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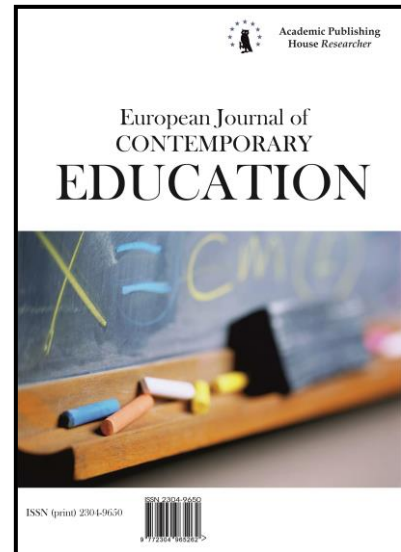
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## **Theological Media Literacy Education and Hermeneutic Analysis of Soviet Audiovisual Anti-religious Media Texts in Students' Classroom**

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### **Abstract**

This article realized the Russian way of theological media education literacy and hermeneutic analysis of specific examples of Soviet anti-religious audiovisual media texts: a study of the process of interpretation of these media texts, cultural and historical factors influencing the views of the media agency / authors. The hermeneutic analysis suggests media text comprehension through comparison with historical, cultural tradition and reality; penetration of its logic; through comparison of media images in historical and cultural context by combining analysis of the structural, plot, ethical, ideological, iconographic / visual, media stereotypes and analysis of media text characters. An analysis of such audiovisual media texts, in our opinion, is particularly important for media literacy education in the training of future historians, culture, art historians, sociologists, linguists, theologians, psychologists and educators.

**Keywords:** media literacy, media education, information literacy, hermeneutical analysis, Soviet, USSR, audiovisual, anti-religious, media texts, students, classroom

### **Introduction**

Following their Western counterparts (Pungente, O'Malley, 1999; Zasepa, 2005 and others) Russian theologians and clerics in recent years, are increasingly turning to the problems of film / media literacy education (Dukhanin, 2005; Ilyashenko, 2006; Patriarch Kirill, 2009; Posadsky, 2006; Prokofiev, 2006 and others). In particular, the Chairman of the Synodal Information

Department Vladimir Legoyda supported the proposal of the director Nikita Mikhalkov on the introduction of film education for pupils of 6-7 classes (Legoyda, 2012).

Unfortunately, such a balanced coexistence between Russian church leaders and a media sphere was not always. So over the years of Soviet power a media created thousands of anti-religious media texts: books, articles, radio / television programs and films. Many media texts of this kind are available now on Internet portals.

In connection with this it is important to define the modern media educational stance towards media anti-religious topics.

In my previous works (Fedorov, 2008; 2011; 2012), I appealed to the technology of hermeneutical analysis of media texts (Eco, 1998; 2005; Eco, 1976; Silverblatt, 2001, p. 80-81). This time this technology will be used as an example of Soviet feature films on the anti-religious theme. An analysis of such audiovisual media texts, in my opinion, is particularly important for media literacy education of future historians, culture & art historians, sociologists, linguists, theologians, psychologists and educators.

### **Materials and methods**

Materials: media and film studies literature, media texts (films) with anti-religious topics.

Methods: following the methodology developed by Umberto Eco (Eco, 2005, p. 209), C. Bazalgette (Bazalgette, 1995) and A. Silverblatt (Silverblatt, 2001, pp. 80-81), I try to make a hermeneutical analysis of Soviet feature films on the anti-religious topic, based on media literacy keywords: *media agencies, media / media text categories, media technologies, media languages, media representations and media audiences*. In my opinion, the hermeneutic analysis of specific examples of Soviet anti-religious audiovisual media texts we can do in this way: a study of the process of interpretation of these media texts, cultural and historical factors influencing the views of the media agency / authors. The hermeneutic analysis suggests media text comprehension through comparison with historical, cultural tradition and reality; penetration of its logic; through comparison of media images in historical and cultural context by combining analysis of the structural, plot, ethical, ideological, iconographic / visual, media stereotypes and analysis of media text characters. An analysis of such audiovisual media texts, in my opinion, is particularly important for media literacy education in the training of future historians, culture, art historians, sociologists, linguists, theologians, psychologists and educators.

### **Discussion**

During the seventy years of the last century religious approaches to mass education in Soviet Union have been virtually banned. And at a time when the religious development of the peoples of Western countries by the beginning of 1960 led to the creation of the theological course in media education (Zasepa, 2005), the contact between the Russian Church and media has been rather confrontational for many years.

For example, Orthodox scholars always emphasize the harm caused to the spiritual and religious education of the Soviet atheistic movies. "I remember - writes V. Ulyahin - how much films in the 50-70 years was a humiliating nature of the name of God, the faith of Christ, of the Church. On a variety of studios, from Mosfilm to Dovzhenko feature films were produced in which faith is declared to shame Christians appeared as a double-dealers, the Pharisees, hypocrites. My mother told me that in the 20 years it has been even worse" (Ulyahin, 2006).

Only in the last 20-25 years, the Russian Christian teachers were not only able to openly express their views, but also to publish the works on issues related to media literacy education. According to the responsible editor of the Moscow Patriarchate, senior lecturer of St. Tikhon Humanitarian University S. Chapnin, "theologians ignore the television, although all the cultural and moral context of our life is defined by the mass media and missionary activity of the Church and its presence in the space of social and political life - is, in fact, broadcasting values and ideas using a variety of media" (Chapnin, 2010).

Let's try to analyze the experience of post-Soviet media education in theological aspect, taking into account the fact the theological model of media literacy education (Dukhanin, 2005; Chapnin 2010, and others.). This model is based on, first of all, theological, ethical and safety theories of media education. This is a spiritual and religious education of the audience with the

dominant religious values of art and the divine and the Earth on media. It is assumed that the media are able to form certain spiritual, ethical / moral, aesthetic values of the audience (especially for minors). For example, the "orthodox view of the work of art is not satisfied with the secular understanding, it should feature more penetration. For the Christian, it is important through the actions and words of the characters felt in their whole spirit, inner spirit, to understand, to use the philosophical language of their value orientation" (Dukhanin 2005, p.17).

Supporters of theological model of media literacy education, seeing the danger of the media in a kind of pseudo-religion, expect the media not "pagan materialism", but maybe the "inner development of the human personality, the disclosure of the spiritual process in man, revealing his inner spiritual growing, closely associated with the Christian idea of repentance - the possibility of a change of heart, mind and will under the influence of a controlled didactic life experience God directly sent by God of insight, as well as with the Christian idea of the feat - stress limit of human strength in the fight against departed from God and the world himself" (Posadsky, 2006). It is worth noting that in this context the theologians reject the relativistic concept of postmodernism (Chapnin, 2010).

It is clear that the value orientation of teachers, theologians depend on the particular religious context, with significant differences for the Christian, Muslim, Buddhist or other faiths.

The main purpose of this kind of media literacy education - the development of spiritual identity, its religious world, familiarizing the audience to a particular pattern of behavior to the value orientations that meet one or another religious dogma. Educational strategy is based on the study of the theological, philosophical and ethical aspects of media and media texts to be implemented in the following main tasks:

- The acquisition of theological knowledge (the result - an understanding of man, that "screen, the script of the film - it's not a place where people can meet Christ. Man meets with the Lord only in the temple and in prayer" (Dukhanin 2005, p.155);

- The formation of the electoral attitude towards the media repertoire (Ishchenko, 2012; Legoyda 2012; Prokofiev, 2006; Chapnin, 2010);

- Training of a critical reflection on the read / heard / seen, the correlation of the content of media texts with the basics of religion and the life around: "The other person is so beautiful to us, as we do with the warmth and love to treat him. TV-Idols deprive us of this love, take it to himself, thereby removed from the heart of man the main core of his life. Just leaving a virtual reality, we can see the beauty of a genuine reality. ... Only renouncing of media-idols, you can see the beauty of other people" (Dukhanin 2005, p.58).

In our view, this theological approach to media literacy education may be synthesized not only from an ethical and safety / protection, but also the ideological, aesthetic, ecological theories of media literacy education and with the theory of critical thinking.

So safety / protective theory of media literacy education is well correlated with the following views expressed by V. Duhanin: "Many confuse well-known thesis: first see, and then judge? Insidious trick: Orthodox want first drink Narcotic provoking fantasy and heavy impression drink, and only then to answer them, good or bad. ... And sometimes the soul of the viewer captured the impressions of the film, it is no longer able to soberly evaluate it. ... Is it worth it to take drugs, jump from an airplane without a parachute, closer to the epicenter of a nuclear explosion, only then to say: "All this is bad"? (Dukhanin 2005, p.170).

M. Prokopenko write that the secular media give the false (to some extent) information and "watching TV today been considered sinful deed" (Prokopenko, 2010). A. Ilyashenko fully agree with him: "In today's television is dominated by the vulgarity, rudeness, moral impurity, sounded offensive to the audience vulgar language" (Ilyashenko, 2006).

Even more bluntly expresses his judgment A. Vishnevsky, noting that "TV rating is needed in order to pay for expensive advertising. ... For the rating fool the greedy vile body, filmmakers exploit the basest instincts. "With youthful nails" cripple the sexual instinct. Provoke brutal aggression. Shows how "relish cheat, kill, loot - and carouse till you drop." Intuitively convinced that to enjoy life does not necessarily make hard work "(Vishnevsky, 2001). And S. Posadsky, arguing that "the pagan materialism of modern cinema should be decisively rejected Christianity claiming uncompromising spiritual and material values, calling man to the heavenly gathering, intangible wealth, requiring non-biased relation to the earth material benefits" (Posadsky, 2006).

However, some the teachers of theology expressed different views, the essence of which can be reduced to the fact that for the Church today to turn away from the media is counterproductive, since "it is clear that for millions of people in the television much more than a religion, creates images and symbols which give an answer to the fundamental questions: "Who am I?", "How should I live?". In this sense, theologians and missionaries quite undeservedly ignored by modern TV series and "soap opera" on the one hand, and advertising clips on the other. ... Genre soap opera as a morality play about modern life plays an important role in maintaining the national outlook. ... Studying contemporary religious, seeking to systematize and analyze contemporary forms of spirituality, it is impossible to ignore these elements of mass culture "(Chapnin, 2010).

Moreover, some supporters of theological media education think that is very useful - and in terms of faith, in terms of ethics (the ideas of purity, the Christian frankness, courage, righteous opposition to evil and defeat it) the aesthetic characteristics - many humane films of the Soviet period (eg, tales), plus such films as "Braveheart," "Ben Hur", "Pop", the television series "The Idiot" and others (Dukhanin, 2005, p.41; Patriarch Kirill, 2009; Prokofiev, 2006).

As correctly noted S. Posadsky, media often reproduce those various aspects of the Christian worldview, as a rule, drawing on the cultural heritage of the Christian era the time when Christianity was the dominant religion of the state, and the Christian system of values permeated all aspects of human life. "By the same Christian-oriented cinema should be assigned and the few secular works of cinema that is extremely sharpened the struggle between good and evil in man, reveal the complexity of the formation of human moral consciousness, thereby reproducing a pagan moral conflict, devoid of true knowledge of God, but keep intact the ability to discern both good and evil - conscience "(Posad, 2006).

However, the secular media texts (including those that are devoted to religious subjects) are often accused by the Russian theologians in the absence of providential idea (representation on the management of the destinies of the world by God), as preference is given to the pagan idea of an impersonal chance, or - even worse - the desire for material values. According, theologians, another serious disadvantage of modern media - ignoring the internal spiritual and religious dimension of the person, displaying mostly "psychophysical life, combining it with all the psycho-physical activity of the animal world, and striving for material comfort, experiencing sexual desire, having a wide range of emotions and rational operations - from the dedication and benefactor to the genetic risk assessment program to create a home, family, public institutions (eg, ants and termites) and skills to the feasibility of using natural forces "(Posadsky, 2006).

In addition, teachers, theologians see the danger that the media world can dislodge from the world of human consciousness of God as "sins, addictions, vices, it seems, are still out there behind the screen - its forgotten compared to that seen in traveling personnel" (Dukhanin 2005, s.51-52);

Of course, not all teachers of theology in the categorical rejection of the modern media culture. For example, under the patronage of the President of the International Orthodox Film Festival "Meeting" nun Sophia (Ishchenko), Ministry of Culture and Education Department of the Kaluga region teachers have developed guidelines on the use of films of spiritual and moral content of the educational process in the school (28 films, recorded on 10 discs, plus Toolkit) (Ishchenko, 2012; Druzhkova, 2012). This theological media education should entice the audience "a beautiful movie about animals, interesting discussion about the pressing issues and, finally, talk about the meaning of life," and "Orthodox public channel due to its public to be a missionary, but because of the maximum non-religious audience - extremely unobtrusive in his missionary work" (Shchukin, 2006).

Russian theologians also offer ways to use the media educational possibilities of television, media texts which should be directed to the successive stages of knowledge (Shchukin, 2006): aesthetic vision of life: nature and art, interpretation, analysis of the special transmission of highly skills; asceticism and respectable values (family, homeland, national culture, law, social and political veracity); from private property - to the absolute religious. It is the practical orientation of media education in educational institutions of theological orientation: both in the compulsory and optional disciplines cycles, so for narrow circle / club sessions. (See, for example, discussion of the film of Pavel Lungin *Island* in the cinema club of Saint Tikhon's Orthodox University.

## Results

*Technology of hermeneutical analysis of Soviet feature films on the anti-religious topic*

*The historical, religious, cultural, political, ideological context*

*Historical context (the dominant concepts: media agency, media category, media representations and media audience):*

*a) the particular historical period of the creation of media texts, market conditions, the process of creating media texts.*

I analyzed the Soviet films were created and demonstrated in different periods. M. Kalatozov's film *Conspiracy of the doomed* (1950) was a typical product of the post-war Stalinist empire. Movies *This should not be forgotten* (1954) and *The Gadfly* (1955) were set and released in a short period of post-Stalinist "dual power" of G. Malenkov and N. Khrushchev. This movie largely correlated with the relevant resolutions of the Central Committee of the Communist Party (from July 7, 1954: "On the major shortcomings in the scientific atheist propaganda and measures to improve it", and from November 10, 1954: "On the errors in the conduct of scientific and atheistic propaganda among the population "). Dozens of anti-religious film was conceived and released (1959-1963) in the period of Khrushchev's "thaw". Approximately the same number of films with anti-religious motives had a much more long L. Brezhnev's era and the period of adjustment.

Given the fact that since the 1940s the ratio of the Stalinist regime to the Orthodox Church has become much more tolerant than active godless 1920s – 1930s, an anti-religious aspect of the "*Conspiracy of the doomed*" and "*Gadfly*" was accented directed towards the Catholic church as Western instrument of influence / pressure on the Soviet Union and its citizens.

After 1956, the situation with the relationship between the Church and the Soviet State has become more tense. The Central Committee of Communist Party accepted the resolution "On the lack of scientific and atheistic propaganda" (October 4, 1958), and then media - followed a government order - began to create of a series of anti-religious media texts (in the press, cinema, radio and television). To some extent the instruction "to deploy offensive against religious remnants" was associated with the anti-Stalinist restoration of the so-called "Leninist norms" (Lenin's violent atheism was all well-known), but I think pretty much anti-religious struggle of Soviet power was necessary as a tool to suppress dissent.

In general, the brunt of a wave of anti-religious feature films (1959-1963) was aimed not so much at the Catholic and Greek Catholic (Uniate) Church (*Ivanna*), but to fight with different religious Protestant sects (*Clouds over Borsk*, *Miraculous*, *Armageddon*, *Sinner*, *End of the World*, *Flower on Stone*, and others).

The case of a screen conceptual dispute with an Orthodox priests was more rarer (*Everything Remains People* (1963) by G. Nathanson).

With Khrushchev's departure from the political arena a number of anti-religious films decreased significantly since anti-religious campaign, as well as many other Khrushchev's initiatives have been attributed to "voluntarism".

However, radical changes in the anti-religious policy of the Soviet government was not going to. For example, Orthodox priests derided as swindlers in the two film adaptations of the novel I. Ilf and E. Petrov's "12 chairs", set in the 1970s... In 1974, was made and where more serious anti-religious film against the Orthodox Church: in A. Manasarova's drama *I am looking for my destiny* intellectual Orthodox priest renounced his faith in God...

In the 1970s the line of anti-Catholic films was extended in Soviet cinema: at the heart of drama *Until the last minute* (1973) was the story of the last period of the life of the famous Ukrainian publicist Yaroslav Galan, who was killed October 24, 1949 in Lviv. Of course, the film was the example of propaganda against Ukrainian nationalism and western influences, but overall revelatory emphasis of the film was largely shifted toward condemnation of the Greek Catholic Church, represented on the screen as ally of Nazi and anti-Soviet Ukrainian nationalist guerrillas.

The theme was supported by anti-Catholic drama *Atonement, the sins of others* (1978) and *The Mystery of St. George* (1982) directed by V. Pidpaly, the new adaptation of *The Gadfly* (1980, directed by N. Mashchenko).

The last outbreak of anti-religious propaganda in the Soviet Union became a drama about a brutal sectarian mores *Hop* (1991).



b) how knowledge of real historical events of specific period helps the understanding of these media texts.

With regard to the cinematic context of historical events in the Soviet Union, it should be noted that along with the traditional and sometimes archaic tapes of the anti-religious series of the end of 1950 - the first half of 1960s, well known and especially - young filmmakers created the truly groundbreaking films (*The Cranes Are Flying*, *Unsent Letter*, *I am Cuba* by M. Kalatozov and S. Urusevsky, *Nine Days of One Year* and *Ordinary Fascism* by M. Romm, *The Forty-First* and *The Ballad of Soldier* by G. Chuhraj, *I am 20 years old* by M. Hutsiev, *Walking the Streets of Moscow* by G. Danelia...

The second half of 1960s is often called the final of a "thaw", when a censorship grip became tighter (the most striking examples - the prohibition of Solzhenitsyn's books, movies *The Passion of Andrew* (1966) by A. Tarkovsky, *Kiev fresco* (1966) by S. Parajanov, *Nasty anecdote* (1966) by A. Alov and V. Naumov, *Commissioner* (1967) by A. Askoldov, *Intervention* (1968) by G. Poloka).

Thus, one can not but admit that the Russian outstanding masters of the screen as a whole have sought to distance themselves from the anti-religious themes. The atheistic government's order was carried out mainly by filmmakers of the second and third row.

c) examples of historical references in these media texts.

The anti-religious Soviet-era films of the 1950s - 1980s were a direct reflection of political decisions with their top features:

- the accusation of the church and the faithful in various sins and an inspiration the atheistic views to wide audience. A striking evidence of this is the comparison of the anti-religious subjects in the movie *Clouds over Borsk*, *Miraculous*, *Armageddon*, *Sinner*, *End of the World*, *I love you, life*, *Flower on Stone* with the text of the Communist Propaganda Department "On the shortcomings of scientific atheist propaganda" (09.12.1958).

2. Socio-cultural, ideological, philosophical, religious context (the dominant concept of media agency, category media / media texts, media representation and media audience).

a) The ideology and philosophy of media texts' authors in these socio-cultural context.

The Soviet feature anti-religious films can clearly be seen ideological message aimed at convincing the audience that:

- Ukrainian nationalists are closely associated with the Unitarian and Catholic Church, first with the Nazis, and then, with the support of Western countries, carried out mass terror against their opponents and the civilian population as a whole (*It should not be forgotten*, *Ivanna*, *Until the last minutes*, *Atonement the sins of others*);

- Religious sect (often supported from abroad) are trying to involve the unstable young people into the fold, thereby diverting them from the Pioneer and Komsomol and other Soviet political, labor and cultural life (*Clouds over Borsk*, *Miraculous*, *Armageddon*, *Sinner*, *End of the World*, *I love you, life*, *Flower on stone*, *Ghosts in captivity* and others);

- The sectarians and Orthodox priests were far from Christian ideals in his real life (*Queen of the petrol station*, *Elusive Avengers*, *12 chairs*).

b) the world outlook of the people depicted in the media texts (pessimism / optimism, success / failure, the ability to control their own destiny, the ability to be happy and so forth.), the hierarchy of values according to the outlook; values; behavior, myths.

The image of a secular world in the Soviet anti-religious feature films:

- An optimistic outlook, based on communist ideology in its Stalinist / Leninist interpretation, throughout the action (despite the fact that the protagonists die sometimes);

- The hierarchy of values: secularism, anti-religion and anti-nationalism, the Communist Party, the Young Communist League, the suppression of dissent, the people, family, love;

- The main stereotype of success in this world: to be an atheist, the member of Komsomol and Communist party, a staunch opponent of religion and nationalism, to be the ruthless enemies, to be a good worker, a family man.

The image of the religious world in the Soviet anti-religious feature films:

- An optimistic outlook, based on religious, nationalist, bourgeois ideology (in early action of media text), an pessimistic outlook (closer to the finale of media text, when the negative characters understand that lost the fight);

- The hierarchy of values: religion, active introduction to the religion of non-believers (first of all - youth), suppression of dissent, family, love, greed, "bourgeois nationalism". However,

sometimes the final one or the other character can be disappointed in religious values, or completely abandon them (*Ivanna, Confessions, I am looking for my destiny*, and others);

- The main stereotype of success in this world: to be a true believer, family man, a nationalist, to cooperate with the occupation forces, foreign organizations.

Meanwhile, the theme of the church during the occupation is not as straightforward as it appeared in the Soviet anti-religious orientation films. So, Patriarch Kirill explains the situation as follows: "For the Church, people - the most important. The political context is always important, but it is secondary to the salvation of the human person. And the Church is called to bear in all circumstances his ministry. After all, once we, too, criticized, including our overseas brethren: why do we continue our ministry in the Soviet era? How dare we serve, and pray, and preach in Stalin's time? It was necessary, they said, to quit, to go underground, open opposition. But the Church was making his ministry, criticized her for it, and still some who criticize. So, of course, they have been and will be people who criticize and criticize priests who committed during the occupation of his ministry. But the vast majority of them were patriots, people support, including the guerrilla movement"(Patriarch Kirill, 2009).

3. *The structure and narrative techniques in these media texts (the dominant concept of media / media texts category, media technologies, media language, media representations).*

Schematically, the structure of the plot, representation, ethics, especially genre modification, the iconography, the characters can be represented as follows:

a) the place and time of action of media texts: the USSR 1940s – 1980s (sometimes earlier periods of Russian history), foreign countries (like this and the earlier period), the province, most of the countryside;

b) typical for these media texts furnishings, household items: a modest furnishings living rooms of ordinary people, including the believers; luxury housing and consumer goods representatives of the highest ecclesiastical hierarchy; Catholic / Uniate Church; spacious premises of educational institutions and public buildings; dark, gloomy rooms (sheds, cellars) where the sectarians carry out their religious rites.

c) modification of the genre: mostly drama, melodrama, at least - a comedy;

d) (stereotypical) image pickup reality: positive (with respect to the positive character atheist or just temporarily succumbed to representatives of religious agitation "fledgling youth"); negative with respect to the negative characters (Uniate, sectarians, Orthodox priests); a negative image on the screen is often created by the black and white pattern - in the face of negative characters, taken in a special perspective distorts the proper proportions, falling gloomy dark stripes and spots, etc.

e) type the characters (character traits, clothing, physique, vocabulary, facial expressions, gestures, characters, the presence or absence of a stereotypical manner of representation of the characters in these media texts)

- the age of the character: 10-70 years;

- the level of education: primary, secondary (complete and incomplete), at least - higher education (complete or incomplete);

- social status, profession: varies and depends on their educational and professional status: the student, an artist, priest, housewife, etc.;

- marital status character: as a rule, the main character is young and has not had time to marry;

- appearance, clothes, physique character traits of his character, vocabulary. Positive characters: commitment, emotion, activity, loyalty, optimism, courage. Negative characters: hypocrisy, cunning, cruelty, purposefulness. Positive characters are dressed modestly (especially - the villagers), and negative - is clearly richer; Athletic characters - both positive and negative - varies widely and depends on the context of a particular film. Negative characters are usually shown unpleasant appearance, with false, hypocritical smiles and gestures, their florid vocabulary. However, at first they may even produce a positive impression, hiding under the guise of compassion and mercy. Cultists usually prefer black clothes. Positive characters are the opposite "code": for it is the stereotypical Soviet screen "correct" figure with a simple and clear vocabulary, slender physique, comely faces, open smile, emotional pathos, strictness in clothes.

The doubting characters (mostly - a Soviet schoolchildren, young people living in the province, in the village), are between the "plus" and "minus": they initially drawn to faith in the Lord, but then (under the influence of a truly positive characters) renounce it.

The most indicative of such a scene is V. Ivchenko's film *Ivanna* (1959). Convinced of hypocrisy of the Uniate Church, because this Church collaborated with the Nazi occupation of Ukraine, the bishop's daughter Ivanna helps the Soviet POWs to escape from a concentration camp. Soon, however, the Nazis arrested her and sent for execution. And here, in front of the penalty, Ivanna finally renounced the faith...

By the way, *Ivanna* was one of the most grossing films of the Soviet "anti-religious series" (30.2 million viewers for first year of release). It is not surprising that Pope John XXIII in order to avoid the negative impact of the film on the believers put the anathema on the *Ivanna*. This accursed fatal responded to the fate of the performer as Ivanna - actress Inna Burduchenko (Kyrylyuk). In August 1960, carrying a dangerous double in the fire at the scene of the shooting of another anti-religious film *So no one liked* (director Anatoly Slesarenko), she received fatal burns and died... Two years later, legendary Sergei Paradjanov has finished this film (new name of this film is *Flower on Stone*).

f) a significant change in the lives of the characters of media texts:

- plot option number 1: a character involve others / friends, standing in the way of initiation to the faith (*Clouds over Borsk, Miraculous, Armageddon, Confessions, I love you, life, Ghosts in captivity*);

- plot option number 2 option: a character discovers the negative features of their "brothers and sisters in faith," or the church as a whole (*The Gadfly, Ivanna, Sinner, Flower on Stone, Confession, Atonement, the sins of others, I am looking for my destiny, Hop*);

j) the characters problem: the choice between religion and atheism;

i) the characters try to solve the problem: a way to solve the problem (with the help of positive characters - atheists) - thinking, analysis of the situation and the final abandonment of the faith.

Students (in the process of hermeneutical analysis) can consider that associative links exist between the screen and viewers' experience - in varying degrees. The emotional empathy with the characters and media texts' authors occurs first on the basis of an intuitive, subconscious perception of the dynamics of the audio-visual, spatial and temporal artistic image of the episode. Then comes the process of analysis and synthesis - identify the values of frames angles, plans, etc., and their synthesis, compound the ambiguity of interpretation. Students can analyze not only psychological and emotional, but also audio-visual, spatial and temporal content of the artistic image of media text. Students can go from more or less linear interpretation of the historical-political, socio-cultural context of the narrative scheme, to the associative, polyphonic analysis.

### Conclusions

This article realized the way for Hermeneutic Analysis of specific examples of Soviet anti-religious audiovisual media texts: a study of the process of interpretation of these media texts, cultural and historical factors influencing the views of the media agency / authors. Our analysis showed that Russian representatives theological concept of media literacy education, noting systematizing and negative media influence, rejecting postmodern notions of self-worth, "pure" nature of art, isolated from the service of Christian religious and moral purposes and, as a consequence, become dependent on ethical relativism, pagan worldview, increasingly oriented not only to "protection from the media," but urged to ensure that the Church's mission has evolved and broadened, including in the information space in order to promote the idea of the unity of the highest aesthetic value with a nice moral and cognitive values of the Christian religion, the indivisibility of religious truth, beauty and true morality. Thus, today we can say that the theological media education in Russia, which had no opportunity to develop almost from the early 1920s until the mid-1980s, is now gaining strength and looking for a practical way to the real audience.

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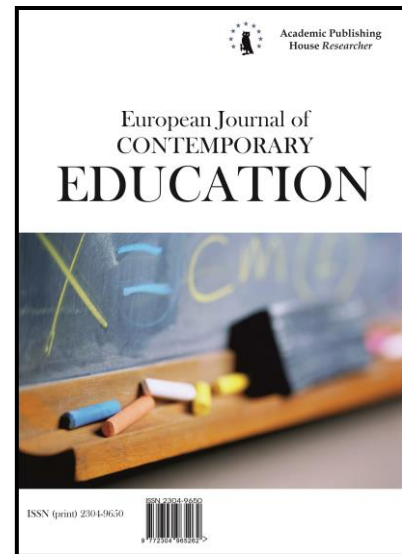
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### **Startup Diagnostics of the Degree of Well-Formedness of Student Design Competence as an Integral Means of Students Plotting Their Own Individual Learning Route**

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#### **Abstract**

This article seeks to substantiate the need for the prognostic assessment of the degree to which school students are prepared to master new types of activity, which underlie their design of an individual learning route at an appropriate senior stage of learning. The authors discuss the concept of project competence as an integral characteristic of such preparedness. The article describes the components of school students' project competence, characterizes the degrees to which they may be formed, and brings to light the possibility of diagnosing these components using specially prepared cases. The authors describe the experience of pilot-testing the methodology, discuss their findings, and identify major gaps in the project competence of present-day school students.

**Keywords:** individual learning route, student project competence, degrees of well-formedness, diagnostics methodology.

## **Introduction**

The making of tiered systems for assessing the quality of education sets the educational community the task to prognostically assess student educational results, while the traditional assessment system is chiefly oriented towards knowledge and skills that are already established and done developing. In this regard, there is a need to not just develop methods, instruments, and procedures required in order to identify the student's forming capacities associated with their mastering new learning actions. Accomplishing this task presupposes changing the very methodology for assessing the results of general education in the context of notions of the nearest development zone (L.S. Vygotsky), construing them both as the personal achievements of the subject of activity and grounds for going through subsequent stages of socialization, inclusive of the objective laws of students' age development.

It appears quite apparent that such assessment ought to, on the one hand, be conducted exclusively at special, "reference", points of the student's passage through his individual learning routes, which can be viewed as landmarks between significant stages in age development, and, on the other hand, have the character of not final (relative to an already completed stage) but startup diagnostics (relative to a new stage in this development which the student is yet to enter). In this regard, special importance is attached to the landmark of passage into one's senior teenage years (13–14) falling on grades 7 and 8 at a core, general education, school. At this age, students experience an extreme sharpening of antagonism between new, forming life goals, which are associated with their personal significance getting recognized in the "adult" world [6], and a lack of means to achieve them. In a broad sense, these means can be characterized as the individual experience of mastering certain ways to act in resolving problems that arise out of the broad context of personal and professional self-determination and bear no direct link to academic disciplines studied at school. Therefore, this age landmark appears to be a whole new stage in the process of students designing their individual learning route, a stage characterized by a high degree of uncertainty in making the choice of objectives for their educational journey and a pronounced design/transformation character of means acquired in the process of mastering various sociocultural practices [1]. In the Western psychological tradition, this landmark, beginning with Donald Super, is normally characterized as the beginning of the stage of embarking on a productive career, reconnoitering, and getting curious, entering which provides the teenager with the opportunity to get a real insight into possible academic and professional/technical variants of his future and possible future approaches he may want to take and approach its design quite realistically [11]. It is in this stage that there can be formed, on a whole new level, an interrelationship between students' educational results and their ability to be the subject of construction of an individual design of their desired future [3]. Therefore, it appears relevant to engage in working out ways and instruments that can be used to assess not just the student's previously mastered design/transformation means of going through the individual learning route but, as a priority, the preconditions for their formation in entering each of its new stages.

Thus, the primary purpose of startup diagnostics of the degree of well-formedness of design competence in students at the landmark of grades 7 and 8 is the prognostic assessment of their preparedness to plot their individual leaning route at a totally new stage that deals with the emergence and resolution of problems in one's personal and professional self-determination.

## **Materials and methods**

Within our methodology, the diagnosed degrees of well-formedness of design competence in 7<sup>th</sup>-8<sup>th</sup> grade students are interpreted in terms of their preparedness to independently set and solve design problems that arise in the process of mastering various sociocultural practices and reflect the personally significant problematics of their socialization and personal and professional self-determination. This process is modeled in the course of students working with a case that contains the description of a problem situation and a number of creative assignments to it. To resolve this situation, students are to make use of an arsenal of relevant universal learning actions and apply the results of their work in selecting a specific design solution.

Here are some of the general requirements for the content of the case:

– the uncertain nature of the situation being described, which requires that students come up with their own position to resolve it; there are no prompts or direct hints provided as to what the "correct" solution is;

- a lack of information in the text to encourage students to make an unequivocal decision, which encourages them to pose questions to clarify the situation;
- the availability of a number of subjects (i.e., participants in the situation) to help establish the diversity of possible objectives in and ways of resolving the situation and the need to analyze the nature of relations between these subjects;
- the personal significance of the problematics of the described situation to students in the context of a stage of personal self-determination they are living through.

As an example of such a case, let us take a look at a situation description we have drawn up based on a novel by A. and B. Strugatsky, “Burdened with Evil, or Forty Years Later” [4].

“Once upon a time, a youth subculture called “Flora” emerged in a little town somewhere in the “hinterland” of Russia. Not even within the town as such but on its outskirts. The “Flowers” (as its members call themselves) lead a virtually “vegetative” lifestyle (hence the name) – they are not aggressive, are languid, relaxed, do not work, and feed on “pasture forage” (they may steal here and there). Their primary principle is ‘You may do whatever you want, but make sure you don’t bother those around you’! They communicate in a jargon which is almost totally incomprehensible to those outside their circle. The Flowers even have their own “guru” who professes this mode of life.

Apparently, the area where they live and gather is governed by total insanitariness, dissolute lifestyles, and idleness. There are members who do drugs.

The attitude of the town’s residents towards “Flora” is extremely negative. The ones who are concerned the most are the parents of “normal” children, since leaving the parents’ home to join “Flora” is becoming a mass phenomenon. For this reason, parents have more than once demanded that this hotbed of harm be destroyed. The head of the local Department of Education totally concurs with them. There is a concern on the part of the law-enforcement agencies as well: there is a rise in cases of larceny and drug sale.

Meanwhile, tempers over “Flora” reach the breaking point, when, following the concert of a touring pop-star at the local stadium, there occurs major crowd unrest, which results in a considerable number of broken windows and upturned cars. The official press is putting all the blame for what happened on the Flowers. Witnesses are not confirming that, saying that, apart from Flowers, there were also lots of members of other youth subcultures, and even regular students and workers, involved. However, it soon becomes known that the authorities have finally decided to get rid of “Flora”, by transporting them by force to a different region and prohibiting them to ever come back. It goes without saying that the majority of the town’s residents are supporting this decision. There is only one person openly protesting against it – a teacher at the local pedagogical lyceum. His main argument is that the existence of “Flora” does not violate any laws, and, therefore, what the authorities are planning to do is illegal. Trying to dissuade the authorities from enforcing their decision, he warns that the activity will result in violence, asserting that the ill-willed “guardians of order” are going to pummel the Flowers, while the authorities will be just conniving at it. There will be casualties.

The town’s residents have varying attitudes towards the teacher. Despite his high standing (he is a deputy and a holder of the title of Honored Teacher), many resent his actions, while others think he is just a “crackpot” who does not know what he is talking about. Malicious gossip has it that there are certain personal nefarious interests that associate him with “Flora”. The only individuals to support him, without even having a clear idea of why he is trying to defend “Flora”, are his students.”

It is not hard to notice that this case, which models the objectness of interpersonal interactions within the “Man and Society” system, reflects the problematics, personally significant to senior teenagers, of their entry into the world of adults, being accepted or not accepted as a subject within society, having their significance recognized, or, on the contrary, having the value of their “I” rejected or disacknowledged. It is also worth noting that the sphere of applicability of such cases is much wider. Note that we once used a case like this in our earlier studies to identify and assess the civil stance of students in conjunction with the “Man and Society” educational area [2]. But here we are discussing the possibility of using the case exclusively as an instrument for startup diagnostics of the degree of well-formedness of student universal learning actions.

## **Discussion**

We are considering universal learning actions, which ensure the possibility of creative transformation of cognized objects, as major preconditions for the formation of design competence in students at the landmark of 13-14 years of age, which is to become the basis of design as the basic type of their learning activity at a senior stage of learning. Object transformation acts as a necessary condition for cognizing them during the teenage years specifically, which are characterized, first of all, by one's inner "Society and I" stance (D.I. Feldstein [5]) and, second of all, by the conceptual side of activity prevailing over its operational side (D.B. El'konin [10]). Let us take a more detailed look at this.

The prevalence of the "Society and I" stance governs the readiness of teenage students to perceive the world around them as an externally preset cultural form mastering which requires that the subject display some creative/transformational activity. Compared with primary school students, who are targeted at mastering a way to act that uncovers the cognized object in its actual state, teenagers are oriented towards using methods to act that are available to them to change this state of the object, that is transform it. Thus, the possibility of changing the object uncovers to the student its real import and its being "built into" a system of other objects. It is in this way that teenagers form their own picture of the world, which they will have to create a design of their adult future in, and actualize their personal and then professional self-determination.

In the same respect we explain the specific correlation between the conceptual and operational sides of the teenager's activity (the second characteristic we have identified). As we said earlier, the conceptual side of activity at that age is the one that is prevalent. However, compared with, say, preschool age, where real transformational means are absent altogether (they are totally replaced by the child's imagination), the teenager's design/transformation activity relies in its making on universal ways to conduct learning activity that get formed at a primary school. Furthermore, these means are primary in relation to activity objectives that are being selected, since, as is held by B.D. El'konin and A.B. Vorontsov, it is the teenager's being in possession of cultural transformational means that motivates him to conduct various trials, in the course of which there opens up a broad spectrum of ways to apply them to attain all kinds of objectives [9]. For this reason, we find to be erroneous attempts, often implemented in the mass practice of present-day education, to equate the teenager's testing actions with design activity proper, for which he has not yet developed the ability to set design objectives, based not on means available as such but rather based on the development of social and cognitive motives.

Based on the above, we can conclude that one of the primary preconditions for the formation of teenage student design/transformation activity, along with the well-formedness of universal learning actions, is being prepared to apply them in uncertain situations which require one to make an independent choice and set a design objective. Of special significance is the issue of the level characteristics of the student's forming activity and his design competence, which characterizes it. In Russian and foreign studies, there are various approaches to resolving this issue. One of them involves purely quantitative assessment of the major structural components of this competence. Thus, for instance, some studies concerned with the making of student design competence employ such characteristics as "high", "medium", and "low", which, in principle, do not reflect the qualitative differences between these levels [13]. Another approach (Spencer and Spencer, 1993) deals with identifying the subject's individual characteristics that reflect the depth of their penetration into his personal sphere: 1) those that are directly "on the surface" and lend themselves to observation and knowledge and skill assessment; 2) the personal characteristics of the subject of activity, and 3) the characteristics of the subject's "I concept" which include individual mindsets, values, and self-concepts (Cit. ex: [12]). In our study, to conduct a level assessment of these learning actions we are using the characteristics of stages in their formation which have been proposed by the authors of the Concept of the Russian Nationwide System for Assessing the Quality of General Education and comport with the degrees of development of mediation skills identified and characterized by a team of researchers under the guidance of P.G. Nezhnov [7]. The concept features the following degrees of well-formedness of universal learning actions.

The first level corresponds to the characteristic "a skillful student", meaning that the person has mastered a set of certain cultural, object-based ways and means to act. Design/transformation activity competence proper is not featured here, and ways to act that have been mastered by the



student exist as it were by themselves, with no relation to the array of problems to solve which they are used.

The second level is the level of literacy characterized by the student's ability to freely apply ways to act formed in him "exactly as intended", i.e. in situations when a particular set of learning problems is being solved.

The third level testifies to the student's competence in terms of his ability to independently determine the boundaries of applying available ways to act in resolving a wide array of life problems and his ability to creatively change and transform the way to act itself depending on the characteristics of the uncertain situation contained in the problem.

With that in mind, we shall characterize the assignments that come with it and the degrees of well-formedness of student universal learning actions diagnosed using them.

Assignment 1. Formulate three questions about the text answers to which have already been provided in the text proper and three more questions to which there are no answers provided in the text. This assignment helps assess the student's ability to separate existing knowledge about the object from knowledge that is not provided ready-to-use and has yet to be obtained. We view this ability as the nearest precondition for the formation of competence to identify and formulate problems in the course of one's learning/research and design activity and determine the "zones of current non-knowledge" in the process of problematizing situations that are preset on-the-spot and the existing experience.

There are the following level characteristics of well-formedness of this action.

1. Formulating questions answers to which are provided in the text proper:

Level 1: the question is formulated in such a way that the answer to the question asked is unequivocally read in the text in the form of a ready-to-use quote (i.e., the student changes a declarative sentence into an interrogative one).

Level 2: the question is formulated in such a way that the answer is formed through selecting a certain amount of information from different fragments of the text and compiling them.

Level 3: the question is formulated in such a way that the answer is formed as a substantive generalization of various text fragments based on their analysis and comparison.

2. Formulating questions to which there are no ready answers in the text:

Level 1: the question is formulated in such a way that the answer to it is formally not present in the text but does not bear a relation to the text's "internal problematics".

Level 2: the question is formulated in such a way that various answers to it can be proposed due to a lack of information.

Level 3: the question is formulated in such a way that to answer it one has to assume the existence of certain internal cause-and-effect relationships between circumstances and events mentioned in the text.

Assignment 2. Formulate at least three sentences on what the causes behind the situation are (for there was no "Flora" in the town at some point in time). How would you verify the correctness of each of these suppositions?

This assignment helps assess the student's ability to analyze the situation, put forth hypotheses, and determine methods to verify them. The result of performing these learning activities is the student getting a comprehensive vision of the described situation in its development and the diversity of factors affecting it. The degrees of well-formedness of these actions can be characterized in the following way:

Level 1: suppositions put forth by the student reflect possible cause-and-effect relationships between particular phenomena. However, they cannot be used to explain the situation on the whole; to verify them, there can be suggested actions as a result of performing which there can be formally established the existence of the assumed cause but not the cause-and-effect relationship proper.

Level 2: in putting forth suppositions, students take into account a set of circumstances reflected in the text whose combination, in their view, acts as a cause behind the existing situation; furthermore, the nature of cause-and-effect relationships is linear, i.e. taken into account are just interrelationships that are immediate, presented on-the-spot; to verify the suppositions put forth, students are ready to employ scientifically substantiated methods for collecting information through the use of various sources.

Level 3: among possible reasons students list general trends in the development of the described situation, to verify which transformation actions need to be performed – namely, setting up an experiment, entering the situation with one’s own design for resolving it, etc.

Assignment 3. Depict in the scheme the characters in the situation and use arrows to mark the relationships between them; use solid lines to mark the relationships that are verifiably reflected in the text and use dotted lines to mark those you can assume as existing.

This assignment is aimed at identifying the degree of well-formedness of the ability to schematize and use a schematic model as an instrument for transforming the situation. There are the following degrees of well-formedness of this learning action.

Level 1: the scheme features just those participants in the situation whose role is unequivocally articulated in the text; the relationships between them illustrated by students also reflect “bare” facts, and those not registered in the text, which can be assumed in the context of suppositions put forth earlier, are not reflected in the scheme.

Level 2: just like in the previous case, the scheme reflects only the actual participants in the situation, who affect its development. However, one can assume the existence of other relationships not reflected in the text but bearing no direct relation to the situation and ways to resolve it.

Level 3: the array of participants in the situation featured in the scheme also includes those whose role in its emergence is reflected in the text just indirectly; the assumed interrelationships characterize students’ assumptions about the hidden causes behind the emergence of the described situation and reflect one’s comprehensive vision of it along with possible ways to resolve it; it is also possible to reflect in the scheme those relationships which are not in the situation preset but can come up in the process of its transformation.

Assignment 4. Formulate objectives aimed at resolving this conflict situation (what specifically needs to be changed in it in order to end the conflict between its participants):

- the way the town’s authorities would formulate this objective;
- the way the Flowers themselves would formulate the objective;
- the way the lyceum teacher would formulate it.

Also propose your own variant of setting the objective in this situation (it may, or may not, overlap with what someone else has already proposed).

This assignment, aimed at identifying the degree of well-formedness of the student’s ability for conscious goal-setting, most importantly helps determine the degree of their readiness to assume the internal position of the subject of activity, who sets himself goals motivated by certain value orientations. Furthermore, understanding the goals of other subjects becomes a sort of “mirror” by virtue of which the teenager can separate his own “I” from the “I” of other subjects in the choice of goals. In this case, we find premature the use of such traditional criteria for assessing the ability for goal-setting as being “concrete”, “realistic”, etc., which characterize, as we noted in the beginning, the operational side of the teenager’s activity. The true purpose of this assignment is to assess the teenager’s ability to identify himself as an independent subject in the choice of the objective for transforming the situation, which reflects his own axiological grounds. In this regard, we are using the following level characteristics.

Level 1: the student properly formulates the objectives of other participants in the situation preset, relying on specific facts contained in the text; however, in determining his own goal, he just formally subscribes to someone else’s position.

Level 2: the student understands the goals of other participants in the situation and also formulates his own goal, which is, however, aimed at a partial transformation of the situation preset in favor of one of the sides with which he associates himself the most.

Level 3: The student competently formulates the goals of others, but, that said, he aims his goal at transforming the situation on the whole, basing his judgment on his understanding of internal causes behind it.

Assignment 5. List several specific steps (actions) that need to be taken in order to attain your goal.

This assignment helps assess the ability of students to construct an algorithm for actions needed to attain the set goal inclusive of specific conditions characterizing the situation preset. That said, what interests us the most here is the student’s ability to preserve the problem being

solved as integral, not divided into separate, unrelated fragments. There are the following level characteristics.

Level 1: the student establishes several relevant steps each of which is quite expedient; however, their overall logic and interrelationship cannot be traced.

Level 2: In formulating the relevant steps, the student uses standard algorithms, known to him, for actions aimed at attaining set objectives but does not reflect in them in any way the substantial characteristics of the situation preset.

Level 3: the student formulates a sequence of relevant steps inclusive of the characteristics of the situation and based on his understanding of the overall logic behind attaining the set objective.

Assignment 6. Imagine that you have made it and the conflict has been successfully resolved. Prepare a presentation with a story of how you did it.

This assignment helps assess the ability of students to reflect in their consciousness the activity they have gone through and picture it in alienated form. The special significance of this assignment is associated with that in the process of preparing a report on results obtained by the students one needs to perform a special, reflexive activity on the activity that has already taken place. This, in turn, governs the need for a shift to a different way of thinking that is radically different from design thinking proper (G.P. Shchedrovitsky [8]). In the process of working on his design, the subject “sees” the baseline state of the practice that is being transformed, but its final state is not obvious to him and is not unequivocal. The situation that is being transformed manifests its uncertainty specifically because we presuppose here the existence of a sort of “delta” between the objective (what is needed) and the result (what has been obtained). While the result that has been attained, which is captured in the socially significant product, on the contrary, governs the full certainty of the situation that has already been transformed. Therefore, the way to present the result presupposes constructing a retrospective of its origination that explains the essence of the “breakthrough” that has taken place. When students do not have such a way to present the result, they substantially limit their capacity to present the product specifically as an alienated form of “real-life” design activity. Based on the above, we can propose the following level characteristics of the degree of well-formedness of this learning action.

Level 1: the student tells us about the performed (assumed) actions in a detailed and consistent manner, without characterizing the results obtained at that.

Level 2: the student limits himself to stating changes in the baseline situation that have taken place, without bringing to light their cause-and-effect relationships with transformational actions he has performed (the existence of such a relationship is assumed by him “by default”).

Level 3: the student lays out the entire logical chain of performed transformational actions and attained results of transforming the baseline situation.

In addition to the characterized levels of well-formedness of teenage student universal learning actions, the teacher also needs to have an idea of and diagnose manifestations of that these actions have not formed yet in a specific student even at the first level. The most typical signs of the absence of these learning actions in the arsenal of students are listed in Table 1.

Table 1: The signs of student universal learning actions being unformed

Universal Learning Actions	Sign of being unformed
Formulating questions about the text for the division of the areas of the known and unknown.	The student formulates questions that bear no relation to the situation described in the text. The student formulates meaningless questions or cannot formulate them altogether.
Putting forth suppositions (hypotheses) and choosing a way to verify them.	The student puts forth admittedly implausible suppositions violating elementary cause-and-effect relationships. In choosing a verification method, the student proposes no method as such and appeals to conventional stereotypes that reflect the mass “life experience”.

Schematizing and creating a model for the object being transformed.	The student features in the scheme just some of the participants and distorts the nature of relationships between them at that.
Setting objectives inclusive of the diversity of stances taken by participants in the situation.	The student limits himself to just general words which do not give you an idea of a specific expected result. The student cites a set of possible moves with no relation to the expected result of performing them.
Establishing a sequence of steps to attain the objective.	The student formulates steps which admittedly will not lead to the set objective.
Assessing and choosing a way to present the results obtained.	The student limits himself to just general words and does not reflect on the results obtained or his own moves at that.

### Results

The pilot testing of the methodology of startup diagnostics of the degree of well-formedness of student design competence was implemented in two formats – individual and group work. In the first case, students (19 individuals) worked on the case individually, while in the second their activity on case assignments was conducted in 3 groups of 7 students each. Thus, the total sample of students featured 40 individuals. Besides, the study involved six pedagogues and two graduate students from Kuban State University, who acted as experts. The obtained results are listed in Tables 2 and 3.

Table 2: The results of diagnosing the levels of well-formedness of student design competence in an individual format

Universal learning actions assessed	Well-formedness levels (%)			
	0	1	2	3
Formulating questions about the text for the division of the areas of the known and unknown.	5.3	63.2	26.3	5.3
Putting forth suppositions (hypotheses) and choosing a way to verify them.	21.1	52.6	21.1	5.3
Schematizing and creating a model for the object being transformed.	5.3	63.2	21.1	10.5
Setting objectives inclusive of the diversity of stances taken by participants in the situation.	36.8	26.3	36.8	0.0
Establishing a sequence of steps to attain the objective.	21.1	47.4	21.1	10.5
Assessing and choosing a way to present the results obtained.	68.4	21.5	10.5	0.0

Table 3: The results of diagnosing the degrees of well-formedness of student design competence in a group format

Universal learning actions assessed	Formedness levels (%)			
	0	1	2	3
Formulating questions about the text for the division of the areas of the known and unknown.	0.0	66.6	33.3	0.0
Putting forth suppositions (hypotheses) and choosing a way to verify them.	0.0	66.6	33.3	0.0
Schematizing and creating a model for the object being transformed.	0.0	0.0	100.0	0.0
Setting objectives inclusive of the diversity of stances taken by participants in the situation.	0.0	33.3	33.3	33.3
Establishing a sequence of steps to attain the objective.	0.0	66.6	33.3	0.0
Assessing and choosing a way to present the results obtained.	0.0	100.0	0.0	0.0

As we can see from the data above, the majority of students are characterized by the first level of well-formedness of almost all the universal learning actions constituting their design competence, except for the ability for goal-setting and presenting the results of one's activity, which has not formed in most students altogether. This shows that the activity of a significant portion of students is constructed by them as a more or less random set of standard actions, which are performed using set templates and bear absolutely no relation to one's own notions of results attaining which it is aimed at. A direct consequence of this is the actual inability to comprehensively reflect one's activity in one's consciousness and picture it in alienated form. It goes without saying that in a situation like this the shift to designing, as a basic type of learning activity at a senior stage of learning, will be considerably complicated and will require much effort on the part of pedagogues in terms of making up the identified deficits in design competence: the ability to identify the unobvious in the obvious; put forth original hypotheses that are based on identifying hidden cause-and-effect relationships; schematize and create governing models for situations being transformed; plan expedient steps on attaining set objectives; reflect on the results and effects of transforming problem situations.

At the same time, it is worth noting that some students do actually demonstrate the second and even third level of well-formedness of particular components of design competence – namely, schematizing and establishing a sequence of steps for transforming the problem situation. Of particular significance is the circumstance that students achieve higher results when they are working on the case as a group. This attests to the great potential of joint forms of learning activity by senior teenagers in terms of fostering design competence in them. Yet, for the time being these forms have been explored in present-day mass practice insufficiently.

Still, the identified situation is, in larger measure, characterized by such manifestations of unformed school student design competence as:

- the “didacticism” of formulated case questions, which by their spirit reproduce the traditional controlling orientation of assessment of the results of working with the text;
- the prevalence of stereotypical statements of an evaluative nature, which do not lend themselves to verification using design/research means (“they are weak”; “parents are doing a bad job raising their children”, etc.), to the disadvantage of identifying cause-and-effect relationships between phenomena and putting forth original hypotheses on this basis;
- failure to differentiate between the real objectives for transforming the problem situation and possible means of attaining them; the ability to perform certain actions without having a thorough idea of expected results and possible consequences;
- the inconcreteness of steps for attaining the results required; a readiness to reduce these steps to general speculations on what things should be or just “good general advice”;
- gravitating towards traditional, non-design solutions to problems, which are mainly founded on a “prohibitive” strategy (a great many works have featured passing a law prohibiting the emergence of youth subcultures as the primary step in resolving the described problem situation).

It is worth admitting that the identified picture characterizes quite well the state of development of the present-day Russian educational system, which has been having a real hard time resolving the issue of switching to new generation Federal State Educational Standards. However, the lack of reliable evaluative and diagnostic instruments that can help identify in this way the hidden “sore points” in continuing education is making resolving these objectives increasingly complicated.

### **Conclusion**

The findings of this study substantiate the need of the present-day system of education for new approaches and instruments for assessing the academic results of students, which characterize not only the attained level of mastering subject content, but being prepared to master new means and ways of acting that ensure the effectiveness of realization of subsequent stages in their continuous educational trajectory. To a special extent, the prognostic assessment of the level of well-formedness of design competence is relevant in the context of issues in the individualization of education for the formation of student preparedness to design one's individual learning route, since it is this that ensures the continuity of various stages in this process. In this regard, we view startup diagnostics, which helps assess the degree of well-formedness of basic ways to act, based on

which there forms the student's integral preparedness to become the subject of plotting the individual learning route, as a necessary instrument for managing the development of student learning activity.

Our findings allow us to assert that the landmark of grades 7 and 8 is quite problematic for present-day school students in terms of a change of the character of learning activity one is engaged in and a shift in its dominant towards the use of productive design/transformation means of attaining individual learning objectives. In existing practice, issues related to the formation of preconditions for their being mastered by students have not been resolved effectively enough.

Among the major conditions for the effectiveness of startup diagnostics of student competence in transitioning to a new stage of the continuous learning process is the use of its level characteristics which help forecast both the degree of one's preparedness to solve a certain array of problems as such and difficulties in using the means being mastered in non-standard life situations arising in the context of personal and professional self-determination.

It goes without saying that the findings obtained through the pilot testing of the instrumentarium created characterize the situation in just the most general terms. The further development of the proposed approach requires conducting systemic studies on large samples of students at various types of educational institutions with the use of various cases, the general principle of creating which has been substantiated in this work. We are pinning on this the prospects of further research into the issue.

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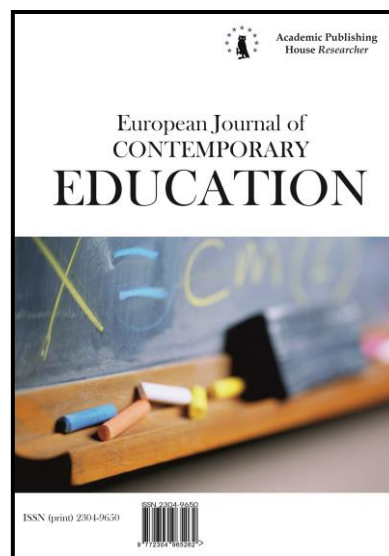
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## Computer-Assisted Simulation Methods of Learning Process

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### Abstract

In this article we analyse: 1) one–component models of training; 2) the multi–component models considering transition of weak knowledge in strong and vice versa; 3) the models considering change of working efficiency of the pupil during the day. The results of imitating modeling are presented, graphs of dependences of the pupil’s knowledge on time are provided.

**Keywords:** computer modeling, didactics, education, mathematical methods, pedagogy, pupil, simulations, teacher.

### Introduction

One of the directions of development of the modern theory of training consists in studying didactic systems by the methods of mathematical [1–7] and imitating (or computer) modelling [8–10]. Using the method of imitating modelling, scientists can investigate complicated objects and processes in those cases when real experiments with them are impossible or inexpedient. The essence of this method consists in creation of computer model of real system and carrying out a series of computing experiments for the purpose of understanding the system’s behavior or an estimation of various strategies of management providing its functioning [11, p. 12]. High speed of modern computers allows to process large amounts of information and quickly enough to carry out computer imitation. Changing initial data and parameters of the model it is possible to investigate ways of the system development, and to define its state at the end of training. This is the advantage of this approach in comparison with the method of the qualitative analysis. Therefore, researching various mathematical and computer models of process of training has a great importance for the development of didactics.



R. Shannon calls the process of creating the imitating model "intuitive art" or "modelling art" which "consists in ability to analyse a problem, to mark out its essential features from it by abstraction, to choose and modify properly the main assumptions characterizing the system and then to fulfill and improve the model until it begins to yield results, useful for practice" [11, p. 34]. In certain cases for studying didactic systems imitating models based on the solution of system of differential equations, discrete models when the pupil is modelled as the probabilistic automats, multi-agent modelling, when each pupil is replaced with the program agent functioning irrespective to other agents, are used [8–10, 12–14].

Let us formulate the main task of imitating modelling the process of training: knowing the parameters of pupils, characteristics of the used methods and the training program (the distribution of educational information), it is necessary to define the amount of knowledge or the level of pupil's skill formation at any stage of training [14]. Also it is possible to solve the optimizing task consisting in finding the distribution of the training material, the level of the teacher's requirements, the duration of lessons for the pupil's amount of knowledge to reach the preset or maximum value at the end of training, and for the process of training to satisfy the restrictions imposed on it.

Methodological basis of the research are ideas and works by N. Winer, K. Shannon, F. Rosenblatt, V. M. Glushkov, D. A. Pospelov (cybernetics, the theory of information), R. Atkinson [1], G. Bauer of [1], O. G. Gohmann [4], L. B. Itel'son [3], L. P. Leontyev [4], Je. Kroters [1], D. A. Novikov [15], F. S. Roberts [5] (mathematical modelling of training), B. Skinner, N. Krauder, S. I. Arkhangel'sky, V. P. Bepalko, E. I. Mashbits, V. E. Firstov [7], V. S. Avanesov, I. V. Robert (cybernetic approach in pedagogy, the programmed training and the automated training systems). The mathematical model of didactic transitional process offered by V. V. Mayer [16, p. 129–140] has great influence too.

The main idea of the research consists in that it really makes sense to use the imitating models based on the solution of differential equations for studying didactic systems in those situations when it is inexpedient or impossible to make pedagogical experiments with people. So, the real pupil is replaced by some abstract model which behavior is described by one or several equations. According to the principle of plurality of the description, any complex system can be modelled by a large number of ways. Therefore, discussing the problem designated above, we will speak about a set or hierarchy of models, each of which is development and specification of the previous. The task consists in researching behavior of this or that abstract model of the pupil or all didactic systems in various situations.

### 1. One-component model of training

In the most rough approach it is possible to consider that the training material is uniform, that is consists of elements, independent and equal in complexity, which are all equally easily acquired, and at the end of training are forgotten with an identical speed. In this case we have a one-component model of training result of which is characterized by the level of pupil's knowledge. Let us formulate its cornerstone principles:

1. The information (knowledge) given to pupils is a set of elements of learning material (ELM) untied among themselves while their number is proportional to its quantity. All ELMs are remembered almost equally and forgotten with an identical speed.

2. The teacher demands of the pupil to acquire all given information  $I(t)$ , that is the level of requirements is  $L = I(t)$ . The speed of change of pupil's knowledge quantity is equal to a difference of speeds of assimilation and forgetting.

3. The speed of increase in knowledge is proportional to the product of amount of pupil's knowledge  $Z$  raised to power  $b$  ( $0 \leq b \leq 1$ ) and amounts of the efforts  $F$  made by the pupil in a unit of time:  $dZ/dt = \alpha F Z^b$ . The more the pupil knows, the easier he acquires new knowledge because of the formed associative links with the existing knowledge. On the other hand, the lower the student's motivation, the less effort  $F$  he is making, and the lower the rate of increase in his knowledge. In the case when the growth of pupil's knowledge  $\Delta Z$  is much less than

his total knowledge  $Z$  (training during one or several lessons), it is possible to consider that  $Z$  almost doesn't increase and  $b = 0$ .

4. The pupil's efforts  $F$  (or motivation  $M$ ) are directly proportional to a difference  $D$  between the level  $L$  of the teacher's requirements (amount of information which the pupil has to acquire) and the quantity of his knowledge  $Z$ :  $F = k(L - Z) = kD$ . In the case when  $D = L - Z$  exceeds some limit  $C$ , the pupil stops to make efforts:  $F = 0$ .

5. In the absence of training the quantity of the pupil's knowledge decreases because of forgetting according to the exponential law. The speed of forgetting is proportional to quantity of the available knowledge:  $dZ/dt = -\gamma Z$ ,  $Z(t) = Z_0 \exp(-\gamma \cdot t)$ . The forgetting coefficient is  $\gamma = 1/\tau$ , where  $\tau$  – the time of knowledge reduction in  $e = 2,72\dots$  times.

Basing on the listed above reasons, we receive that during training the pupil's knowledge increase speed is equal to:

$$\frac{dZ}{dt} = \begin{cases} \alpha \cdot (L - Z)Z^b - \gamma \cdot Z, & \text{if } Z < L \leq Z + C, \\ -\gamma \cdot Z, & \text{if } L > Z + C. \end{cases}$$

When  $Z$  isn't big, the growth rate of knowledge level is low due to the lack of possibility to form associative links. With increasing knowledge  $Z$  the rate grows, but at  $Z \rightarrow L$  it decreases due to the decrease in efforts  $F$  (the pupil's motivation  $M$ ). If  $L$  exceeds  $Z$  by an amount which is greater than the critical value  $C$ , the pupil stops to study. In the considered equations, time is an independent variable and can be measured in days, months or years. It is also convenient to measure it in the conventional units of time (CUT), and coefficients of assimilation and forgetting – in  $\text{CUT}^{-1}$ . The state of the didactic system is characterized by quantities of this or that type of the knowledge reported by the teacher and acquired by the pupils; these quantities are proportional to the number of the studied notions, formulas and other ELMs and can be measured in conventional units too. The coefficients of these and subsequent models are selected so that the results of modelling could correspond to common sense and teaching.

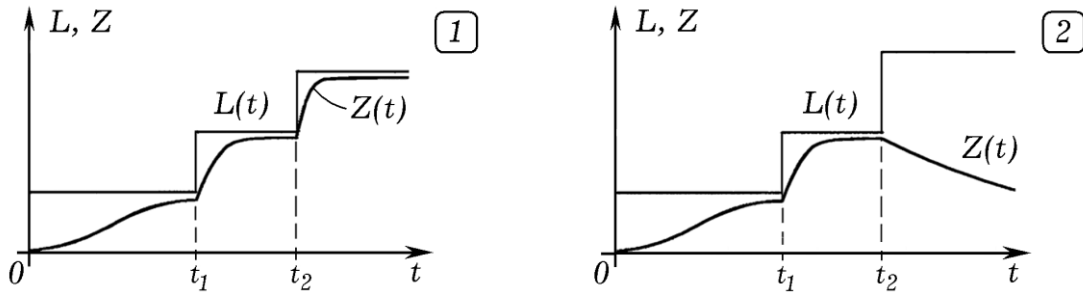
Also other approaches are possible. For example, it is possible to consider that the efforts  $F$  made by the pupil are connected with the level of teacher's requirements  $L$  as follows:

$$F = \begin{cases} L - Z, & \text{if } Z < L \leq Z + C, \\ C \exp[-\beta(L - Z - C)], & \text{if } L > Z + C. \end{cases}$$

That is if  $L - Z < C$ , then  $F = L - Z$ , and in the case when  $L \geq Z + C$  the motivation gradually decreases exponentially:  $F = C \exp[-\beta(L - Z - C)]$ . By means of this model it is possible to prove the well-known principle "from simple to complicated" [17]. Let us say, at first a complicated theme is studied, and then a simple one, that is at first the level of teacher's requirements are high, and then – low ( $L_1 > L_2$ ). If  $L_1$  strongly surpasses the quantity of the pupil's knowledge  $Z$ , the motivation to training decreases, and the level of pupil's knowledge doesn't grow (the pupil can't simply acquire the material). If the pupil has acquired a difficult theme, and after studying the next simpler theme, the growth rate of knowledge is low because the requirements level  $L$  slightly surpasses the quantity of the pupil's knowledge  $Z$ , and he doesn't make many efforts. Therefore, it is expedient to study the simple theme first and then a difficult (or complicated) one.

Pic. 1 shows the considered above training model when the level  $L$  of the teacher's requirements (or amount of the knowledge reported by the teacher) increases in steps. Initially the teacher offers pupils rather simple educational material, and when they master it the teacher increases the level of requirements, offering more difficult material. To ensure increasing of the pupil's knowledge, it is necessary to provide not a very big difference between  $Z$  and  $L$ .

Too sharp increase in the level of requirements  $L$  (complexity and the amount of new material) leads to decrease in motivation and reduction of quantity of knowledge owing to forgetting (pic. 1.2). At the moment  $t_2$  the pupil "comes off" or gets behind the teacher, ceasing to acquire the information given to him. If at first too difficult tasks (requirements level is high) are offered, and then – simple ones, results of training will be low. For the best of educational process it is necessary to select the level of requirements so that motivation to training should stay high.



Pic. 1. Training at intermittent (step-wise) increase of requirements level

The particular interest is represented by the case when the speed of assimilation of educational information is constant and equal to the maximum value  $v_m$ . That is what a skilled teacher aims to reach. If the pupil's initial knowledge is  $Z_0$  then:

$$\frac{dZ}{dt} = v_m - \gamma Z, \quad \int_{Z_0}^{Z(t)} \frac{dZ}{v_m - \gamma Z} = \int_0^t dt, \quad Z(t) = \frac{v_m}{\gamma} (1 - \exp(-\gamma t)) + Z_0 \exp(-\gamma t).$$

At the end of training, speed of assimilation is equal 0,  $dZ/dt = -\gamma Z$ ; the amount of knowledge decreases exponentially.

## 2. Results of one-component model use

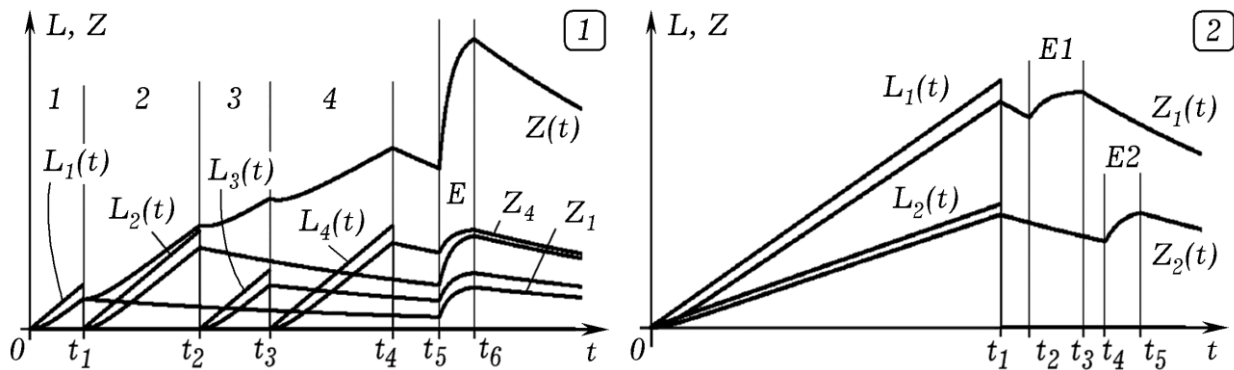
With the help of the considered model let us analyse studying independent themes of various complexity which aren't connected among themselves, that is mastering of one theme doesn't influence mastering of another.

**Situation 1.** A group of pupils studies a subject of four independent themes. Each theme is finished with a test, and at the end of the course there is an examination while preparing for which the pupil has to learn all ELMs. Requirements level for each theme grows according to the law  $L_i = 0,05(t - t_{0i})$ , and time of studying each theme is equal  $T_i = \{ 90; 200; 120; 210 \}$  ( $i = 1, 2, 3, 4$ ). We get the graph of pupil's knowledge dependence on time. The coefficients of the pupil's assimilation (mastering) and forgetting  $\alpha = 0,035 \text{ CUT}^{-1}$ ,  $\gamma = 0,0015 \text{ CUT}^{-1}$ . For the solution of this task a special computer program created with the help of Free Pascal is used. It contains a cycle on time which calculates the quantity of the pupil's knowledge in consecutive timepoints and draws the graphs  $Z_i(t)$ . If  $\Delta\tau$  – step on time, then we have the equations:

$$dZ_i / dt = \alpha \cdot (L_i - Z_i) - \gamma \cdot Z_i, \quad Z_i^{t+1} = Z_i^t + (\alpha \cdot (L_i^t - Z_i^t) - \gamma \cdot Z_i^t) \Delta\tau.$$

The received graphs are shown in pic. 2. It is obvious that when studying each theme the level of requirements  $L_i = L_i(t)$  grows in proportion to time. At each of the following lessons within one theme the teacher requires mastering new knowledge and preservation of the knowledge obtained earlier. Studying the theme is finished with a test; then the teacher reminds about it only at the examination. During studying the  $i$ -th theme, the quantity of the pupil's knowledge  $Z_i$  of this theme increases, and after its termination  $Z_i$  decreases exponentially because of forgetting.

During preparation for the examination E (an interval  $[t_5; t_6]$ ) the pupils revise and recall the material of all themes. As they use more efforts and study all free time, their knowledge considerably increases. After the examination levels of knowledge  $Z_i$  decrease owing to forgetting.



Pic. 2. Studying of the training courses which are finished with examinations

**Situation 2.** Within several months at the same time (that is in parallel) the pupil studies two courses. At each subsequent lesson the teacher requires the knowledge of all previous material, and requirements levels  $L_1$  and  $L_2$  grow in proportion to time  $t$ . At the end of the term the examinations in all themes are provided.

The program modelling the training process should contain a cycle on time  $t$  in which the speed of knowledge increase is calculated, amounts of the pupil's knowledge  $Z_1(t)$  and  $Z_2(t)$  in the following timepoint  $t + \Delta t$  are defined; the results are displayed on the screen. Then everything is repeated again. The received graphs  $Z_1(t)$  and  $Z_2(t)$  are shown in pic. 2.2. Parameters of the model are selected so that reasonable results should be obtained. During the term (from 0 to  $t_1$ ) the pupil's knowledge level monotonously grows, then decreases a little (pic. 2.2). While revising (preparing) for examinations (from  $t_2$  to  $t_3$  and from  $t_4$  to  $t_5$ ) the level of the corresponding knowledge increases again, and after passing the examination – decreases because of forgetting.

Now let us consider the situation when themes have various complexity  $S_i$  and are not independent, that is mastering one theme demands understanding some other themes. When studying each theme the level of requirements increases; pupils prepare for the test paper consisting of several tasks. At the end of the course an examination is held. The time  $T_i$  ( $i = 1, 2, \dots, n$ ) corresponding to each theme is given. Let us construct a computer model of the training process.

We take into account that the difficulty, or the subjective complexity  $S_l$  of the studied  $l$ -th theme of the course, can depend on the pupil's knowledge quantity  $Z_k$  of the  $k$ -th theme. Let this dependence be expressed as:  $S_l = a + b \exp(-cZ_k)$ , where  $a, b, c > 0$ ,  $a + b \leq 1$ . The difficulty of the theme lies in the range of  $[0, 1]$ ; if  $Z_k$  is growing, the difficulty  $S_l$  decreases to  $a$ . The minimum difficulty  $S = 0$  corresponds to a very simple (easy) theme, maximum  $S = 1$  – to the theme which the pupil can not understand in principle (very much time is required for this purpose). The equation is:

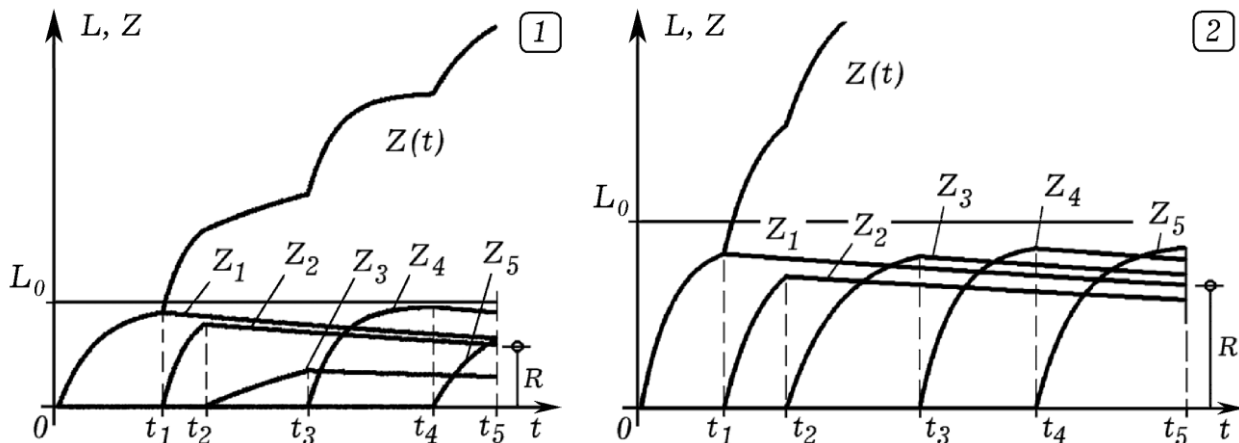
$$\frac{dZ_i}{dt} = \alpha(1 - S_i)(L_i - Z_i) - \gamma \cdot Z_i; \quad Z_i > 0; \quad L_i > Z_i; \quad \alpha, \gamma > 0,$$

where  $Z_i$  – the level of the pupil’s knowledge of the  $i$  –th theme,  $L_i$  – the level of teacher’s requirements, that is the knowledge amount of the  $i$  –th theme which the pupil should to acquire. We receive in the final differences:

$$Z_i^{t+1} = Z_i^t + (\alpha(1 - S_i)(L_i - Z_i^t) - \gamma \cdot Z_i^t) \Delta \tau.$$

After studying the course the teacher holds an examination (test) of  $m$  tasks  $K = \{z_1(1), z_2(1,2), \dots, z_m(4,5)\}$ . If for the solution of task  $z_k(i)$  it is enough to have the knowledge of the  $i$  –th theme, the probability of its solution is equal to the level of the pupil’s mastering of this theme:  $p_k = Z_i / L_i$ ; so  $Z_i \leq L_i$ , then  $0 < p_k \leq 1$ . Let us use the law of multiplication of probabilities. If the  $k$  –th task  $z_k(r, s)$  is of the combined type and demands the knowledge of the  $r$  –th and  $s$  –th themes, then the probability of its solution is  $p_k = (Z_r / L_r)(Z_s / L_s)$ .

**Situation 3.** The student studies the course consisting of five themes which are not connected among themselves and presented consistently one after another: 1, 2, 3, 4, 5. The difficulties  $S_i$  of the themes and the time  $T_i$  given for studying are set by two matrixes:  $S = (0,3; 0,1; 0,4; 0,7; 0,2)$  and  $T = (1,2; 1,7; 1,5; 1,8; 2,4)$ . At the end of the course the test of five tasks is held:  $K = \{z_1(1), z_2(1,2), z_3(2,3), z_4(3,4), z_5(3,5)\}$ . Let us create the imitating model of this process and calculate the result of fulfilling the test.



Pic. 3. Modelling of studying the themes with various complexities (difficulties).

The used computer program contains the cycle on time which values  $Z_i$  for every  $i$  –th theme ( $i = 1, 2, \dots, 5$ ), and the total level of knowledge is defined. The results are displayed in the graph (pic. 3.1). The grade for the examination is calculated with a formula:  $R = (Z_1 + Z_1Z_2 + Z_2Z_3 + Z_3Z_4 + Z_3Z_5) / 5$ . In pic. 3.1 the mark  $R$  corresponds to the segment in the right part of the graph. At other values of  $S_i$  and  $T_i$  we have the graphs presented in pic. 3.2.

### 3. Two-component model of training of the first type

To increase the accuracy of results let us consider that durability of various mastered ELMs is not identical. We divide all the pupil’s knowledge into two categories: strong (or solid) and weak (poor). Strong knowledge is more involved in the pupil’s educational activity and therefore is forgotten significantly slower than the weak knowledge. Let us consider a two-component model of the pupil, and let us divide all acquired information into two categories: 1) knowledge  $K_{n-1}$  which is used daily and therefore is hardly forgotten (reading, writing, arithmetic operations, the simple facts, etc.); 2) knowledge  $K_{n-2}$  which is seldom used and therefore is forgotten quickly (difficult

ideas, principles, facts, theories). The offered two-component model of training is expressed by the system of the equations:

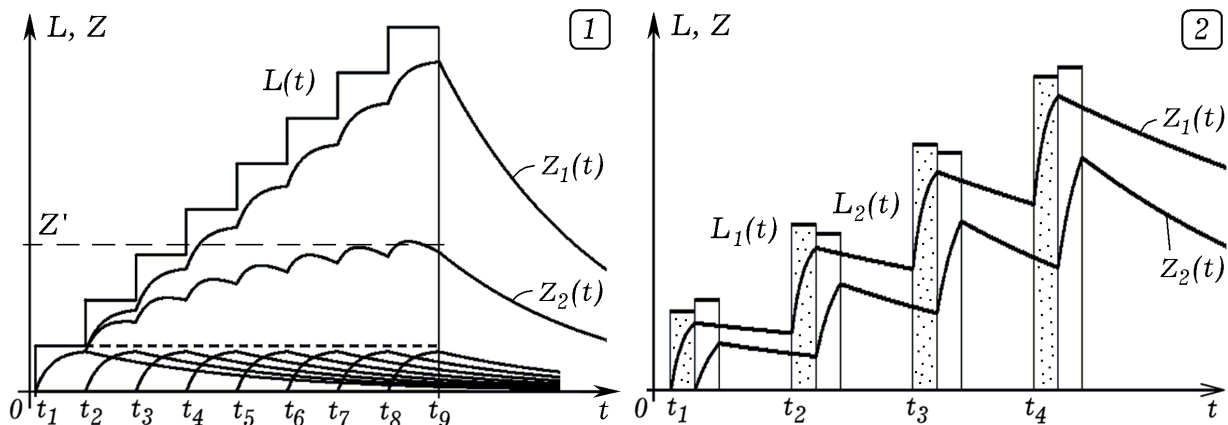
$$dZ_1 / dt = k\alpha_1(L_1 - Z_1) - \gamma_1 Z_1, \quad dZ_2 / dt = k\alpha_2(L_2 - Z_2) - \gamma_2 Z_2, \quad Z = Z_1 + Z_2.$$

Here  $L_1$  and  $L_2$  – are levels of the teacher’s requirements, corresponding to  $Kn-1$  and  $Kn-2$ , amount of which is equal  $Z_1$  and  $Z_2$ ;  $Z$  – is the pupil’s total knowledge. While training  $k = 1$ , else  $k = 0$ .

**Situation 4.** When studying some theme during eight lessons pupils gain knowledge of two types: 1) knowledge  $Kn-1$  which after studying is used at the subsequent lessons; 2) knowledge  $Kn-2$  which is studied once and is not used any more. The requirement levels equal to quantity of knowledge which must be acquired at each lesson, are known:  $L_{1i} = (30, 60, 90, 120, 150, 180, 210, 240)$ ,  $L_{2i} = (30, 30, 30, 30, 30, 30, 30, 30)$ . Let us simulate the training process.

At the  $i$ -th lesson the teacher reports  $L_{1i}$  knowledge  $Kn-1$  and  $L_{2i}$  knowledge  $Kn-2$ , requiring full mastering of each piece. Requirements level for knowledge  $Kn-1$  every week increases in steps: the pupil should remember the information received at previous and present (current) lessons. The requirements level to knowledge  $Kn-2$  in the process of studying of the course remains constant and is equal 70; the teacher requires pupils to master knowledge  $Kn-2$  studied only at the present  $i$ -th lesson.

The results of modelling are presented in pic. 4.1. It is obvious that the quantity of knowledge  $Kn-1$  in the process of studying the course monotonously increases while the amount of knowledge  $Kn-2$  at first grows, and then, having reached  $Z'$ , fluctuates relative to this value. Since  $t_8$  there comes dynamic balance: the average amount of knowledge  $Kn-2$  acquired by the pupil during rather a long time is equal to the amount of the knowledge forgotten by him during the same time. At the end of training forgetting begins.



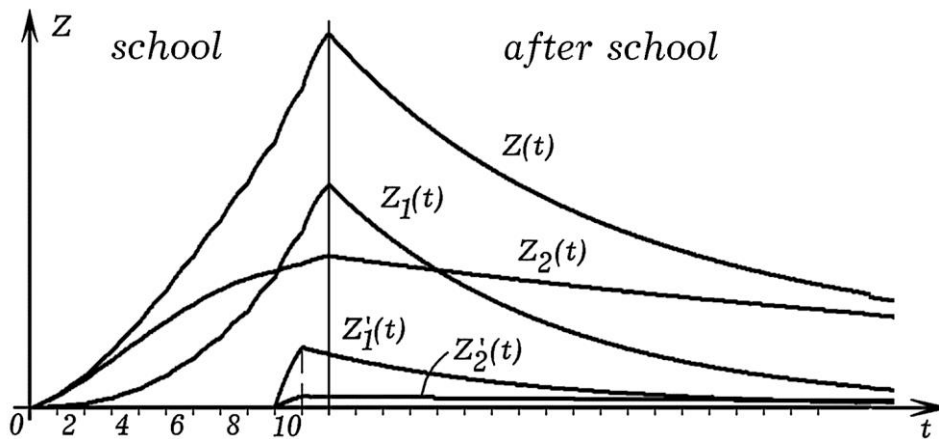
Pic. 4. Results of modelling: situations 4 and 5.

**Situation 5.** Within four weeks the pupil visits lessons of subjects 1 and 2 (for example, English and German), following each another once a week. The quantity of knowledge  $L_i$  ( $i = 1, 2$ ) which the pupil should acquire, is given. The pupil’s coefficients of assimilation and forgetting for subject 1 are equal  $\alpha_1 = 0,025 \text{ CUT}^{-1}$  and  $\gamma_1 = 0,0005 \text{ CUT}^{-1}$ , and for subject 2 –  $\alpha_2 = 0,012 \text{ CUT}^{-1}$  and  $\gamma_2 = 0,001 \text{ CUT}^{-1}$ . It is necessary to investigate the change of the pupil’s knowledge level in the process of studying both education courses.

Modelling is carried out similarly. In the cycle on time  $Z_1$  and  $Z_2$  are separately calculated; the results are displayed in the form of graphs (pic. 4.2). It is obvious that during lessons the knowledge quantity of subject 1 and subject 2 increases. In breaks between lessons the knowledge level decreases owing to forgetting.

**Situation 6.** The pupil studies at school for 11 years. While training the coefficient of assimilation of information increases and is set by the matrix  $\alpha_i = (0,01; 0,015; 0,02; 0,025; 0,03; 0,035; 0,04; 0,045; 0,05; 0,055; 0,06)$ . The requirements levels of the teacher is corresponding to knowledge  $Kn-1$  and  $Kn-2$  to be acquired in the  $i$ -th class are set by the matrixes:  $L_1 = (50, 46, 42, 36, 30, 25, 20, 15, 10, 10, 10)$  and  $L_2 = (4, 8, 14, 18, 24, 28, 33, 38, 46, 58, 62)$ . Forgetting coefficients of  $Kn-1$  and  $Kn-2$  are equal  $\gamma_1 = 0.002 \text{ CUT}^{-1}$  and  $\gamma_2 = 0.01 \text{ CUT}^{-1}$ . It is necessary to calculate the total level of the pupil's knowledge and quantity of knowledge  $Kn-1$  and  $Kn-2$  at various moments  $t$ .

The results of modelling are given in pic. 5. It presents: 1) graphs of  $Z_1(t)$  and  $Z_2(t)$  dependences of knowledge quantity  $Kn-1$  and  $Kn-2$  on time; 2) the graph  $Z(t) = Z_1 + Z_2$  of dependence of total of knowledge on time; 3) graphs  $Z_1'(t)$  and  $Z_2'(t)$  dependences of knowledge  $Kn-1$  and  $Kn-2$  acquired by the pupil in the 10-th class on time. It is obvious that during training the total knowledge quantity, and also levels of knowledge  $Kn-1$  and  $Kn-2$  monotonously increase in school, and after training decrease owing to forgetting. The pupil's knowledge  $Kn-1$  is forgotten significantly quicker, than  $Kn-2$ . The parameters of the model and requirements levels  $L_1(t)$ ,  $L_2(t)$  are selected so that the model approximately corresponds the typical situation which is found in practice.



Pic. 5. Change of knowledge quantity when training at school.

#### 4. Multi-component model of training of the second type

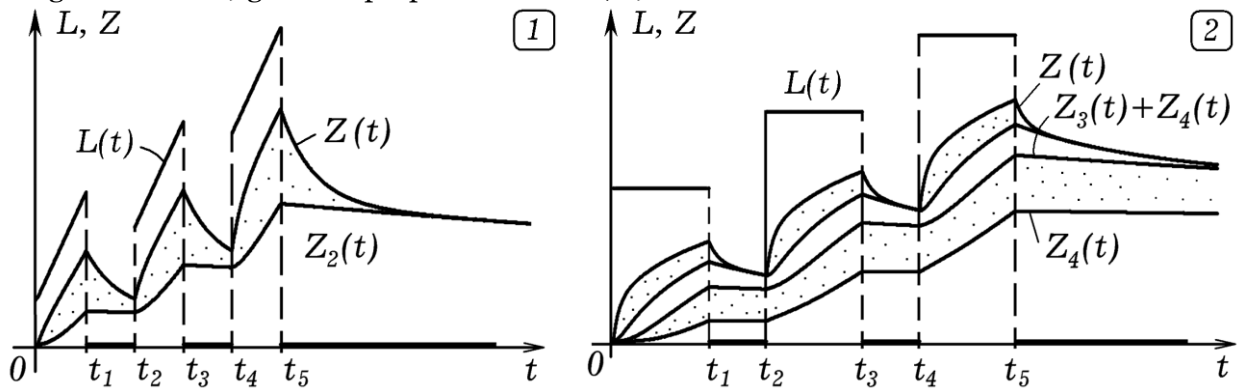
It is known that process of mastering (assimilation) and remembering of the given information consists in establishing associative links between new and existing knowledge. As a result, the acquired knowledge becomes stronger and is forgotten much slower. Let us consider a multi-component model of training which takes into account transformation of weak (poor) knowledge into the strong (solid) knowledge:

$$\begin{aligned} dZ_1 / dt &= k\alpha(L - Z)Z^b - k\alpha_1 Z_1 - \gamma_1 Z_1, & dZ_2 / dt &= k\alpha_1 Z_1 - k\alpha_2 Z_2 - \gamma_2 Z_2, \\ dZ_3 / dt &= k\alpha_2 Z_2 - k\alpha_3 Z_3 - \gamma_3 Z_3, & dZ_4 / dt &= k\alpha_3 Z_3 - \gamma_4 Z_4, \end{aligned}$$

where  $L$  – the requirements level equal to the knowledge quantity  $I(t)$  presented by the teacher,  $Z$  – the pupil's total knowledge,  $Z_1$  – the weakest knowledge of the first category (type) with high coefficient of forgetting  $\gamma_1$ , and  $Z_4$  – the strongest knowledge of the fourth category (or type) with low  $\gamma_4$  ( $\gamma_4 < \gamma_3 < \gamma_2 < \gamma_1$ ). Coefficients of assimilation  $\alpha_i$  characterize the transformation speed of knowledge of  $i$ -th category into the knowledge of  $(i + 1)$ -th category.

While training,  $k = 1$ , and when it stops  $k = 0$ . If the increase of the pupil's knowledge is significantly less than their total knowledge, then  $b = 0$ . The forgetting coefficient is  $\gamma_i = 1/\tau_i$ , where  $\tau_i$  – time during which the knowledge quantity of  $i$ -th category decreases by  $e = 2,72\dots$ . The result of training is characterized by the total level of the acquired knowledge  $Z = Z_1 + Z_2 + Z_3 + Z_4$  and the durability coefficient  $K_D = (Z_2/4 + Z_3/2 + Z_4)/Z$  which is within the interval  $[0; 1]$ . In the course of training the amount of weak knowledge  $Z_1$  and  $Z_2$  grows, weak knowledge transforms into strong, the quantity of strong knowledge  $Z_3$  and  $Z_4$  increases, durability  $K_D$  grows.

**Situation 7.** The teacher gives three lessons. Let us analyse the training process of the pupil by means of two and four-component models in the cases, when the requirements level  $L(t)$  during the lesson: 1) grows in proportion to time; 2) remains constants.



Pic. 6. Two- and four-component model of training.

The two-component model of training is expressed by the equations:

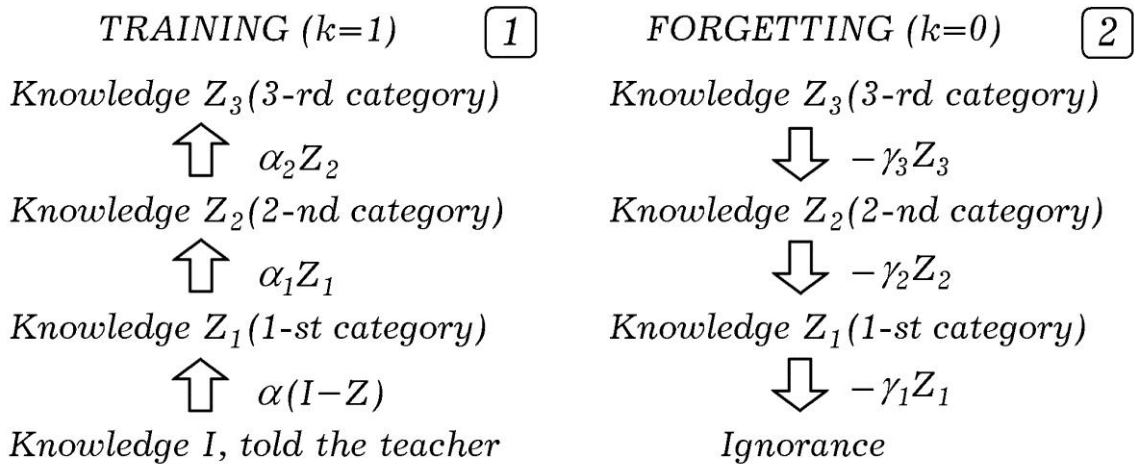
$$\begin{aligned} dZ_1 / dt &= k\alpha(L - Z) - k\alpha_1 Z_1 - \gamma_1 Z_1, \\ dZ_2 / dt &= k\alpha_1 Z_1 - \gamma_2 Z_2, \quad Z = Z_1 + Z_2. \end{aligned}$$

The results of imitating modelling are shown in pic. 6.1. The teacher gives three lessons during which the requirements level grows in proportion to time:  $L = a(t - t_0) + b$ . It is obvious that during breaks and after training the quantity of weak (poor) pupil's knowledge  $Z_1$  decreases quickly, and strong knowledge  $Z_2$  is forgotten significantly slower. When using four-component model of training similar results (pic. 6.2) turn out. It is considered that the requirements level  $L(t)$  during lessons remains constant.

### 5. Multi-component model of training of the third type

The pupil's total knowledge  $Z$  includes weak knowledge of the first category (or type)  $Z_1$ , stronger knowledge of the second category (know-how or ability)  $Z_2$  and very strong knowledge of the third category (skills)  $Z_3$ :  $Z = Z_1 + Z_2 + Z_3$ . In the course of training ( $k = 1$ ) at first information given by the teacher turns into knowledge of the first category, and then as a result of its use when performing educational tasks – into knowledge of the second and third category (pic. 7). So, durability of the acquired material gradually increases. The speed of transformation (or transition) of weak knowledge into category of stronger knowledge is characterized by coefficients of assimilation  $\alpha$ ,  $\alpha_1$  and  $\alpha_2$ .





Pic. 7. Change of durability of the acquired knowledge during training and forgetting.

With no training ( $k = 0$ ) there is the back transition (pic. 7): a part of strong knowledge of the third category gradually becomes less strong knowledge of the second category, then partially turns into the category of weak knowledge of the first category and is forgotten. Transformation speeds of strong knowledge into weak and into ignorance while forgetting are characterized by coefficients of forgetting  $\gamma_1$ ,  $\gamma_2$  and  $\gamma_3$ . So, the following principles are the cornerstone of the offered model:

1. In the course of training the pupil operates with the information which is available for him, performing various educational tasks. Thus the knowledge reported by the teacher at first is acquired as weak or fragile (become knowledge of the first category), then in the process of their revision and use – is stronger (turn into knowledge of the second category), and then becomes strong (knowledge of the third category).

2. The increase speed of pupil’s weak knowledge in the course of training is proportional to a difference between the level of the teacher’s requirements  $L$  (the quantity of the reported knowledge) and the pupil’s total knowledge  $Z = Z_1 + Z_2 + Z_3$  and is equal  $\alpha(L - Z)$ .

3. While training the speed of transformation of weak knowledge  $Z_i$  into stronger knowledge  $Z_{i+1}$  is proportional to the quantity of weak knowledge  $Z_i$  and is equal  $\alpha_i Z_i$  ( $i = 1, 2$ ). Thus the quantity of forgotten information is negligible.

4. With no training there is forgetting: the pupil’s knowledge becomes less strong, and then turns into ignorance. The speed of transformation of strong pupil’s knowledge  $Z_i$  into less strong knowledge  $Z_{i-1}$  or into ignorance is proportional to quantity  $Z_i$  and is equal  $-\gamma_i Z_i$  ( $i = 1, 2, 3$ ).

The result of training is characterized by the total level of the acquired pupil’s knowledge  $Z$  and durability coefficient  $K_D = (Z_2 / 2 + Z_3) / Z$ . If all knowledge acquired by the pupil during studies is weak ( $Z_1 = Z$ ,  $Z_2 = Z_3 = 0$ ), the durability coefficient  $K_D = 0$ . It is necessary to aspire to a situation, when all acquired knowledge is strong ( $Z_3 = Z$ ,  $Z_1 = Z_2 = 0$ ), then  $K_D = 1$ . With long studying of one theme the knowledge level  $Z$  increases to  $L$ , along with it there is a share increase of strong knowledge  $Z_3 / Z$ , durability  $K_D$  grows, tending to 1.

The offered three–component model of training is expressed by the system of the equations (when training  $k = 1$ ; while forgetting  $k = 0$ ):

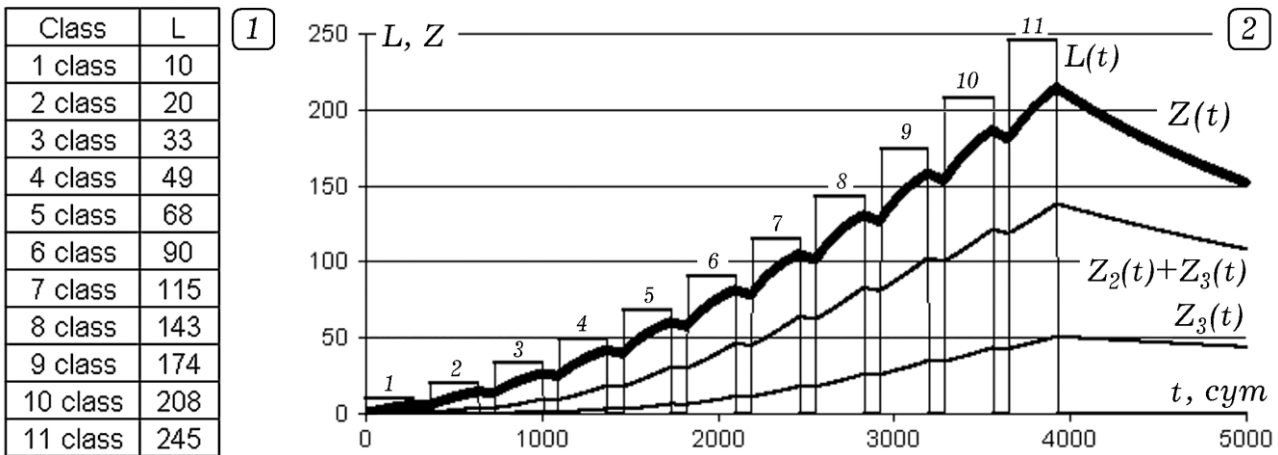
$$\begin{aligned} dZ_1 / dt &= k(\alpha(L - Z) - \alpha_1 Z_1) - (1 - k)(\gamma_1 Z_1 - \gamma_2 Z_2), \\ dZ_2 / dt &= k(\alpha_1 Z_1 - \alpha_2 Z_2) - (1 - k)(\gamma_2 Z_2 - \gamma_3 Z_3), \end{aligned}$$

$$dZ_3 / dt = k\alpha_2 Z_2 - (1-k)\gamma_3 Z_3, \quad Z = Z_1 + Z_2 + Z_3.$$

$$\alpha = (0,003 + 0,01 \cdot (1 - \exp(-Z/100))) \cdot (1 - 0,07 \cdot S_j), \quad \alpha_1 = \alpha / e,$$

$$\alpha_2 = \alpha_1 / e, \quad \gamma_1 = 0,001, \quad \gamma_2 = \gamma_1 / e, \quad \gamma_3 = \gamma_2 / e, \quad e = 2,72\dots$$

To solve this system of the equations with the help of the numerical method there is a special computer program. Thanks to it is possible to make the imitational model of training at 11-year school. The table (pic. 8.1) shows tentative (or estimated) values of the teacher’s requirements level  $L_j$  ( $j = 1, 2, \dots, 11$ ) for each class; the complexity  $S_j$  of training material is given as:  $S_j = 0,07 j$ . It is considered that within a year the pupil studies for 275 days, and has a rest during 90 days of summer vacation. Coefficients of assimilation and forgetting are selected so that the graph of the total knowledge would approximately correspond to a rather successful pupil who acquires 70–90 percent of the required information (pic. 8). Abscissa axis shows the time in days from the moment of the pupil arrival at school in the first form. It is obvious that eventually the quantity of total knowledge  $Z(t)$  and levels of formation of abilities (know-how) and skills increase. After the course of training forgetting begins; first of all, the pupil loses weak knowledge which is not demanded in practice. Failures in graphics  $Z(t)$  correspond to three-month vacation.



Pic. 8. Results of imitating modelling of training at school.

**6. Accounting of change of the pupil’s efficiency during the day**

It is known that the pupil’s efficiency (working capacity) during the day gradually decreases and leads to reduction of speed (or deceleration) of assimilating knowledge. Let us consider that the speed of the pupil’s knowledge increase is proportional to his coefficient of learning  $\alpha$ , working efficiency coefficient  $r$ , the applied efforts  $F$  (or motivation  $M$ ) and quantity of knowledge  $Z$  in degree  $b$  ( $0 \leq b \leq 1$ ):  $dZ / dt = r\alpha F Z^b - \gamma \cdot Z$  where  $\gamma$  – the forgetting coefficient. When the pupil does the work, at first value  $r$  is equal  $r_0$  ( $0 < r_0 \leq 1$ ), and then smoothly decreases to 0 according to the law:  $r = r_0 / (1 + \exp(k_1(P - P_0)))$ . Here  $P_0$  – the work (product of activity) done by the pupil at the lesson where its working capacity decreases from  $r_0 = 1$  to  $r = 0,5$ . While training the level of teacher’s requirements (the knowledge he told to pupil) is more than the level of pupil’s knowledge ( $L > Z$ ), and the study work done by the pupil (the number of the fulfilled tasks) depends on the applied efforts (intensity of mental activity) and training duration. The pupil’s efforts  $F$  are proportional to the difference between the level of the teacher’s requirements  $L$  and quantity of pupil’s knowledge  $Z$ . We receive that:

$$F = L - Z, \Delta P = k_2 F \Delta t = k_2 (L - Z) \Delta t, P = \sum_{i=1}^N (k_2 F_i + k_2') \Delta t.$$

Here  $N$  – the number of elementary periods into which the lesson is divided. If the level of teacher’s requirements is low ( $L \leq Z$ ), that is the pupil is occupied with the solution of tasks, simple for him, the work made by him are proportional to time:  $P = k_2' t$ . It allows to consider the appearance of fatigue and decrease in working capacity of the pupil even in the case when he does simple tasks for a long time. In breaks between lessons the pupil has a rest, his working capacity is restored according to the exponential law:

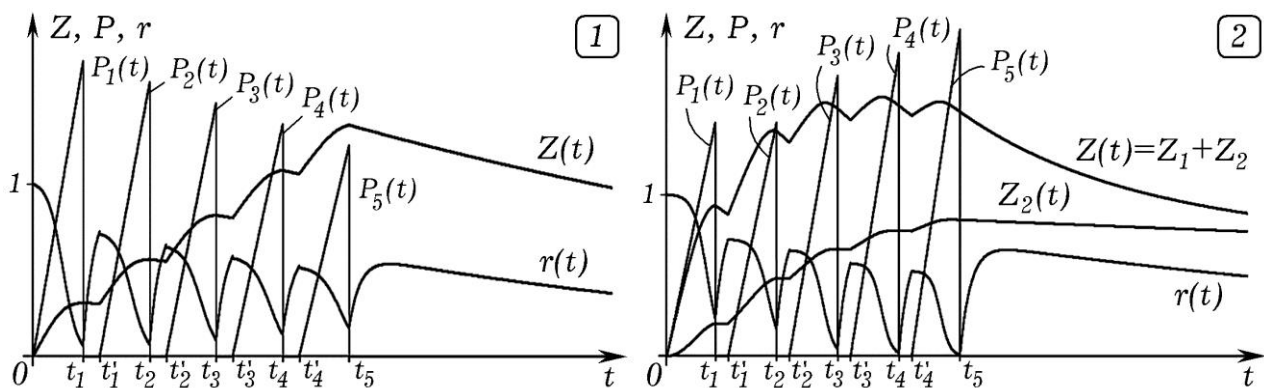
$$dr/dt = k_3(r_{\max} - r), r(t) = r_{\max} - (r_{\max} - r_0) \exp(-k_3(t - t_0)),$$

where  $r_0 = r(t_0)$  – the working capacity at the moment of beginning of rest  $t_0$ , where  $r_{\max}$  – the maximum efficiency of the pupil at the given time  $t$  of the school day. It smoothly decreases according to the law  $r_{\max} = \exp(-k_4 t)$ . With other things being equal, the speed of knowledge increase is higher when the subjective complexity (difficulty of understanding)  $S$  of the studied material is less:  $dZ/dt = \alpha \cdot r(1 - S)FZ^b$ . The complexity of the training material  $S$  lies within the interval  $[0; 1]$  and generally depends on the level of studying (or understanding) other ELMs. So, the one–component model of training looks like:

During training ( $L > Z$ ): 
$$\frac{dZ}{dt} = \frac{\alpha(1 - S)(L - Z)Z^b}{1 + \exp(k_1(P - P_0))} - \gamma Z.$$

During break ( $L = 0$ ): 
$$dZ/dt = -\gamma Z.$$

Let the teacher organize the training process so that during the day pupils work with the maximum tension  $F = L - Z = const$ . Five lessons of identical duration  $T_l = t_1 = t_2 - t'_1 = \dots = t_5 - t'_4$  divided by breaks with the duration  $T_b = t'_1 - t_1 = t'_2 - t_2 = \dots = t'_4 - t_4$  are conducted (given). The results of imitating modelling with reasonable parameters of the model are presented in pic. 9.1. In the interval from 0 to  $t_5$  the coefficient of working capacity  $r$  oscillates relative by to smoothly decreasing value. When breaks between lessons are shortened, pupils don't manage to restore the working capacity, and the results of training decrease.



Pic. 9. One – and two–component models considering changes of the pupil’s efficiency

Let us consider the multi–component model of training taking into account various complexity of the studied themes and change of the pupil’s efficiency during the school day. Let  $Z$  be the pupil’s total knowledge,  $Z_1$  – the weakest knowledge of the first category with high

coefficient of forgetting  $\gamma_1$ ,  $Z_2$  – knowledge of the second category with smaller coefficient of forgetting  $\gamma_2$ , ..., and  $Z_n$  – the strongest knowledge of the  $n$  –th categories with low  $\gamma_n$  ( $\gamma_1 > \gamma_2 > \dots > \gamma_n$ ). Coefficients of assimilation  $\alpha_i$  characterize the speed of transition (or transformation) of the knowledge of the  $(i - 1)$  –th categories into stronger knowledge of  $i$  –th categories. Training is characterized not only by the quantity of the acquired knowledge  $Z = Z_1 + Z_2 + \dots + Z_n$ , but also by the durability coefficient:  $K_D = (Z_2 / 2^{n-2} + \dots + Z_{n-1} / 2 + Z_n) / Z$ .

When studying one theme, at first the level of knowledge  $Z$  grows, then there is an increase in the share of strong knowledge  $Z_n$ , and the durability  $K_D$  increases. The author offers the generalized training model which doesn't have any analogs in the literature known to him. Let the pupil's initial efficiency be  $r_0 = 1$ . At any moment  $Z(t) = Z_1(t) + \dots + Z_n(t)$ . The mathematical model is expressed by the equations:

During training:  $F = L - Z > 0$ ,

$$r = r_0 / (1 + \exp(k_1(P - P_0))), \quad P = k_2 \int_{t_0}^t (1 + S)(L - Z) dt,$$

$$\begin{aligned} dZ_1 / dt &= r(1 - S)(\alpha F Z^b - \alpha_1 Z_1) - \gamma_1 Z_1, \\ dZ_2 / dt &= r(1 - S)(\alpha_1 Z_1 - \alpha_2 Z_2) - \gamma_2 Z_2, \\ \dots, \quad dZ_n / dt &= r(1 - S)\alpha_{n-1} Z_{n-1} - \gamma_n Z_n. \end{aligned}$$

If complexity  $S = 0$  then pupil's work is equal  $P = k_2 \int_{t_0}^t (L - Z) dt > 0$ .

$$\begin{aligned} \text{During the break: } L &= 0, \quad dr / dt = k_3(r_{\max} - r), \quad r_{\max} = \exp(-k_4 t), \\ dZ_1 / dt &= -\gamma_1 Z_1, \quad dZ_2 / dt = -\gamma_2 Z_2, \quad \dots, \quad dZ_n / dt = -\gamma_n Z_n. \end{aligned}$$

The results of using the two–component model ( $n = 2$ ) are given in pic. 9.2. The quantity of strong knowledge  $Z_2$  during training grows, and after its completing – remains almost stable. After the end of training weak knowledge  $Z_1 = Z - Z_2$  is forgotten significantly quicker. The pupil's efficiency during the lesson smoothly decreases, and during breaks – increases up to the amount which gradually decreases during the day because of the accumulative fatigue.

### Conclusion

The present article is devoted to the research of various models of the didactic systems demanding the numerical solution of the differential equations. It analyses: 1) one–component models of training; 2) the multi–component models considering transformation of weak knowledge into strong and vice versa; 3) the models considering change of the pupil's efficiency during the day. They form the sequence in which each following model is formed by complicating the previous one at the expense of accounting of some additional factors.

The known models of training process [1–10] are based on the assumption that all ELMs are acquired and forgotten equally easily. The multi–component models of didactic systems which are analysed in the article, consider that in the course of training a part of the pupil's knowledge becomes strong and is forgotten slower. The process of increase of durability of the acquired

knowledge while its using by the pupil in every day activity is the cornerstone of formation of abilities (know-hows) and skills which remain for a long time [17, p. 211–212].

Also there is a certain interest to the models considering the decrease of the pupil's working capacity during the day. For example, with their help we can prove that changing types of activities, alternation of studying the theory and fulfilling practical tasks lead to increase of the pupil's knowledge at the end of training [12]. Thus, the imitating models of didactic systems based on the solution of the differential equations allow to analyse the training process, to reveal its features, to establish links between the level of the pupil's knowledge at the end of training, distribution of educational information and the pupil's parameters, and help to plan ways to improve or optimize training.

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