes of a systematic approach and assessment of product quality. In the center of the figure there are purely philosophical categories, on the left and right - branches of systemic-dialectical analysis.

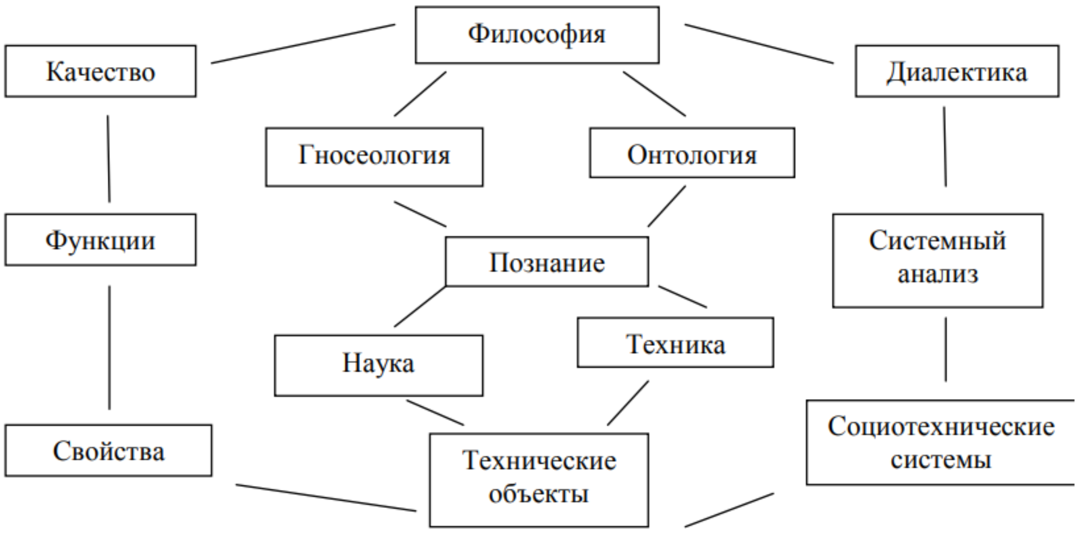


Figure 7. Conceptual cycle "ascent from abstract to concrete"

I would like to answer one more fundamental question: why was it necessary to talk about the laws of dialectics in such a brief, incomplete form, when there are professionally valuable works in this area? The fact is that the connection that is associated with the presentation of philosophy in relation to technology is made, as a rule, by professional philosophers only from the position of philosophy. And this is correct, since it guarantees methodologically correct coverage of the issues under consideration. But this, relatively speaking, is the external side of the problem. An engineer who is "inside" his task needs a philosophical understanding of what is happening. Therefore, such a concept as "philosophy of technology" or "philosophy of engineering" was introduced. Just as there is a philosophy of history, a philosophy of culture, a philosophy of science, etc., with its own subjects, structure and history, so a philosophy associated with engineering has actually already developed. However, to present it for a "technical audience" at the level of classical philosophy courses means dooming the whole matter to misunderstanding. Therefore, the authors believe that, by analogy with various introductory courses such as "Introduction to a Specialty," it is necessary to present the fundamentals of engineering thinking, constantly and purposefully leading the student to master the fundamentals of a systems approach. There is a fairly common misconception that a system for assessing the quality of a finished product and assessing the quality of production of this product can exist independently of each other. Failure to understand the essence of the existence of a single life cycle for any product of human (and, as a derivative, technical) activity has led and continues to lead to the release of low-quality goods. Using a systems approach radically changes the situation. Entrepreneurs in industrialized countries (the USA and Germany) were the first to understand that the success of production is inevitably associated with the development of general theoretical concepts for analyzing the patterns of technology development. This has led to the emergence of theoretical and practical universal developments, the originality and value of which lies in the fact that they are not related to a specific subject area and at the same time are necessary for the successful activities of any manufacturer. Let us note that the emergence and development of methods and techniques of technical creativity is evidence of the urgent need to develop "mechanisms and tools" for transferring the "general" - social, economic and technical development trends - to the "particular" - a specific engineering or scientific research task. In essence, this is what, since the time of Hegel, in philosophy has been called the ascent from the abstract to the concrete. This process is the turning of theory to real specifics and reflects the content-constructive development of theoretical thought.

If in these works system analysis is considered primarily from the perspective of optimizing a technical solution, then in the second half of the last century many works appeared that reached the sociotechnical level of problem solving. Specialists from Japanese companies were the first to not only sense, but also implement this approach. For example, the son of the founder and head of the Omron corporation, in the afterword to his father's book "The Eternal Spirit of Entrepreneurship," writes: "In the meantime, I am doing everything in my power to guide Omron along the path of humanism... Previously, we gave priority degrees of education, now, along with "excellent students" in their studies, we also accept those who have proven themselves in other areas, for example, in sports or such unique fields of knowledge as the Chinese language or astronomy. We are happy to hire simply erudite people, people who know a little bit about everything. For us, the main thing is talent as such, regardless of the sphere of its manifestation."

It seems to us that the above transition from the purely technical to the "human" characterizes the main trend of reform activities not only in the sphere of education, but also in the sphere of production. Scientists and businessmen both in the USA and in Europe quickly understood the essence of what was happening, as evidenced by a number of fundamental works from the point of view of scientific research. Despite the fact that each of them examines an area of specialized knowledge - labor productivity, economics, management, marketing - it is emphasized throughout that high quality can only be ensured through the understanding of the problems by the performer himself - the person. The most advanced technology without such training of the worker is unable to provide sufficient quality. An example is the level of quality of products produced on foreign equipment in Russia.

However, we do not find either in educational or scientific literature a clear explanation of the "joining" of two stages of the life cycle - production and consumption. Perhaps only in the work of K. Ishikawa are clear formulations given. The author writes: "I never tire of repeating that quality management begins with personnel training and ends with personnel training... In the West, it seems, they emphasize the production aspect of training in order to develop in workers certain skills that can be used by a particular company. In my opinion, we must turn the workers into well-educated people. We have to teach them to think and then direct their thinking in the right direction." In the modern situation, no one will argue with this thesis. But one fundamental question remains, and the success of the matter depends on its resolution: what needs to be taught to think? This is where the term "engineering thinking" that we introduced comes in handy. In fact, as a rule, we are offered two options for use: either the theoretical concept of production analysis, or the economic approach. Let's look at them using specific developments as examples. One of the most successful and fundamental implementations of the first option is the work of the Polish scientist V. Gasparsky.

"Praxeological analysis of design and construction developments." At the same time, praxeology is understood as the science of the effectiveness of actions, i.e. a science that deals with the study and development of rational and effective actions based on a comprehensive analysis of consumer or beneficial effects. The author quite rightly believes that materials, energy, tools are only the means by which "actions" are performed, i.e. technologies. "By comparing different technical objects with each other, we are actually comparing their suitability for meeting our needs. A comparison of the individual characteristics of these objects is nothing more than a way of assessing certain qualities of objects in relation to satisfying certain needs."

An example of a fairly successful implementation of the second option - economic and practical - is the methodology for planning and forecasting durable goods, set out in a domestic publication. Of interest to us is the classification of consumer properties introduced by the author. Table 3 shows the structure of consumer properties, which, in our opinion, can be extended to most products manufactured in Russia.

Table 3. Structure of consumer properties of durable goods

Classification	Composition and characteristics of consumer properties

View	The main properties that distinguish these durable goods from the general world, formulate the base of consumer value, causing the emergence of a qualitatively new need and a qualitatively new production
Group	Leading properties that determine qualitative diversity, significant differences in products that embody the properties of the species and cause development, an increase in the needs embodied in these products, as well as major changes in production
Class	Significant properties that complement the main and leading properties, expanding and differentiating the needs for products of a given type and its constituent groups; their implementation places special demands on production
Type	Levels of properties (main, leading, significant) - numerical values obtained as a result of calculations, measurements, tests, or identified by expert methods, determining the degree of development of the need and the degree of its satisfaction; ensuring these levels is an inherent task of production
Model	The embodiment of the main, leading, significant properties in compliance with the levels corresponding to the type, in unity with private auxiliary properties that determine the completeness of a particular thing

So, in any case, the necessary steps in determining consumer properties are:

system analysis of the process; selection of quality assessment criteria.

It is obvious that analysis is unthinkable without selecting appropriate criteria. The following consideration may help in understanding this choice. Whatever the degree of complexity of the product manufacturing process, the following sequence of actions is inevitable: obtaining raw materials or semi-finished products, manufacturing products, selling products.

If you start moving not from the supplier to the customer, as is usually explained in the classroom for the simple reason that the production cycle of the product is structured this way, but from the consumer to the raw materials, then it becomes clear how the consumer properties of the product should be formulated and what specific criteria will be effective. The starting point is the consumer's request, on the basis of which consumer properties—product quality—are formulated. Then the properties of the finished product must be converted into quality requirements for semi-finished products and raw materials, which will make it possible to clearly and clearly formulate the properties of both semi-finished products and starting materials. Then the task of developing a control methodology that should be followed is simplified: from output control to production control and incoming control. Let us note the most significant thing in this matter.

The most "subtle" point is the need to translate consumer properties from the language of the consumer into the language of the manufacturer (technical and economic engineering language). Moreover, the main thing is that in the process of such a transition the properties of the product that determine the performance of its main functions are not lost. Violations of this rule occur everywhere when, in order to improve manufacturability, in the pursuit of savings on production, they completely lose sight of the final goal of the entire production process.

No less complex is the procedure for transferring consumer properties to each previous operation of the technological process, right down to the properties of the starting materials. The rule should apply here: each subsequent operation is needed not in itself, but to perform the next one.

The basis for solving such problems, a kind of guiding star for an engineer, should be the following thought: the essence of any technological process is to transform the properties of materials (raw materials) into the properties of the finished product.

A huge number of publications are devoted to the issues of assessing product quality. Their topics range from deep theoretical research reaching the level of fundamental science to GOSTs, OSTs and similar regulatory documents. We are interested in the relationship between quality and consumer properties. Before moving on to consider these connections, we will examine several cases from practice. As a typical situation, I remember an incident that occurred while the authors were working as part of a factory commission assessing a machine for the "Quality Mark". When checking the finished part, a significant "runout" was discovered - the eccentricity of the outer surface - up to 0.3 mm, which is unacceptable even for machines from blank shops. And we were dealing with equipment designed for finishing. After a long search, a completely absurd thing became clear - the position of the tailstock of the machine was not checked, the displacement of the center of which determined the delay in the work of the commission of twelve people.

The second example is from the process of debugging a new generation machine with program control at the pilot production of a large research institute. The machine support did not move after switching on. The engine is powerful, the system is in order. After a futile search conducted by the adjuster and the lead designer, we turned to the chief of scientific work. He said: "Well, sometimes science can come in handy," he went to the workshop. What happened next was ridiculously simple. "Turn off the engine," the chief said. "Try turning the feed screw by hand." It turned out that a colossal amount of effort was required. "Disassemble the screw-nut pair." And what? There was a felt O-ring there, which the fitter installed "very conscientiously." It's hard to blame him. After all, he carefully sealed the screw pair, protecting it from contamination. If he had thought about the main, and not the auxiliary, function of this node, then this would not have happened. And finally, let's look at another feature of low quality.

In this case, the situation is typical for the production of things with adhesive joints. An example from the shoe industry. The boots were made using proprietary foreign equipment, and yet, under our production conditions, for some reason they fell apart. A representative of the company analyzed the production process and demanded a sharp increase in payment for the operation "coating the soles with glue." The marriage disappeared. The fact is that this operation was performed manually, was considered primitive and was paid according to one of the lowest categories. Therefore, either trainees or temporary workers were assigned to carry out this operation. From the point of view of the complexity of execution, this operation is the simplest, but from the point of view of future consumer properties, it is the main one.

What is the real, root cause of marriage in the above and similar cases? In the first of them (the center of the machine) - the distribution of responsibility for one task simultaneously among several performers, i.e. lack of responsibility; in the second (sealing) - the assembler's lack of understanding of the functional purpose of the unit; in the third (applying glue) - an error by the production management engineer in assessing the significance of the operation. The analysis of such situations was the reason for the emergence of the now world famous "quality circles" in Japan. Many specialists, getting acquainted with the methods of their work, are quickly disappointed - their activity seems very elementary, even primitive. Let's try to approach this issue from an engineering perspective.

Regardless of what this production does, the following scheme of its "circulation" remains valid (Figure 8). The initial data for understanding the design process are materials and design, for the manufacturing process - the technological process and equipment, for the operating process - the operating conditions, storage and transportation of the finished product. In colleges (nowadays most of them have become academies and universities, which makes this material even more necessary due to its universality), the specialization of faculties occurs, as a rule, according to the above scheme. To understand the technological process, they train technologists, to understand the operation of equipment - mechanics, to calculate all stages of production - economists, for the design stage - artists (designers), to sell products - merchandisers. The names of specialties for each university, of course, have their own characteristics, but in general the approach described above remains the same. The stages of the production cycle shown in the figure also determine a set of special disciplines: materials science, mechanics, strength of materials, theory of mechanisms and machines, machine parts, etc. Obviously, each stage is responsible for the quality of future products. But how exactly?

In the center of Figure 8 there is a triangle - quality control. In fact, it has a dual nature: technological and constructive. Two triangles arise, which determine the sources of future quality.

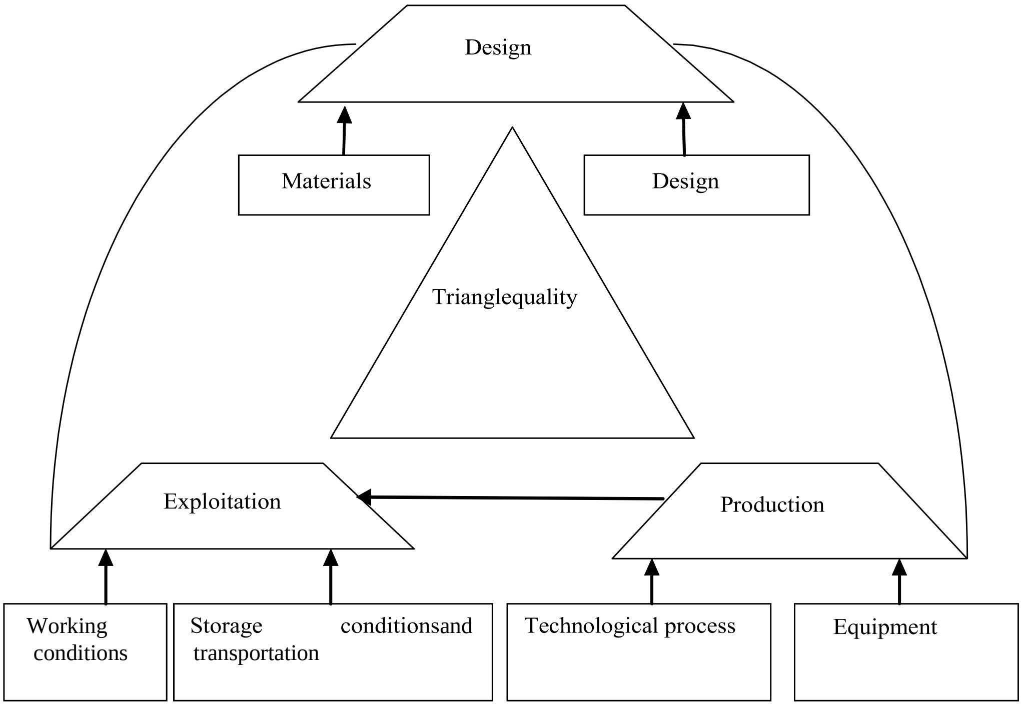
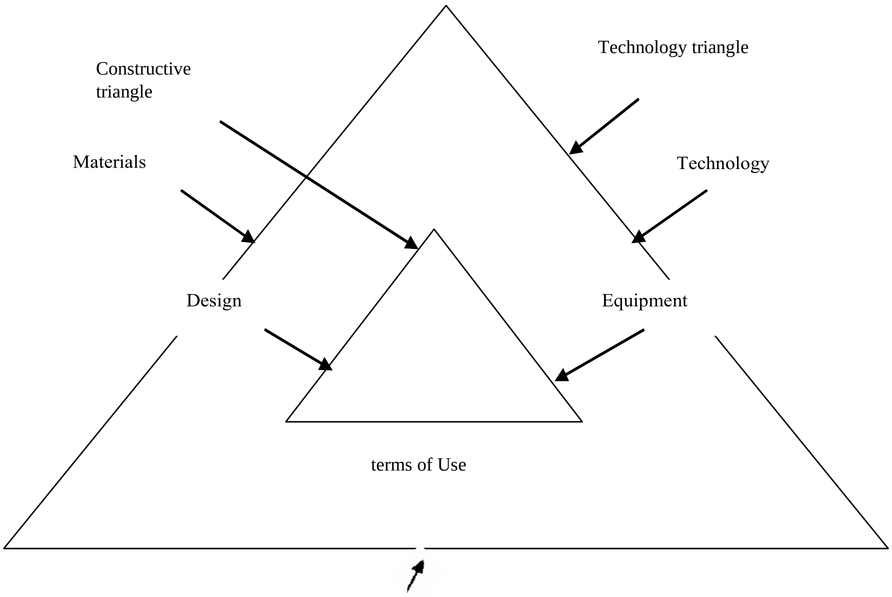


Figure 8. The stages of the production cyclological triangle are nothing more than a line of properties that determines the function of the future product, and the constructive triangle is the organization of its structure in space and time (Figure 9).

In the future, we will specifically discuss such a concept as "constructive-technological analysis". Here we note that placing the constructive triangle inside the technological triangle is not accidental. This emphasizes the primacy of technology. Just as in inventions there can be many devices that implement one method, so the same technology can be implemented using different equipment. Let us try to identify the sources of origin of the category "quality", which, by philosophical definition, should express the essential certainty of the object. These sources are based on two concepts, which we will conventionally designate as "I want" and "I can". Let's reveal their contents. As already mentioned, on one side of the production process there is the consumer - "I want it this way", and on the other - the production process - "I can do it this way". What the buyer wants can be determined through marketing - market research. What production can do is clarified with the help of management - the management of people carrying out the production process.



Consumer properties

Figure 9. Quality triangle

There is always a discrepancy between these "I want" and "I can". The task of reducing the degree of this mismatch falls on the shoulders of the engineer. What can help him? Of course, knowledge. But knowledge not only about the subject area of his activity, but also an understanding of the entire circuit of relationships shown in Figure 9. Awareness of the origin of the sources of quality - production capabilities, standard of living, value orientation - enables the engineer to use not only the stock of knowledge in the specialty, conventionally designated " technology", but also make it necessary to use data from sociology, HTT. With such a scheme of reasoning, which essentially implements a systematic approach, the engineer has a chance to "float" to the "surface" of quality, leaving the problems of both technocratic and social reasoning at lower levels. Only in this case will he be able to create a quality product, in the totality of whose properties the contradictions between "I want" and "I can," between the consumer and production will be eliminated. Then we can talk about engineering as an art, since with this approach the category "quality" acquires its primary scientific and philosophical meaning - the ability to express a certain degree of human knowledge of objective reality. Knowledge of technology, i.e. the ability to transform the properties of source materials into consumer properties is the main part of the content of an engineer's knowledge. It is for this that he needs to know physical and chemical laws and effects, and it is for this that he needs to master the mathematical and economic apparatus. To truly master the art of engineering, he needs to enter the "supersystem" of socio-psychological aspects associated with the formulation of consumer properties and production conditions. In practical work, the situation is as follows. Each specialist has his own idea of the concept of "quality". And at meetings devoted to production issues, long discussions arise, which can ultimately be reduced to the question: what is good and what is bad? As mentioned earlier, there are numerous instructions regulating the quality of products in production and giving a clear answer to this question. But the complexity of the situation is that no instructions can provide for a change in the situation in real conditions. The need to make local decisions depending on the requirements of today and production capabilities at the moment makes thick volumes of publications such as KSUKP (integrated product quality management system) ineffective. This is especially evident at the present time, since the prospect for the development of Russian industry is associated with the denationalization of large enterprises and the need to organize numerous independent joint-stock, private, joint and similar industries. Scientific and technical workers and managers need to make operational decisions to develop successful strategies and tactics for their enterprises. And, of course, it's not just a matter of the abstract concept of "product quality." The fate of both the enterprise and the people working at it depends on what exactly is manufactured and with what consumer properties. Therefore, the responsibility of providing the decision maker with data that reflects the situation as objectively as possible falls on the shoulders of the engineer who is thinking through what and how to do. These considerations become even more important when assessing development prospects, when the development of a new object associated with innovation processes throughout the organization is required.

The methodology outlined below is a general tool that an engineer can use to solve a specific problem. The value and meaning of the following approach to assessing quality based on consumer properties lies in the fact that a specialist breaks out of the framework of instructions and regulations given to him from the outside and often contradict each other, and acquires the opportunity to "create quality" from the inside, i.e. according to his own ideas, relying on the capabilities of the production that he knows. First, we will consider the method of transition from general requirements related to the fulfillment of consumer properties to specific standards. Before talking about constructing a "properties - norms" diagram, it is necessary to analyze several levels of concepts related to the production process. The starting point for us is the structural-functional approach, the main provisions of which are based on the systems approach and FSA (functional-cost analysis). First of all, we are interested in the property level, which is a derivative of the functional level, as well as the constructive level, which is a derivative of the structural level. In turn, the technological level is determined by the level of properties, and the level of equipment is determined by the design level. Table 4 provides a semantic explanation of the above levels, and Figure 11 reveals their connection and subordination. There are three pairs of levels with corresponding relations of the two concepts, namely:

1. first level structure/function;
2. design/properties;

equipment/technology and two communication lines:

second level

1) function - properties - technology;

2) structure - design - equipment.

Although in practice the engineer has to deal with either technology (process engineer) or equipment (mechanical engineer), it should be clear that both technology and equipment are derived from previous levels. It should also be understood that a mistake at the upper levels (1 and 2 pairs) will cost immeasurably more than at the third level.

Table 4. The semantic content of various levels of the production process

Level name	Content
Functional	Defines all functions performed by a product from raw materials to the finished product. Functions are formulated on the basis of value orientation. The main function is primary
Structural	Defines the relationships between product elements from raw material to finished product. Connections are determined using a systematic approach and taking into account the analysis of subsystems
Properties	Determines the properties inherent in a product - from raw materials to the finished product. Properties are formed based on functions. Consumer properties are primary
Constructive	Determines the composition and relative arrangement of product elements - from raw materials to the finished product. The design option is determined based on the optimal organization of the structure from the point of view of its consumer properties.
Technological	Determines the composition and sequence of operations to ensure the properties that the product must have during the manufacturing process - from raw materials to the finished product. Technological operations, their sequence and modes are determined based on the level of properties
Equipment	Defines a set of tools, devices, mechanisms, machines necessary for implementation in a specific production environment with the appropriate technological level. Equipment is selected based on the need to ensure the relative position of elements in space and to give them certain properties

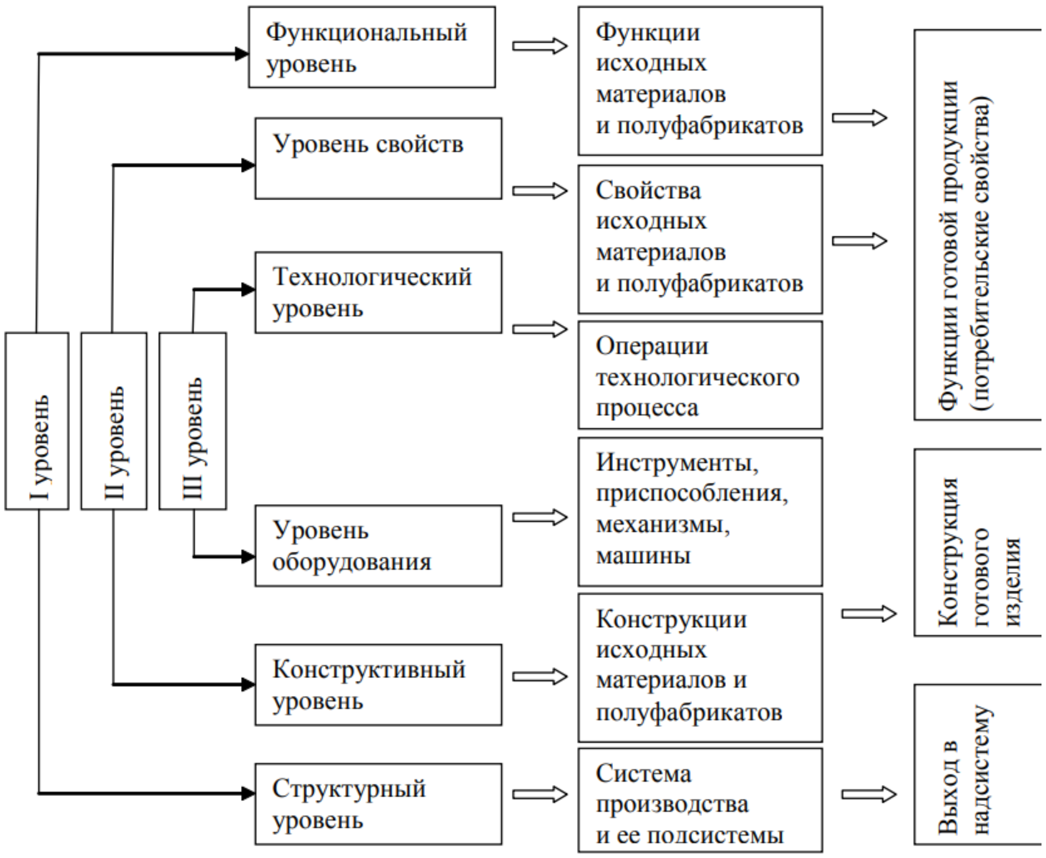


Figure 10. Connection and subordination of levels of analysis of the production of a given subject area of specialists.

Teaching university students using special disciplines is preparation for work at the third level. The considered three-level analysis of the production process of the finished product allows us to move on to developing a methodology for assessing production from the position of forming consumer properties during the technological process. In reality, we are dealing with finished products (or their components), as well as with the means of production and control of these products. Between these two materialized objects there is a hierarchical system of transitional "concepts - steps". The content of each stage is clearly revealed using a diagram, in the center of which is the finished product, and on the periphery are control tools. In the most general case, consumer properties can be divided into technical, economic and aesthetic.

This makes it possible to work with a chart for certain sectors. Each sector of consumer properties may correspond to one to several evaluation criteria. Control methods may also be ambiguous, i.e. the same criterion can be assessed in different ways. The contents of circles - units of measurement and norms - are well known to any engineer. In each subject course, they are regulated by very specific units of measurement and a recommended range of tolerances. The entire production process, from the first to the last technological operation, is inherently characterized by a "ladder of transition" from the finished product to the means of control. Figuratively speaking, we are dealing with a whole range of diagrams sequentially transforming into each other in the production process. This system of diagrams is integrated into the production process and differentiated into individual operations of the technological process. How many internal sections of diagrams are needed depends on the technology and production conditions. Let us explain this situation. As a result of the technological process, properties are converted from the initial elements to the finished product. Each slice of the diagrams can correspond to a specific operation (stage) of the production cycle. An indispensable condition for the development of such diagrams is the following: the consumer properties of semi-finished products are determined based on the properties of the finished product. The analysis should begin from the end of the technological process to its beginning, right down to the starting elements. After such elaboration of the production process, a complete picture of possible requirements and conditions for their implementation for specific products appears.

Conclusion

The circumstances are such that you have to choose between a traditional and a new solution that promises increased efficiency and reduced costs. The choice, however, should be based only on preliminary testing. The young engineer's boss unexpectedly informs a group of colleagues that the recommendations must be substantiated within two days. At an engineering school, a young employee had the opportunity to research a new device, but now, in production conditions, there is no time for thorough research. Nevertheless, the device is promising. The engineering team agrees with the boss and recommends an old, proven device. The boss instructs a young employee on how to write a report praising an old device and recommending its use. The report should not contain a word about a new alternative. What should an engineer do?

Summarizing the above, it should be noted that against the backdrop of an increase in the number of publications devoted to certain aspects of engineering work, the scarcity of studies in which it would be considered as a spiritual and practical activity becomes noticeable. The creativity of an engineer has not yet been studied deeply enough in the sociological and philosophical literature. Scientific, technical and engineering activities as a cumulative source of technological innovation in a number of important aspects are outside the field of research. Therefore, the need arose not so much to optimize the processes of scientific and technical creativity and scientific and technical activity, but to develop a general concept for the further development of a system for training specialists with higher technical education and a methodology for managing this system. The creation of a new paradigm for the educational process has become not only a pedagogical, technological or environmental problem, but also becomes a philosophical and socio-economic problem, on the successful solution of which scientific and technological progress throughout the country depends. It should be noted that until now the process of both theoretical and practical understanding of the categories “engineering activity”, “engineering thinking”, “scientific and technical creativity” has developed in such a way that its psychological, logical and epistemological aspects have received the greatest development, and general sociological , in essence, have been studied very little and, as a rule, are in the nature of general recommendations that are difficult to actually implement in the socio-technical activities of an engineer. Therefore, it is natural that the public consciousness is dominated by the idea of scientific, technical and engineering activity as a special kind of spiritual activity, as if divorced from creativity in general and especially from art. Without accepting the limitations of such views, the author came to the conclusion that engineering activity should be considered as a dialectical unity of change in the object and subject of activity, as a constant divergent-convergent process of scientific and technical activity, including its subject, spiritual and organizational components. Engineering activity can be understood and revealed only through a specific historical study of socio-technical and socio-economic processes. Such an analysis makes it possible to understand the inextricable connection between the method of production and scientific and technological progress, scientific and technological progress and culture, the connection between engineering activity and art, with the moral values of a creative person. Modern highly industrialized and largely technocratic society is in dire need of such theoretical works that carry the potential of practicality and make it possible to harmonize the processes of scientific and technical activity with the help of technological innovations. It should also be noted that there has been a sharply increased public need to unite representatives of different scientific disciplines in solving technical problems.This is confirmed by the material incentives Japanese and American firms provide for scientists and engineers to obtain second and third degrees, including the study of foreign languages and non-technical sciences. The real embodiment of this trend is the synector teams in manufacturing performance analysis consulting firms. An example indicating the negative impact of differentiation of sciences is the division of engineering departments of a higher educational institution into departments for equipment and technology in the same branch of production. Such a separation, formally convenient for organizing the educational process and for compiling a range of specialties, led to a deep and long-term mutual alienation of the style of engineering thinking of process engineers and mechanical engineers, as a result of which many unsuccessful and ineffective decisions arose in the design and manufacture of technical objects. To give universal recommendations for changing the entire system of higher technical education is an unrealistic task. This work is only an attempt to fill the “blank spots” that have arisen between the socio-philosophical and subject-technical areas of training in the education system, with the help of concrete sociological and concrete methodological research.

Solving the problems posed in the work is complicated by the fact that during times of crisis many social contradictions appear that are inherent in the existing social system. Therefore, this study does not claim to solve all problems associated with scientific, technical and engineering activities. Considering the multifaceted nature of engineering activity in the light of the onset of a new period in the education system, conditioned by the need to develop students' systems and computer styles of thinking, the author puts forward the following thesis as a basic one: the process of development of natural intelligence should not be identified with the development of increasingly universal artificial intelligence systems, including including computerization. The author also does not agree with the statements that engineering activity will become art only when, on the basis of fully automated and computerized labor, the techniques and methods of scientific and technical technology are combined with artistic creativity. The emergence of value-based approaches to human activity is a long-standing humanistic tradition. Mythology is actually considered the beginning of humanitarian culture. Religion divided the world into material and immaterial (mystical, otherworldly, supernatural), which led to an awareness of the importance of the spiritual in this world, which can also be attributed to humanistic cultural studies. Philosophy develops a rationalistic picture of existence, based on the human mind and scientific achievements. The humanistic orientation of philosophical concepts is expressed in value systems developed by philosophy. As shown in this work, art, including technical art (techne), originating in the springs of myth-making, religious teachings, and philosophy, ultimately led humanity to the development of rationalism, which degenerated in the 20th century into technicism and technocracy. There has been a shift in the value system towards greater satisfaction of human material needs. In the history of its development, humanity has moved further and further away from truly humanistic ideals, moving away from the social-humanistic direction of progress towards scientific and technological progress. Frightened by the results of such a movement, which led to an ecological and moral catastrophe, the world community, at least its leading part, is trying to change the course of human development towards humanization. This process is most important for the education system. In the education system itself - to humanize the process of technical education. Using various sociocultural approaches (social, philosophical, systemic, structural-functional, general systems theory), we tried to formulate a technology paradigm for the formation of engineering thinking associated with the destruction of ideologies of utilitarian-pragmatic goals. We also tried to contribute to the work of streamlining the mass of recommendations, conglomerative in form and eclectic in content,introducing a sociotechnical approach to solving technical problems using NTT and innovative technologies. In contrast to the descriptive (descriptive) method of constructing humanistic concepts adopted in socio-philosophical works, the study proposes a constructive definition of the methodology for moving the system of higher technical education along the path of humanization. To reveal this approach, the present study raised issues of dialectics, ethics and aesthetics as necessary. Over the past decades, society's requirements for specialists have significantly transformed. In addition to being highly qualified in their field, workers in science, technology, and management must be capable of creative activity and self-improvement. Engineering activity began to have a planetary character, technogenesis became commensurate with natural scales, covering the entire territory of the earth. The humanization of scientific and technological progress to mitigate technocratic blows should be directed primarily towards the humanization of the process of education of engineers. Nowadays, the disciplinary paradigm of education continues to operate, fostering “chauvinism of special disciplines.”

Those who call for a shift in the training of engineers to a paradigm shift, to the introduction of a problem-based method, and the like, are right, in fact. The difficulty of such a transition lies in the fact that there are no simple and quick solutions leading to successful results in education. It is obvious that the transition period requires not only time, but also special techniques. During this period, an understanding should come of how to move from technical knowledge, how to move from technocratic thinking to sociotechnical knowledge, to humanistic thinking.

First of all, the purpose of education must be changed; it is not knowledge itself that is important, but the development of personality with the help of knowledge. Such goal setting requires solving the problem of teaching students creativity and self-improvement. It is not enough to call for internalist activities focused on self-education. Tools for this activity need to be developed. If this is successful, then both the student and the graduate engineer will be able to take advantage of the content and scope of knowledge that is already available in existing educational programs, using this knowledge to humanize technical activities. The stated position is the main goal of this work. It is to achieve this goal that it is shown how, with the help of a sociotechnical approach, using the diversity of such concepts as “consumer properties” and “result quality”, one can arrive at a full-fledged creative educational process. Therefore, in this work, significant attention is paid to the consideration of the transcendental in engineering activities, i.e. such categories as faith, intuition, imagination, fantasy, creativity, “working” for the humanization of engineering thinking. The introduction of such conventional concepts as “efficiency coefficient” is associated with the need for an instrumental and constructive description of innovative processes in engineering activities. The ability to operate with these concepts will enable the engineer not only to adapt to innovation, but also to actively participate in the creative process and master the art of solving real life problems. The tools that the NTT methodology has in its arsenal will help the engineer make the transition from a system of conceptual knowledge to a system of instrumental knowledge, and move on to real creativity.

The search for effective criteria for optimizing engineering activities is a fundamental point to which considerable attention is paid in the study. The anthropological aspect of performance results can be realized with a sufficiently in-depth analysis of the concept of “result quality”. This will help in teaching to move from explanatory and illustrative methods to problem-search methods.

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Issue Article

Zulfiya Mirsharapovna Sidiknazarova
Tashkent State Transport University
English teacher
Department of Foreign Languages
Tashkent, Uzbekistan

FORMATION OF DISCOURSE COMPETENCE IN THE FIELD OF ORAL COMMUNICATION

Abstract: *The place of discursive competence in the structure of communicative competence is determined by summarizing the results of the analysis of scientific and methodological literature. A definition of the concepts "discourse" and "discursive competence" is given. The novelty of the study lies in the fact that it presents the component composition of the content of discursive competence, which is formed when teaching a foreign language through an educational forum. The main characteristics of the educational forum are described. The results can be applied when using electronic courses in the educational process.*

Key words: *communicative competence, discursive competence: component, content, discourse, educational forum, process of teaching a foreign language.*

Language: *Russian*

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ФОРМИРОВАНИЕ ДИСКУРСОВОЙ КОМПЕТЕНТНОСТИ В СФЕРЕ УСТНОГО ОБЩЕНИЯ

Аннотация: *Место дискурсивной компетентности в структуре коммуникативной компетентности определяется путем обобщения результатов анализа научно-методической литературы. Дано определение понятий «дискурс» и «дискурсивная компетентность». Новизна исследования заключается в том, что в нем представлен компонентный состав содержания дискурсивной компетенции, которая формируется при обучении иностранному языку посредством образовательного форума. Описаны основные характеристики образовательного форума. Результаты могут быть применены при использовании электронных курсов в образовательном процессе.*

Ключевые слова: *коммуникативная компетентность, дискурсивная компетентность: компонент, содержание, дискурс, учебный форум, процесс обучения иностранному языку.*

Введение

Социальный заказ современного информационного и поликультурного общества требует, чтобы высшие учебные заведения обеспечивали создание оптимальных условий для обучения студентов иноязычному общению в целях решения проблем межкультурного взаимодействия на мировом уровне. Умение общаться становится необходимой составляющей подготовки высококвалифицированных специалистов. Необходимость повышения качества языковой подготовки в высшем профессиональном образовании является актуальной.

Современная модель образования формирует у студентов высокий уровень профессиональной компетентности, одной из составляющих которой является коммуникативная компетентность. Умение осуществлять эффективное речевое взаимодействие на иностранном языке входит в содержание иноязычной коммуникативной компетенции, что позволяет выпускникам вуза свободно общаться в полиязычной среде [1. с 145]. Коммуникативная компетентность является основой профессионального образования, если речь идет о специальностях, основной деятельностью которых является общение в профессиональной сфере.

В последнее время появились исследования, посвященные рассмотрению отдельных компонентов коммуникативной компетентности. Однако не всем компонентам уделяется одинаковое внимание. В связи с растущим интересом теоретиков и практиков к различным аспектам межкультурной коммуникации основная часть исследований направлена на решение вопросов, связанных с социокультурными параметрами коммуникации [1. с 45]. Значительное количество работ посвящено проблемам социокультурной компетентности.

В данной статье мы определим место дискурсивной компетентности как части коммуникативной компетентности, проанализировав научно-методическую литературу по данной теме. Цель нашего исследования – определить содержание дискурсивной компетентности, формируемой при обучении иностранному языку студентам языкового вуза посредством образовательного форума.

В науке и практике преподавания иностранных языков недостаточно внимания уделяется понятию «дискурс», имеющему чрезвычайно важное значение для формирования дискурсивной компетенции [2. с 16]. Большинство существующих исследований посвящено лингвистическому аспекту проблемы дискурсов или дискурсивному анализу: «Структура и семантика аргументативного дискурса» Е.Н. Белова; «Лирический дискурс как объект лингвоэстетической интерпретации» А.В. Флори и другие.

В научной литературе существует множество определений понятия «дискурс». В разное время различные учёные предлагали свои трактовки этого понятия (Т. А. Ван Дейк, П. Серио, Н. Д. Арутюнова, В. И. Карасик, А. А. Кибрик, Е. С. Кубрякова, Ю. С. Степанов, Г. Г. Слышкин, В. Е. Чернявская и другие). Но в целом они не противоречат друг другу, а дополняют и дают более полную характеристику этого понятия с точки зрения разных наук. Т.А. Ван Дейк — один из основоположников теории дискурса. Ученый предложил определение дискурса, которое стало активно использоваться в научном сообществе и послужило основой для более детальных определений этого термина и создания классификаций основных характеристик дискурса. Значение определения, предложенного Т.А. ван Дейка, заключается в определении «коммуникативного события» как сложного единства языковой формы, значения и действия.

Дискурс предлагается рассматривать с позиций функционального подхода как коммуникативное событие, происходящее между говорящим и слушающим (наблюдателем и т.п.) в процессе коммуникативного действия в определенных временных, пространственных и других контекстах [3. с 122]. Отметим также, что дискурс как коммуникативное событие может быть речевым (письменным или устным) и иметь вербальный и невербальный компоненты. Следуя доктрине дискурса, предложенной Т.А. ван Дейк, А.А. Кибрик создает квалификацию системных характеристик дискурса, согласно которой при характеристике дискурса указываются: жанр; регистр (игровой, деловой или институциональный); тип или канал передачи информации (устный, письменный, мысленный, жестовый и электронный субмодус); функциональный стиль; формальность.

Что касается дискурсивной компетентности студентов языкового вуза, то здесь мы определяем ее как совокупность знаний и умений, которыми должны обладать студенты, изучающие иностранный язык, для того, чтобы логически выражать мысли, создавая грамматически и лексически правильный текст, адекватный изучаемому языку, коммуникативной ситуации, а также за правильную интерпретацию текста [4. с 78]. Несомненно, понятие «дискурс» является не последним по значимости в определении дискурсивной компетентности. Это связано с недавним изменением отношения к «дискурсу» и «тексту». Ранее эти два термина в лингвистической литературе были равнозначными и использовались параллельно. В настоящее время лингвисты различают эти два понятия и определяют текст как продукт речевой деятельности, выраженный в устной или письменной форме, который является целостным и связным. Дискурс воспринимается как сложное коммуникативное явление, как «совокупность всего сказанного и понятого в определенной конкретной ситуации в ту или иную эпоху жизни данной социальной группы» [6. с 95], или, как текст, погруженный в жизнь.

Одними из ключевых знаний, которыми должны обладать изучающие иностранный язык, являются знания о видах и категориях дискурса. В И. Карасик выделяет следующие категории дискурса:

1) участники общения (категория, включающая статусно-ролевые и ситуативно-коммуникативные характеристики);

2) условия общения (категория, определяющая сферу общения, коммуникативную среду);

3) организация общения (категория, определяющая мотивы, цели и стратегии общения, управление общением и вариативность средств общения);

4) способы общения (категория, определяющая стиль и жанр) [7. с 62].

В.И. Карасик также выделяет два типа дискурса – личностно-ориентированный и статусно-ориентированный. Первый существует в форме бытового и экзистенциального (философско-художественного диалога) общения, а второй — в форме ролевого общения в соответствии со сферами деятельности, например, массовой информации, политической, деловой, научный, педагогический, военный, спортивный, религиозный, правовой и другие виды статусно-ориентированного дискурса.

Чем больше методических решений, тем эффективнее поиск новых способов обучения. В последнее время усиливается коммуникативная направленность обучения иностранному языку, что приводит к ряду кардинальных изменений в целях и содержании обучения иностранному языку. Необходимо не просто знать язык, но и уметь адекватно использовать его в реальных коммуникативных ситуациях. Таким образом, возникает необходимость развития «дискурсивной компетентности». Прежде чем говорить о дискурсивной компетентности, следует сначала проанализировать основные понятия, имеющие непосредственное отношение к этому термину. Прежде всего, необходимо разграничить понятия «компетентность» и компетентность и рассматривать коммуникативную компетентность как базовую структуру, включающую в себя дискурсивную компетентность. Наиболее важным в данной работе является понятие дискурса, его природа и структура. Говоря о компетентности, стоит отметить, что ученые часто отождествляют этот термин с компетентностью. Я. Зимняя выделяет два варианта соотношения этих понятий, ученые либо разграничивают их, либо идентифицируют, что происходит гораздо чаще.

Проследим основные вехи формирования понятия «коммуникативная компетентность» от момента его зарождения до наших дней. С самого начала разработки понятия «коммуникативная компетентность» существовало противоречие между сторонниками узкого и широкого понимания знаний и умений, необходимых для общения на иностранном языке.

В научном мире всегда существовало различие между знанием и его реализацией, поэтому само понятие «компетентность» нельзя назвать новым. Термин «компетенция» впервые был введен американским лингвистом Н. Хомским в 1965 г. в отношении знания языковой системы, языковых знаков, лексических и грамматических форм, а не в отношении использования этих знаний в ситуациях реального общения. Если Н. Хомский, предложивший в 1960-е гг. прошлого века концепция «лингвистической компетентности» считала ментальную («знания») модель языковой компетенции в виде универсальных правил необходимой и достаточной для общения, тогда уже в этот период Д. Хаймс и С. Савиньон отстаивал идею не языковой, а коммуникативной компетентности. Вскоре появилось и понятие «коммуникативная способность» - способность, о которой писали Л. Бахман, С. Савиньон, Х. Виддоусон.

Н. Хомский продолжил идеи грамматики, развитые Ф. де Соссюром. Постепенно в отечественной и зарубежной методологии появился методологический термин «коммуникативная компетентность» в противовес «лексической компетентности» Н. Хомского. Другой американский лингвист, Д. Хаймс, утверждал, что для полноценного общения (коммуникативного акта) недостаточно иметь лишь знания о языковой системе, лексических и грамматических правилах.

М.Н. Вятютнев предложил понимать коммуникативную компетентность «как выбор и реализацию программ речевого поведения в зависимости от способности человека ориентироваться в той или иной среде общения; умение классифицировать ситуации в зависимости от темы, задач, коммуникативных установок, умений, возникающих у учащихся перед беседой, а также во время беседы в процессе взаимной адаптации».

Таким образом, можно сделать вывод, что учебный форум служит образовательным контекстом формирования дискурсивной иноязычной компетенции, что предопределяет знание и понимание обучающимися системных характеристик дискурса и умение применять их в соответствующих ситуациях общения как способ реализации речевых намерений. Формирование дискурсивной компетентности посредством обучающего форума необходимо рассматривать в тесной связи с возникновением потребности и мотива высказывания. Следует использовать такие приемы, которые обогащают речь учащихся новыми речевыми клише, формируют коммуникативные навыки, в частности применительно к разным форматам письма, развивают способность учащихся извлекать информацию из текста. Применительно к условиям форума, а именно общения в виртуальной среде, особое значение приобретает умение логически строить высказывание, что и составляет, собственно, содержание дискурсивной компетентности.

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