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SELF-EDUCATIONAL COMPETENCE OF SUBJECTS OF EDUCATION AS A PREREQUISITE FOR ACHIEVING LEARNING OUTCOMES

Abstract

The development of self-educational competence is determined not so much by fixed learning outcomes as by the ability to determine and plan the necessary time to achieve the best learning outcomes. The purpose of the article is to present a methodology for determining the time to achieve learning outcomes based on a mathematical model in the process of self-educational activity of subjects of an educational organization of higher education.

The study was conducted on the basis of the Kazakh National Women's Teacher Training University (Almaty, Republic of Kazakhstan) and the State University of Humanities and Technology (Orekhovo-Zuyevo, Russian Federation). The results of the study were obtained on the basis of a comparative analysis of the development of self-educational competence of the subjects of the Kazakh and Russian educational organizations of higher education, the method of designing the applied orientation of teaching pedagogy, the mathematical method using the "didactics equation". The following methods were used: theoretical analysis, comparison, survey, expert observation.

According to the results of scientific research of the subjective activity of students of the Kazakhstani university, an underestimation of the importance of the formation of algorithmic skills for monitoring the achievements of learning outcomes was revealed: 58% of future teachers have a low level of self-educational competence; 44% of students have difficulties in self-planning self-educational activities. 38% of Russian university students were found to be unable to independently choose an algorithm of actions when planning and controlling the time of self-educational activities and productively implement it in the course of the module "Innovative technologies of educational activity". A mathematical method has been developed using the "didactics equation" (M.I. Poteyev), which allows determining the necessary time for effective learning in the process of self-educational activity of university students.

Keywords: diagnostics of achievements, learning outcomes, mathematical model of measurement, self-educational competence, subject of education.

Introduction. The subject of education shows competence in the ability to apply what he / she has learned in practice, that is, to transfer competence to certain situations in real life. The solution of this problem will contribute to improving the quality of training of future specialists in the context of the globalization of education and ensuring competitiveness in the process of lifelong learning (Serjozhnikova et al., 2020). This means that the priority competence

is self-educational competence, the development of which is promoted by active self-educational activity.

We consider the self-educational competence of the subject of education as an integrated personality quality characterized by the presence of external and internal motives, a clear system of knowledge and skills that allow implementing an individual strategy of self-development and self-improvement on the path of professional development. It can be said that this competence is formed by the subject himself/herself, organized and controlled by him / her, developed as the author of efforts. At its core, self-educational competence is the result of self-educational activity of students as a systematic independent cognitive activity, the purpose of which is to acquire professional knowledge, skills and experience that contribute to the development of professional and personal qualities and abilities that ensure the achievement of high results in professional activity. In this context, the self-educational competence of the subject of education is formed on the basis of the acquisition of experience of independent trials and achievements, the development of their own individual learning strategy, the transition from copying samples of self-education to the development of their own model of self-education and quality control through the use of the "didactics equation".

Within the framework of our research, the terms "subject of education" and "self-educational competence" should be considered. Firstly, the subject of education is a new status – an independent, high-potential personality who, first of all, must rely on his / her own strength, intelligence and energy and not justify his / her failures by social troubles. The success of the subject of education in achieving learning outcomes is due to the aspiration for self-realization (Maralov et al., 2022). Secondly, in accordance with the priority in higher education, determined by regulatory documents, is "the development of creative abilities and skills of independent scientific knowledge, self-education and self-realization of the individual", which indicates the subjectivity of the student.

Main part. *Literature review.* Foreign scientists, actively engaged in the problems of self-education, introduce several terms representing this phenomenon (self-directed learning, self-planned learning, learning projects, self-education, self-teaching, autonomous learning, autodidaxy, independent study, open learning), define it also as multidimensional and multifunctional, namely as:

1 a learning strategy that allows its users to independently manage their learning process (diagnose learning needs, define learning goals, choose learning strategies and evaluate learning outcomes) (Yang et al., 2021);

2 the ability of a person to formulate a plan and identify the tools, resources and strategies needed for training. Behavior and characteristics related to independent learning, internal motivation, diligence and perseverance (Chowdhury et al., 2023);

3 training, in which the decision to learn what and how to learn and how to decide whether something has learned well enough is made by the participants of the process themselves (Lepp et al., 2021);

4 self-conception or self-initiated learning as one of the six principles of adult learning (Berkovich-Ohana et al., 2020);

5 the individual initiative and responsibility of the student (with or without the help of a teacher) to determine, evaluate and set priorities for learning needs (Roberts et al., 2022);

6 the type of training by which students take responsibility for what to teach, when and how (Morris, 2019);

7 a learning mode characterized by increased responsibility of the individual for his/her learning, including the choice of topic, resources, method of teaching and evaluation (Sasson et al., 2022);

8 the process by which students initiate the diagnosis of their learning needs, formulate learning goals and direct their learning activities (Clark, 2020).

Such a detailed analysis of the scientific definition of the concept of "self-education" allows us to distinguish two different approaches to its interpretation. The first – cognitive-personal approach – allows us to interpret the concept of "self-education" as a process of purposeful and systematic improvement, development of personality and its activities. This interpretation

assumes the personal nature of self-education as self-development and the presence of a process of self-knowledge. The second approach suggests considering self-education as a type, form, means of cognitive activity organized independently.

Consequently, self-educational competence is based on self-education, which is a necessary component of modern life and the only determinant of self-development of one's inner world. According to E.S. Chebotareva, "self-educational competence is inherent in the subject and is realized by him / her not only as a result of activity, but also in himself / herself, transforming himself / herself in it. Thus, self–educational competence is a person's creation of himself / herself" (Maralov et al., 2022).

Taking into account the available scientific research on the essence of self-educational activity (Krasnoshchechenko et al., 2018), as well as competence, we define the self-educational competence of a future specialist as an integrated personality quality, which is characterized by: motivational and value attitude to self-education; self-educational skills and skills aimed at continuous learning process; readiness to organize self-education throughout life.

The analysis and systematization of a number of interpretations of the concept of "self-education" as a form of cognitive activity of the subject, allowed us to identify the phenomenon of "self-educational competence of the future teacher", which is defined as an integrative personal and professional construct, representing the internal orientation of the individual to self-identification, self-realization and self-improvement as a subject of professional pedagogical activity and concentrating the desire of the individual to realize educational, professional and creative potential at the axiological and ideological level.

The interpretation of the concept of "self-educational competence" allowed us to determine the criteria for measuring the levels of its manifestation: subjective (with indicators: the student's awareness of the content and functions of self-educational competence, the innovative orientation of the individual); instrumental (with indicators: predictive skills, information and analytical skills, organizational skills).

Taking into account the fact that it is fashionable to increase the knowledge of subjects of education about the content and functions of self-educational competence, independent personal development in the process of studying pedagogy, this gives special importance to this discipline when updating the ways of organizing self-education of subjects of education, especially the applied aspect of learning. We point out that "we consider the method of activity as a component of the dynamic structure of activity, a set of techniques and methods of activity that ensure its result" (Pasternatskyi et al., 2022). This makes it possible for the applied orientation of teaching pedagogy to act as a way of developing the self-educational competence of subjects of higher education.

With the shift of emphasis from measuring the amount of knowledge to identifying the ability of students to independently extract educational information, the improvement of the control system for evaluating the success of training is activated (Suleymanov, 2022). This served as the basis and indicates the urgency of the problem of activating the improvement of the control system for assessing the success of self-educational activities of subjects of training. As a diagnostic tool, a mathematical model was developed using the "didactics equation" (M.I. Poteyev), as well as taking into account the mathematical model of training specialists presented in the study of V.N. Sobolin (Kdyrbaeva et al., 2020). This model was used to determine the necessary time for effective learning in the process of self-educational activities of students of Kazakhstani and Russian universities.

Research materials and methods. The study was conducted in 2021-2022 on the basis of the Kazakh National Women's Teacher Training University (hereinafter KazNWTTU) (Almaty, Republic of Kazakhstan) and the State University of Humanities and Technology (hereinafter SUHT) (Orekhovo-Zuyevo, Russian Federation). The study involved 122 students of Kazakhstani and Russian universities planning their self-educational activities in the conditions of the additional module "Innovative technologies of educational activity", introduced into the educational process of universities as an autonomous interdisciplinary organizational and

methodological structure of academic disciplines ("Pedagogy" and "Technology of classroom management").

The research methodology is based on expert discussion, which makes it possible to obtain a qualitative assessment of the planning of self-educational activities by the subjects of education, based on a mathematical model using the "didactics equation" of learning, with the fixation of the transition from copying samples of self-education to developing their own model of self-education organization. The survey and questioning of students revealed the level of manifestation of self-educational competence.

Results and discussion. The applied orientation of teaching pedagogy is considered as a purposeful selection and rational use of the content of the material (situation) in the learning process, focused on the application of pedagogy in interdisciplinary relations with professional disciplines. The structural unit of interdisciplinary connections is situational modeling – it is a real or simulated professional activity of future specialists, based on the choice of adequate forms, methods and means of training that contribute to the assimilation by the subjects of training of the knowledge system of the professional sphere in the process of self-educational activity in an educational organization.

The effectiveness of the formation of self-educational competence was promoted by the developed technology of applied orientation of teaching pedagogy in interdisciplinary relations with a professional discipline, the structural unit of which is situational modeling. Situational modeling includes a set of interactive teaching methods based on the reproduction and analysis by students of real and really possible professional situations (in the form of business games, case studies and situational tasks) and measures for their implementation in the educational process. The technology, represented by a structural set of methods and techniques, organizational forms, combined in accordance with the goals and process of professional training of future specialists, having certain stages, cycles due to didactic conditions, is reflected in the additional module "Innovative technologies of educational activity". The module includes didactic goals, a logically completed unit of educational material, methodological guidance in the process of integrating individual topics, which allows students to independently analyze professional and pedagogical information, build on its basis an individual strategy of independent cognitive activity, carry out self-diagnosis, contributes to the dynamics of professional growth [13].

It should be noted that in the context of the implementation of the additional module "Innovative technologies of educational activity", there was a need to control the time parameter in the process of evaluating the effectiveness of the formation of self-educational competence of future teachers. As a diagnostic tool for the time parameter of the effectiveness of the organization of self-educational activity, a mathematical model was developed using the "didactics equation" (M.I. Poteev) [15].

In accordance with the basic "didactics equation", according to which the rate of knowledge acquisition is equal to the algebraic sum of all the forces of didactic influence on the student, measured in $\frac{unit\ .part\ .\inf}{hour}$, the mathematical level of the student's learning result can be written in the form of a system of differential equations. Let's imagine a model with the introduction of some designations:

T_1 – the student's work time with the teacher;

T_2 – the time of the student's self-educational activity;

$g(T_1, T_2)$ – the value characterizing the level of the student's learning outcome, measured in relative units $0 \le g(T_1, T_2) \le 1$. The closer this level is to 1, the higher the student's learning result. One can, for example, assume that $g(T_1, T_2)$ s a student's rating assigned to the maximum possible indicator of the rating data. If, for example, the rating is measured on a one–hundred-point scale, so $g(T_1, T_2)$ is the student's score divided by 100

$f(T_1, T_2)$ – a value that characterizes the level or degree of the student's learning outcome: $f(T_1, T_2) = 1 - g(T_1, T_2)$.

The levels of achievement of the student's learning result depend on the time spent working with the teacher and on the time allotted for self-educational activities. This is reflected in the arguments of the corresponding functions. If the student was not actively engaged in self–

education, then his level of learning outcome did not decrease, but remained at the same level, that is $f(0,0) = f_0$, where f_0 – is the initial level of the student's learning outcome. With the increase of time T_1 and T_2 the level of the student's learning result should decrease, that is, the function $f(T_1, T_2)$ is decreasing for both arguments.

To assess the effectiveness of self-educational activities, its impact on the achievement of the effectiveness of the subjects of learning, one can also use the general principles of information theory. From the perspective of this science, learning is considered as a certain amount of knowledge, abilities, and skills that changes over time under the influence of various factors. For students who are at different stages of learning, this volume differs in size, and the knowledge and skills themselves are characterized by varying degrees of order (or disorder). In information theory, the amount of disorder is characterized by entropy. In relation to the learning process, the value of the entropy of the student's knowledge can serve as a measure of achieving the effectiveness of learning. The learning result is achieved by a systematic influence on the amount of entropy.

As information is acquired, the disorder of actions and skills of learning subjects will decrease, which will lead to a decrease in entropy, and this, of course, will lead to an increase in the level of learning outcomes. The basic relation of information theory relating the amount of information to entropy has the form:

$$I = -\log_2 H, \quad (1)$$

where I – is the amount of information received by the student,

H – entropy of the student's knowledge.

From formula (1) it follows that $H = e^{-kI}$, where $k = \ln 2 = const$.

Let's apply this formula for two states of the learning process. Let's suppose that at the initial stage the condition of the student was characterized by the parameters I_0 and H_0, and after obtaining knowledge ΔI the entropy decreased to a value H. Then we get:

$$H_0 = e^{-kI_0}$$

$$H = e^{-k(I_0+\Delta I)}.$$

Hence,

$$H = H_0 \cdot e^{-k\Delta I} \quad (2)$$

Value g, which characterizes a certain relative level of achievement of student learning outcomes, is associated with disorder, that is

$$g = f(H), \quad (3)$$

where $f(H)$ – is a function that increases the level of student learning outcomes not due to the influence of disordered connections, but namely, due to the decrease in entropy. Since with a decrease in entropy, the level of achievement of student learning results increases, the function $f(H)$ should be decreasing. If the magnitude of the decrease has a power-law character, then this function can be represented as

$$f(H) = 1 - a \cdot H^b \quad (4)$$

where a and b – are some coefficients characterizing the degree of increase in the level of achievement of learning outcomes depending on the decrease in entropy.

Taking into account the expression (3), the dependency (4) takes the form:

$$g = 1 - a \cdot H^b.$$

Using (2), we obtain:

$$g = 1 - a \cdot H_0^b \cdot e^{-kb\Delta I} \quad (5)$$

Introducing the designation:

$$1 - a \cdot H_0^b = g_0,$$

where g_0 –is the value characterizing the relative level of student learning outcomes with the initial disordered connections in the system, and substituting it into dependence (5), we obtain:

$$g = 1 - (1 - g_0) \cdot e^{-p\Delta I} \quad (6)$$

where the designation is accepted $p = kb$.

It is natural to assume that the amount of information processed and assimilated by the student consists of the information I_1, received by the student during the hours of classes with the teacher, and the information I_2, received by the student in self-educational activities, that is

$$\Delta I = I_1 + I_2.$$

The amount of information I_1 s proportional to the time allocated by the curriculum to study the discipline, so one can write:

$$I_1 = \beta_1 \cdot T_1 \quad (7)$$

where β_1 –is a function that takes into account the level of methodical skill of the teacher and the ability of the student to assimilate the educational material,

T_1 – is the volume of the discipline.

m – is the coefficient characterizing the methodical skill of the teacher.

The ability of the student to assimilate the educational material is expressed by the formula:

$$\beta_1 = \frac{m}{1 - c_1} \quad (8)$$

where the coefficient c_1 characterizes his / her ability to learn, $0 \le c_1 < 1$.

The amount of information is proportional to the time allotted to the student's independent work on the study of this discipline.

$$I_2 = \beta_2 \cdot T_2, \quad (9)$$

where β_2 –is a function that takes into account the student's ability to independently assimilate educational material,

T_2– the amount of time spent on self-educational activities.

The ability of a student to independently assimilate educational material is expressed by the formula:

$$\beta_2 = \frac{1}{1 - c_2} \quad (10)$$

where the coefficient c_2 characterizes his / her ability to self-study, $0 \le c_2 < 1$.

The presented procedure is an algorithm for determining the effectiveness of managerial support by a teacher of independent cognitive activity of students in the process of self-educational activity in achieving learning outcomes. Calculations based on this algorithm make it possible to determine individual achievements of learning outcomes as one of the indicators of the formation of self-educational competence.

Each level of formation of algorithmic skills of self-educational activity of future teachers was reflected in the criteria of certain quantitative values, with the help of which the studied process was diagnosed. Criteria indicators of self-educational competence were manifested in the formation of the motivational and value component of the algorithmic skills of independent work of future teachers and were measured by the number of requests from students to the teacher during a lesson for monitoring the activity performed or for help in its implementation, or to the verification procedure in the control software modules (for SUHT students). It should be noted that at SUHT, the training of students was organized on the basis of synchronous pedagogical control with the independent work of students. Taking into account the importance of the formation of algorithmic skills of independent work of students (in accordance with the Federal State Educational Standard in the direction of training 44.03.05 "Pedagogical Education" and the Professional standard "Teacher"), the research work covered the areas of classroom extracurricular activities, and research activities, including teacher participation in student activities.

Self-educational activities were also organized in groups of students of KazNWTTU, but without the use of pedagogical control synchronous with it, and without excluding the possibility of its implementation on the initiative of the students themselves. The final pedagogical verification and evaluation of the results of solving educational tasks dominated in terms of the effectiveness of the formation of algorithmic skills of self-educational activities of future teachers through pedagogical control.

The table presents the values of criteria for assessing the formation of algorithmic skills of self-educational activity, identified at the adaptational, reproductive, situational-analytical, perspective-heuristic and autonomous stages of their formation.

Table 1. *Changes in the values of criteria for assessing the formation of algorithmic skills of self-educational activity*

Stages	In % of the maximum number of requests for pedagogical control		In % of the maximum number of errors committed		% of correctly solved problems from the number of given ones	
	KazNWTTU	SUHT	KazNWTTU	SUHT	KazNWTTU	SUHT
Adaptational	71,3%	50,2%	75,9%	77,9%	68%	66%
Reproductive	91,8%	100%	93,4%	100%	54%	64%
Situational-analytical	100%	71,7%	100%	91,6%	55%	68%
Perspective-heuristic	93,0%	48,0%	81,4%	62,5%	63%	77%
Autonomous	88,3%	42,7%	77,9%	49,2%	70%	88%

*Note:100 % – the maximum value of the criterion based on the results of all stages of the formation of algorithmic skills

The values determining the number of requests for pedagogical control initiated by students and the number of mistakes made in the process of solving educational tasks were calculated relative to their maximum values in groups. These values were determined based on the results of all stages of the formation of algorithmic skills of independent work of future teachers.

The analysis of the table data showed that in a group of SUHT students, a significant increase in the number of student requests for control was observed at the situational and analytical stage of the formation of the studied skills. This meant that the students of this group, realizing the usefulness and possibilities of synchronous control, preferred to turn more often both directly to the teacher and to programmatically implemented procedures for checking and evaluating the results of self-educational activities. While the students of KazNWTTU groups were limited by the possibilities of a teacher.

Under the influence of the growth of cognitive activity and independence of future teachers in groups of SUHT students, there was a constant and outstripping decrease in the number of appeals to pedagogical control and the number of mistakes made compared to the groups of KazNWTTU students. This influenced the dynamics of the formation of algorithmic skills of students' self-educational activity according to the criterion of cognitive independence: the number of solved tasks in groups of SUHT students constantly exceeded the same indicator in groups of KazNWTTU students. Figure1 clearly shows the dynamics of changes in the value of the criterion "Effectiveness of self-educational activity" by groups, identified in the course of the study.

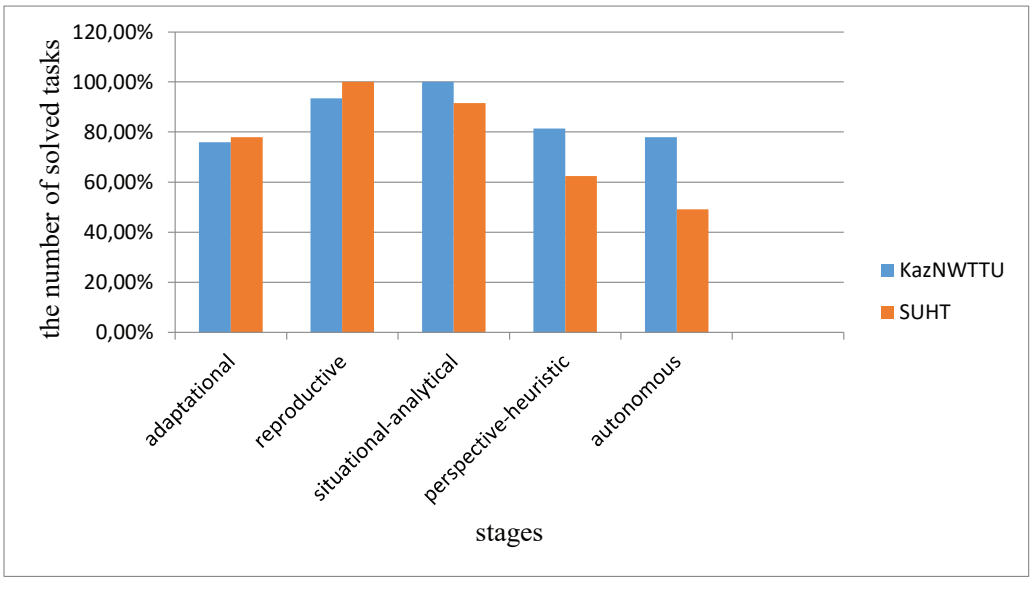

Figure 1. Change in the values of the criterion "Effectiveness of self-educational activity"

A comparative analysis of the data obtained has shown the great effectiveness of the process of formation of algorithmic skills of self-educational activity through pedagogical control in groups of SUHT students.

We came to the conclusion that the control synchronous with the students' self-educational activity accelerated the process of formation of cognitive independence and intensity of self-control among students of SUHT groups. It became possible, as we noted earlier, on the basis of the created situation of success from the results of training, when the effectiveness of self-educational activity fully corresponded to or even exceeded the expectations of students, and also as a result of the implementation of the process model in the educational process of the formation of algorithmic skills of future teachers through pedagogical control.

Conclusion

Analyzing the results of modern research, it should be noted that the self–educational

competence of subjects of education is an integrated personal characteristic, which is provided by a value attitude to self-educational activities and self-development, a system of knowledge on planning and implementing self-educational activities. It is necessary to emphasize the importance of having a component in its structure, which is manifested in the rational selection and application of technology of applied orientation of teaching pedagogy in interdisciplinary relations with a professional discipline, the structural unit of which is situational modeling. At the same time, an important factor is the time parameter in the organization of self-educational activities of subjects of education, which affects the level of achievement of learning outcomes. A mathematical model has been developed as a diagnostic tool for the temporal parameter of the formation of self-educational competence of subjects of training. The mathematical model differs from the diagnostics by the continuity of the process; technology of data collection, allows obtaining a significant amount of primary information and evaluating it.

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