Student's educational goal and formalization of its representation in E-learning

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Abstract. The transition to e-learning implies the student's independent setting of the individual educational goal. In this case, the educational platform of the university is used as a pedagogical tool for calculating the optimal educational trajectory and ensuring the student's guaranteed achievement of the educational goal by organizing the educational process on the specified platform. The main problem here is the formalization of the individual educational goal of the student with programming languages of various levels. The authors propose an algorithm for formalizing the individual educational goal of a student and building on its basis a logical-semantic model of the educational process, suitable for implementation by means of computer technology. It is shown that in the logical-semantic model of the educational process, the individual educational goal of the student can be adequately described by the pedagogical category "Educational situation", which is defined as a set, the elements of which are quantitative values of the level of formation and development of basic qualities of competencies. It is concluded that the educational platform of the university in this case is a set of educational situations of various levels, and the student is the current educational situation. It is shown that the current educational situation and educational situations of the educational platform of the university are equal sets on a single scale, which makes it possible to carry out mathematical operations for comparing sets. Based on the results obtained during the comparison operations, a conclusion is made about the achievement of the educational goal by the student, or the individual trajectory of its achievement is calculated. The description of the pedagogical experiment is given. Based on the data obtained, a conclusion is made about the adequacy of the model to the process under consideration.

1. Introduction

The fundamental difference between e-learning and other forms of organization of the educational process at the university is individualization in setting the student's educational goal. If in the "classical" form of the educational process the educational goal was set, as a rule, by the state, and control over achieving it by the student was entrusted to the teachers, then when switching to e-learning, the student independently formulates his educational goal. In this case the educational platform of the university is in charge of organizing the educational process and monitoring the achieving the individual educational goal by the student.
Generally, the educational platform of a university in e-learning is software implemented by means of computer technology (computer). Currently, educational platforms, as a rule, implement the educational process as a linear sequence of educational materials provided in electronic form to the student: lecture notes in various formats, video lessons and master classes, tests to check the level of learning material, etc. However, such an organization of the educational process actually repeats the “classical” form and does not allow to organize the educational process depending on the individual educational goal of the student. The adaptation of the educational process to the individual educational goal of the student cannot be realized due to the absence of a formalized model of the student and his individual educational goal, suitable for implementation in low-level programming languages.

The issue of constructing such formalized models divides researchers into two irreconcilable camps. Supporters of creative concepts of teaching students adhere to the position of the impossibility of creating a model of a person due to its complexity and multi-parameterism. Supporters of the opposite approach believe that the models have been empirically applied in educational institutions of various levels for a long time in the form of plans, programs, pedagogical approaches, techniques and methods of the successfully proven cognitive paradigm of education.

However, technological progress, as well as the general direction of the development of human society, makes it necessary to create universal human models for use in the pedagogical activities of educational institutions, on the one hand, possessing pedagogical validity in relation to the modeled process and its elements, participants, the environment, and on the other - easily formalized, which makes it possible to implement such models by means of computer technology. Modeling is the basis of personalized, adaptive learning in modern conditions [1].

The purpose of our research is to develop theoretical provisions for constructing a model of the educational process of e-learning based on the formalized description of the individual educational goal of a student, suitable for implementation by means of the educational platform of the university when organizing e-learning.

2. Literature review
Various aspects of the construction of the educational process at the university when organizing e-learning, depending on the individual educational goal of the student, are comprehensively considered in modern scientific literature.

For the first time, the issues of creating man-machine educational systems were raised in the 70s of the XX century [2]. Against the background of the transition from the intensive to the extensive form of development of the world economy, due to the development and widespread introduction of computer technology, the necessity of transition from the dominant at that time cognitive to a different - competence - paradigm of education is shown. The goals of education have changed from the transfer of accumulated knowledge and work skills between generations to the individual development of the student, from "know" to "be able to apply" the acquired knowledge in new conditions, adapting work skills to new technologies, the ability to handle huge amounts of information and choose from them what is needed "here and now".

Accordingly, the educational goal began to be formulated as getting by the state and society a competent specialist with a wide range of necessary competencies.

A new unit of pedagogical measurements, in which the goal of education is described and the level of achieving by the student the educational goal, is the pedagogical category “Educational situation”. “It seems to us that the transition to the competence-based and acmeological paradigms, ..., involves the choice of other units of analysis - not knowledge and not separate private competences. An educational situation can become such a unit” [3].

“If, in the design of traditional education, the subject of the project activity is a fragment of the content of this education and its activity-procedural support, then in student-centered education, it is not a fragment of material that becomes a design element, but an event in the life of an individual, giving it a holistic life experience. in which knowledge is a part of it...” [4].
With regard to man-machine educational systems, the pedagogical category "Educational situation" is defined as "a purposeful formalized display of the microenvironment in which the object of research (student) is located, which significantly affects the object of research, using a system of interrelated, identifiable, informatively determined parameters and relationships" [5].

The main problem of pedagogy here is the quantitative measurement of the level of formation and development of the student's competencies in a certain educational situation and, accordingly, the determination of the level of achieving the educational goal, as well as the construction of the individual educational trajectory of its achievement, optimized in terms of temporary and other parameters affecting the effectiveness of the educational process. ...

The scientific literature offers various options for solving the problem of quantitatively measuring the level of formation and development of a student's competencies, as well as creating, based on the proposed options, models of the educational process for various educational platforms of universities [6, 7].

The work "Using Competence Modeling to create Knowledge Engineering" examines the setting of an educational goal for training engineers at WBSA as a body of 11 competencies [8]. The body of competencies is determined by obtaining an expert assessment. The interview is the applied method of extracting expert knowledge. The educational process is built as a sequence of situations, the educational trajectory is determined depending on the behavior model. The data showing the pedagogical validity of the proposed method and an increase in the efficiency of the training process for engineers at WBSA are presented.

The work "Modeling Competences - Developing a Holistic Competence Model for Engineering Education" shows the need to individualize the student's educational goal through a combination of professional and personal, which leads to a new and holistically defined model of competence [9]. The authors show that with the help of the model they have developed, it is possible to describe both existing courses in relation to the intended development of competencies, the areas of competence under consideration, and to develop an individual educational trajectory for individual students. The results of the application of the developed competence model are given. They prove the increase in the effectiveness of the educational process.

The work "Formation of students' social competence in a virtual educational environment" shows the possibility of taking into account not only cognitive competencies, but other, such as ethical or social, in competency models. It is shown that taking these competencies into account in the model contributes to the harmonious development of the student's personality in the educational space of the university, leads to a more accurate formulation of the individual educational goal, and, as a result, contributes to the student's desire to receive education, which generally increases the efficiency of the educational process in the university [10].

The book "Towards a Competence-Based View on Models and Modeling in Science Education", which covers the latest achievements of pedagogical science in the development of competence models and their application in various fields of human activity is of particular importance for the pedagogical problem under consideration [11].

The work shows that the best indicators of pedagogical validity are provided by logical-semantic models based on the use of the mathematical apparatus of the logic of predicates of both the first and higher orders [12]. These models, on the one hand, are simple and understandable for the user, since the predicate language is a version of the natural human language that has a number of restrictions in order to eliminate uncertainties, and on the other hand, there is a mathematical apparatus that is easily implemented by means of low-level programming languages in the form of applied software ... The works of Veryaev A., Piecha T., Andréka H. [13, 14, 15] are devoted to the specific features of the use of natural languages in modeling processes.

However, today there is no single universal model of the educational process suitable for its implementation on various educational platforms of universities. In scientific works, as a rule, competence models are considered, the educational goal of which is set a priori. In most cases, the educational goal is set by analogy with the "classical" form of organizing the educational process,
according to the results of an expert assessment by an external for the university or by an internal group of experts.

Thus, there is a contradiction between the available opportunities for the individualization of the educational process depending on the individual educational goal of a student and the absence of a developed and tested universal model (algorithm, technology) for formalizing the individual educational goal of a student and building on its basis an individual educational trajectory in the organization of e-learning at the university.

The development of the algorithm for constructing the educational process at the university, depending on the individual educational goal of the student, is an urgent pedagogical task.

3. Materials and methods
Let us consider the algorithm for formalizing the individual educational goal of a student when organizing e-learning at the university in relation to the logical-semantic model of organizing e-learning [16].

Our research shows that students quite easily describe an individual educational goal as a kind of situation (professional, social, etc.) in which they can show themselves as a competent specialist in any field of human activity, that is, having a certain number of formed in the process of learning competencies. At the same time, he has the highest possible level of these competencies, which allows him to prove himself as a competent specialist in an appropriate situation.

Then we denote the educational situation as $\mathcal{A}$. Accordingly, the individual educational goal of a student is an individual target educational situation $\mathcal{A}^0$. At the same time, $\mathcal{A}^0 = \{Y\}$ where $Y = \{Y_1, Y_2, ..., Y_i\}$ is a set of student's competencies, the development of which is necessary for a student to achieve an individual target educational situation $\mathcal{A}^0$. The total number of competencies is different for each individual target educational situation, but in practice, in a first approximation, they can be enlarged without a significant loss of adequacy to the modeled process. In the mentioned work "Using Competence Modeling to create Knowledge Engineering" (Nicolini A., Santos C., Hoeschl H., Theiss I. and Bueno T., 2006), 11 competencies are included into the individual target educational situation, selected by a peer review. But in most cases, 7 competencies are taken into account as components of the pedagogical category "competence": cognitive, activity, technological, motivational, ethical, social, and behavioral. The last of them - motivational, ethical, social, behavioral - describe the student's personal qualities and are considered as dominant in some, for example, acmeological, pedagogical approaches to the organization of the educational process. The first three - cognitive, activity, technological competencies - describe the level of knowledge, abilities and skills formed and developed by the student in the learning process.

The work "Modeling and Measuring Competencies in Higher Education: Tasks and Challenges" shows that each competency is a set of basic qualities displayed on the quantitative or relative scales [17]. For cognitive, activity and technological competencies, quantitative scales are mainly used: “Knows 5 poems”, “Can read 100 characters per minute”. Relative scales are usually used for motivational, ethical, social and behavioral competences.

Then competence $Y = \{y^1, y^2, ..., y^i\}$ is a set of basic qualities of the corresponding competence. Given the presence of measuring scales, it is more correct to write down $Y = \{\mu_1(y^1)/y^1, \mu_2(y^2)/y^2, ..., \mu_i(y^i)/y^i\}$, where $\mu_i(y^i)$ is a quantitative indicator of the level of formation and development of a student of the corresponding basic quality of competence.

It is clear that $0 \leq \mu_i(y^i) \leq 1$, where conditionally "0" is the minimum level of formation and development of the basic quality of competence, and "1" is the maximum level of its development.

Obviously, the individual target educational situation of the student assumes the student's desire to achieve the maximum possible level of development of basic qualities and competencies, that is, $\mathcal{A}^0 = \{Y_1, Y_2, ..., Y_i\} = \{\mu_1(y^1)/y^1, \mu_2(y^2)/y^2, ..., \mu_i(y^i)/y^i\} = \{1/y^1, 1/y^2, ..., 1/y^i\}$.
Accordingly, there are other educational situations, such as $\tilde{A}_1=\{\mu_1(y_1)/y_1^1, \mu_2(y_1)/y_1^2, \ldots, \mu_i(y_1)/y_1^i, \ldots\}$, $\{\mu_1(y_2^1)/y_2^1, \mu_2(y_2^1)/y_2^2, \ldots, \mu_i(y_2^1)/y_2^i, \ldots\}$, $\{\mu_1(y_3^1)/y_3^1, \mu_2(y_3^1)/y_3^2, \ldots, \mu_i(y_3^1)/y_3^i, \ldots\}$, $\{\mu_1(y_4^1)/y_4^1, \mu_2(y_4^1)/y_4^2, \ldots, \mu_i(y_4^1)/y_4^i, \ldots\}$

Then the educational platform of the university is a set of educational situations of the form $
\tilde{A}=\{\mu_a(y_a)/y_a^1\}$, where $0\leq \mu_a(y_a)\leq 1$, which fully meets the completeness requirements for pedagogical models. In this case, all educational situations are sets displayed on uniform quantitative or relative scales, which makes it possible to perform mathematical comparison operations with them. Unified measuring scales allow us to discard them when performing mathematical comparison operations and carry out these operations using only quantitative elements $\mu_a(y_a)$, that is $\tilde{A}=\{\mu_a(y_a)\}$.

Thus, we are moving from a “qualitative” description of the individual educational goal of a student to quantitative values. This makes it possible to build mathematical (to be precise, formalized) models and their subsequent implementation in the form of applied software for the educational platform of the university.

Then the individual educational trajectory of a student is a graph of movement in the educational space from a certain educational situation of the lower level, which has quantitative values of indicators of the level of development of basic qualities of competencies $\mu_a(y_a)=0$ to the individual target educational situation of a student, which has quantitative values of indicators of the level of development of basic qualities of competencies $\mu_a(y_a)=1$, that is $\tilde{A}_1\rightarrow \tilde{A}_2\rightarrow \tilde{A}_3\rightarrow \ldots\rightarrow \tilde{A}_n\rightarrow \tilde{A}_0$.

However, such a schedule for achieving the educational goal does not allow to conduct pedagogical measurements of the levels of formation and development of the basic qualities of competencies in a student. It also doesn’t allow to introduce, using pedagogical techniques and methods, appropriate adjustments to the educational process, and finally to optimize it in terms of temporary or other parameters that affect its effectiveness ...

To overcome this disadvantage, we will put forward the following hypotheses.

Hypothesis 1. The student is educational situation $\tilde{A}_0$, the structure of which is similar to the individual target educational situation $\tilde{A}_0$. Then the values $\mu_a(y_a)$ of the educational situation $\tilde{A}_0$ reflect the quantitative assessment of the level of development of the student’s basic qualities at the current time.

In fact, we discard and do not take into account other qualities of a student as a biological object, except for the presence or absence of basic qualities of competencies, which he seeks to form and develop.

Hypothesis 2. The student at the current time is in the educational situation $\tilde{A}_n$. The degree of fuzzy equality of the current educational situation $\tilde{A}_n$ with it is maximum for all educational situations $\tilde{A}$ that are part of the educational platform of the university.

The degree of equality of the educational situation $\tilde{A}_0$ with the educational situation $\tilde{A}_n$, we define as: $\mu(\tilde{A}_0, \tilde{A}_n)=\cap (\mu(\tilde{A}_0)(Y_i) \rightarrow \mu(\tilde{A}_n)(Y_i)) \& (\mu(\tilde{A}_0)(Y_i) \rightarrow \mu(\tilde{A}_n)(Y_i))$, for all possible $Y_i=\{\mu_a(y_a^1)/y_1^1, \mu_a(y_a^2)/y_2^1, \ldots, \mu_a(y_a^i)/y_i^1\}$.

Then, the educational process in E-learning, implemented on the educational platform of the university, is transformed into the sequence $T^1\rightarrow \tilde{A}_0\rightarrow S_1 \rightarrow T^2 \rightarrow \tilde{A}_0\rightarrow S_2 \rightarrow T^3 \rightarrow \ldots \rightarrow \tilde{A}_0\rightarrow S_n \rightarrow T^n \rightarrow \tilde{A}_0=\tilde{A}_0$. Here $T^1$ is the test task # 1 from the set of test tasks $T=\{T^1, \ldots, T^n\}$ of the educational platform of the university. $S_1$ - pedagogical situation No. 1 from the set $S=\{S_1, \ldots, S^n\}$ of pedagogical situations of the educational platform of the university, defined by us as "a body of conditions and obligations arising spontaneously in the pedagogical process or specially created by the teacher in order to form and develop the personality of the student" [4].

Depending on the student's achievements in the formation and development of the basic qualities of the competencies that make up his individual educational goal, $T^1\rightarrow \tilde{A}_0=\tilde{A}_3=S_3 \rightarrow T^2 \rightarrow \tilde{A}_0=\tilde{A}_3=S_3 \rightarrow S_4 \rightarrow T^3 \rightarrow \ldots \rightarrow \tilde{A}_0=\tilde{A}_{n+1}=S_{n+1} \rightarrow T^{n+1} \rightarrow \tilde{A}_0=\tilde{A}_0$. As a result $T^1\rightarrow \tilde{A}_0=\tilde{A}_3=S_3 \rightarrow T^2 \rightarrow \tilde{A}_0=\tilde{A}_3=S_3 \rightarrow S_4 \rightarrow T^3 \rightarrow \tilde{A}_0=\tilde{A}_3=S_3 \rightarrow T^4 \rightarrow \ldots \rightarrow \tilde{A}_0=\tilde{A}_{n+2}=S_{n+2} \rightarrow T^{n+2} \rightarrow \tilde{A}_0=\tilde{A}_0$ can be implemented in the pedagogical platform of the university. Thus, the individual educational trajectory of achieving the individual
4. Research results and discussion

Approbation of the proposed method of presenting the student’s individual educational goal and its formalization, as well as the algorithm for constructing the individual educational trajectory of the student, was carried out by us on the basis of the Federal State Educational Institution of Higher Education "Voronezh State Pedagogical University" in 2018-2020. Specialty - "Pedagogical education". The profile of training students is "Technology". The number of students who took part in the experiment was 60 people, united in 4 experimental groups. The obtained results were compared with the results of the control groups trained in a similar direction of training.

At the beginning of the experiment, each student wrote an essay, which was a short description, using linguistic constructions of natural language, of a professional or social situation in which he can prove himself as a specialist possessing the necessary competencies. Then, for each competence, the teacher-tutor determined and agreed with the student 5 basic qualities that make up the corresponding competence, and a quantitative or relative scale was determined according to which a quantitative measurement of the basic quality could be made. For example, if a student in an essay describes his desire to successfully make an economic calculation of a product made by the student at a lesson of technology, then the cognitive competence includes the basic quality "knowledge of taxation systems for individual entrepreneurs", and the activity competence includes "the ability to fill in 3-income tax forms".

The quantitative scale that reflects the basic quality of "knowledge of taxation systems for individual entrepreneurs" ranges from 0 to 10 in accordance with the number of maximum possible taxation regimes for an individual entrepreneur. The quantitative scale of the basic quality "the ability to fill in the 3-income tax forms" accordingly ranges from 0 to 17, depending on the number of mistakes that a student can make when filling it in. The rest of the competencies and the corresponding basic qualities and their quantitative or relative scales are defined similarly.

Then the individual target educational situation of a student is a set of basic qualities of competencies for which \( \mu_s(y^i) = 1 \). Accordingly, by means of the educational platform of the university, educational situations of the lower level are formed, for which \( \mu_s(y^i) = 0 \) and further with a step of 0.1. That is, for educational situation \( \hat{A}_1 \) all \( \mu_s(y^i) = 0 \), for educational situation \( \hat{A}_2 \) one of \( \mu_s(y^i) = 1 \), the rest are 0, etc. Thus, the individual student's educational space is created in the educational platform of the university. It consists of a set of educational situations \( \hat{A} \) describing all possible options for the levels of formation of the student's basic qualities of competencies, to the maximum development of which he strives.

Next, by the means of the educational platform of the university, test tasks and pedagogical situations are selected in the electronic database. They ensure the implementation of the student's individual educational trajectory, for example, \( T^1 \rightarrow \hat{A}_0 \rightarrow \hat{A}_1 \rightarrow S_1 \rightarrow T^1 \rightarrow \hat{A}_0 \rightarrow \hat{A}_k \rightarrow S_k \rightarrow T^k \rightarrow \ldots \rightarrow \hat{A}_0 \rightarrow \hat{A}_{k+1} \rightarrow S_{k+1} \rightarrow T^{k+1} \rightarrow \hat{A}_0 \rightarrow \hat{A}^0 \). The first step towards the implementation of the student's individual educational trajectory is the primary assessment of his basic qualities of competencies and their level of development in relation to the individual educational goal, that is, the formation of the current educational situation \( \hat{A}^0 \). Then we consider that the student is in educational situation \( \hat{A}_1, \hat{A}_3, \ldots \hat{A}_m \); the degree of fuzzy equality with it is maximum in comparison with other educational situations. So in the experimental group, as a result of their fulfillment of test tasks at the initial moment of time, 34 students were ranked at the educational situation \( \hat{A}_{14} \), 14 students were ranked at one of the educational situations of the lower level \( \hat{A}_3, \hat{A}_5, \ldots \hat{A}_{14} \); 10 students showed the level of formation of their basic qualities of competencies, sufficient for referring to intermediate educational situations of the second level \( \hat{A}_{21}, \hat{A}_{30}, \ldots \hat{A}_{36} \); 2 students demonstrated the level of formation of their basic qualities of competencies corresponding to educational situations of the third level \( \hat{A}_{46}, \hat{A}_{46} \).
An individual educational trajectory is calculated for each of the students by means of the university educational platform. The pedagogical situation of set \( S = \{S_1, \ldots, S^n\} \) of pedagogical situations is proposed for implementation. Its “playing” by the student develops his basic competencies to the next level. Then, again, the student performs a test task, according to the results of which the current educational situation is formed, the educational situation \( \tilde{A}_0 \), is determined, the individual educational trajectory is recalculated. It occurs until the student reaches the individual target educational situation \( \tilde{A}_0 \), that is, the achievement of his individual educational goal.

Then, again, the student performs a test task, according to the results of which the current educational situation is formed, the educational situation \( \tilde{A}_0 \), is determined, the individual educational trajectory is recalculated, and so on until the student reaches the individual target educational situation \( \tilde{A}_0 \), that is, the achievement of his individual educational goal.

According to the results of the experiment, 55 people out of 60 members of the experimental group, reached the individual target educational situation. 2 people were expelled from the Voronezh State Pedagogical University, 3 people could not realize their individual educational trajectory even with the help of the tutor.

Out of 55 students who successfully achieved their individual educational goals, 6 people achieved it, "playing" less than 20 pedagogical situations, which approximately corresponds to 5 months of training in the classical form of organizing the educational process. 9 students achieved their individual educational goal, “playing” less than 30 pedagogical situations, and the remaining 40 students spent all the time on achieving their individual educational goal, consistently “playing” all pedagogical situations \( S = \{S_1, \ldots, S^n\} \), offered by the educational university platform.

Thus, we can conclude that the formalization of the individual educational goal of a student when organizing E-learning allows creating a logical-semantic model for organizing E-learning, pedagogically valid in relation to the process under consideration, suitable for its implementation by means of computer technology. The results of the experiment show an increase in the efficiency of organizing the educational process in its individualization, reduction of the time spent by the student to achieve an individual educational goal, round-the-clock access to the educational process from the educational platform of the university.

Similar studies and the results obtained during their implementation on the formalization of the individual educational goal of the student and the corresponding organization of the educational process of E-learning on the educational platform of the university are given in the works: "Introduction to Educational Technology: A Primer for the 21st Century", "Artificial Intelligence Supported Educational Technologies", "Goal pursuit in education using focused action research", "Development experience, development trends and implementation of information systems to support the main educational process" [18, 19, 20, 21].

The authors note the relevance of the problem under consideration: “In the context of the emergence of new educational needs, changes in the principles of access to knowledge, including the requirements to generalize existing and introduce new approaches to formalizing and systematizing the collection and accumulation of data, taking into account the specifics of a particular field of education, the practice of introducing information support systems in the educational process is becoming relevant as well as organization of a unified educational information space both at the level of a specific institution and of the education system as a whole” [21]. It has been shown that 83% of students studying at universities which have their own educational platform use it on a regular basis [21]. The papers consider models and algorithms for constructing the educational process in the educational platform of the university, taking into account the individual educational goals of the student.

However, the practical implementation of the construction of individual educational trajectories of each student is currently very difficult due to the complexity of formulating an individual educational goal by the student, the lack of universal methods of formalizing the natural human language, high requirements for the computational capabilities of the hardware of computer technology that provide the educational platform of the university [22 ]. There is also a lack of an unambiguous definition of the pedagogical category “Educational situation”, uncertainty in the choice of competencies and their
classification, in the definition of basic qualities and their quantitative and relative scales [23]. The solution to these problems lies primarily in the integration of pedagogical technologies and mathematical methods, which can fully ensure the accuracy of the characteristics of the educational process, its individualization, versatility and efficiency.

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