Artificial intelligence for effective professional training of teachers in the Russian Federation

Inteligencia artificial para la formación profesional efectiva de docentes en la Federación Rusa

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Contents

ABSTRACT:

The purpose of the article is to propose mechanisms of effective and adaptive training of future teachers to solve problems of their professional activity using a technique based on students' fulfillment of complex tasks to design knowledge bases of expert systems for learning. The study has proved the viability of the proposed training methodology to be ready for professional activity as a teacher. As a result of its implementation, the willingness of trainees to work in developing creative educational environment has improved.
Keywords: teacher; professional activity; artificial intelligence; interdisciplinarity

RESUMEN:

El propósito de esta investigación es proponer mecanismos de capacitación efectiva y adaptativa de futuros maestros para resolver problemas de su actividad profesional utilizando una técnica basada en el cumplimiento de tareas complejas por parte de los estudiantes para diseñar una base de conocimiento de sistemas requeridos para el aprendizaje. El estudio ha demostrado la viabilidad de la metodología de capacitación propuesta y estar listos para la actividad profesional como docente. Como resultado de su implementación, mejoro sustancialmente la disposición de los participantes para trabajar en el desarrollo de un ambiente educativo creativo.
Palabras clave: profesor; actividad profesional; inteligencia artificial; interdisciplinariedad

1. Introduction

The problem of education quality, especially in teacher training, is urgent for any country. It is adapting to changing complex social and cultural processes the dynamics of which is caused by refocusing the society in the field of its theoretical and practical activities. To solve the problem the society approaches an educational process considering it a way to change the situation and protect individuals who face challenges qualitatively. A protective function

of education can be implemented if a level of scholarship of each member of the society provides the possibility to develop abilities to solve essential and professionally important problems. Education in the Russian Federation is a priority for the development of the state. The "Concept of a long-term social and economic development of the Russian Federation for the period up to 2020" notes that "the competition of various systems of education... requires constant updating of technologies, expeditious assimilation of innovations, rapid adaptation to demands and requirements of a fast-changing world" (The Concept, 2008). This certainly makes researches in the field of adaptive learning relevant. The return of teachers to ideas of adaptation has become possible and actual not only due to needs of the society in qualitatively new learning but also with the advent of a fundamentally new scientific and practical basis for the research in this regard. Advances in information science, AI, psychology, decision-making theory, and mathematics make possible and somewhat logical the appearance of innovations in teacher training based on the joint use of ideas of adaptation (Seth et al., 2017), interdisciplinarity (Hessels et al., 2015), and educational activities of students. At the same time the developers of the teacher professional standard (Yamburg, 2017) note that modern graduates of teacher training universities with a sufficiently high level of preparation in subjects have insufficient professional experience and minimal practical skills and abilities in organizing an educational process at a modern level using innovations in teacher training including those based on AI ideas and methods. To solve this problem, there has been conducted a joint study in which lecturers of the Herzen State Teacher Training University of Russia (St. Petersburg) and North-Eastern Federal University in Yakutsk (Republic of Sakha (Yakutia) have taken part. It aims to develop and implement a teaching method based on the design and development of the knowledge bases of expert systems for learning into an educational process of universities.

2. Literature review

Achievements in the field of AI, expert training systems are still little applied in education. At the same time, researchers from different countries conduct multi-aspect studies to research and develop AI in an educational segment. Both general (Osipov, 2014; Ren et al., 2018) and particular issues of applying AI in learning (Bialik and Fadel, 2018; Keith, 2017) are studied. Particular attention is paid to the study of psychological (Luxton, 2014) and cognitive (Osipov et al., 2018) problems that are important to design knowledge bases as main structural components of expert systems for learning (Ogu and Adekunle, 2013). The issues to develop knowledge bases refer to key ones and are studied from both technical and humanitarian points of view. In particular, the author of the article (Sarita et al., 2013) draws attention to the need for using useful models to acquire knowledge. Scientists from Australia note that AI will change the nature of higher education in the world and has already become an integral part of modern universities (Stefan, 2017). Examples of the use of AI to develop e-learning are didactically significant (Camilleri, 2017; dos Santos, 2017). This, in turn, contributes to innovative changes in the educational environment (Schulz, 2014; Pathak, 2016), the motivation for new educational activities (Clark and Mayer, 2016, Rani et al., 2016) in them using new tools. The confirmation to this is found in work (Gunter and Reeves, 2017). Its authors study the attitudes of teachers, their involvement in and support of online professional development. Many researchers suggest using AI adaptation ideas and methods in e-learning. This includes the work (Redko, 2016) about the importance of adaptive behavior in an educational process. The work (Weinstein et al., 2018) has a practical implementation. Its authors propose algorithms to adapt mathematical educational content and options of their integrating into the system of e-learning. Their ideas are complemented by suggestions of the author of the article (Yoshioka and Ishitani, 2018) about adaptive tests relevant to machine learning (Brink et al., 2017).

At the same time, the analyzed works do not adequately reflect the problem of studying effective ways of an adaptive preparation of students specifically of teacher training establishments to use AI elements in learning, in general, and in e-learning, in particular, as well as in their professional activity.

The works of Russian authors in the field of applying adaptive learning (Vlasova et al., 2018; Barakhsanova et al., 2016), e-learning (Prokopiev, 2015) and AI-based learning (Eremeev et

al., 2018; Uvarov, 2018) have become a theoretical framework of this study.

3. Methodology

The study was conducted in the period from 2010 to 2018 by a team of authors on the agreed and pedagogically relevant subject. Joint study provided an opportunity to efficiently utilize the existing professional and scientific resources of the study participants, explore the subject from different perspectives and consider various approaches to its solution, arrange cooperative work of teaching staff groups to let them adapt to apply various forms of innovation, and, therefore, stay dynamic and versatile professionals.

As a result of the analysis of the methods used in training and refresher courses given to future teachers, monitoring of the educational process in a number of pedagogical universities in Russia, conversations with fellow teachers of pedagogical universities, a general conclusion has been made on the necessity to develop innovative strategies, or methods to engage student of pedagogical universities that will actively involve them in the process of obtaining knowledge necessary in their profession, as well as formation and development of practical activities. Also, higher pedagogical school teachers practice very poorly represents options of adaptive work with students, which directs their professional activities in intellectual, educational environments. The conducted study was based on the results reflected in the thesis research by Vlasova E.Z. on the construction of expert training systems knowledge bases for systematic training of physics students and subsequent studies developing this methodology for e-learning (Barakhsanova et al., 2017; Aksyutin et al., 2017). On the scientific, methodological and practical level, the thesis proved that the application of the methodology based on the construction of ETS KB by the students could significantly expand the methodological basis for training future teachers by applying multivariate methods, forms, means of working with students and refresher courses attendees, enhancing their cognitive capabilities, using interdisciplinary tools and stimulating self-organizing activities. The accomplished study was further developed in the thesis of the article authors (Goncharova, 2017; Kaprova, 2012) in teachers refresher courses (2012 - 2018). Considering the specifics of professional training of students and refresher students, they were asked to develop areas of knowledge bases to solve specific methodological problems, taking into account their professional subject field. Analysis of their activities concerning the professional direction and the results of implementation showed that the students considered KB construction as an active method of their professional self-development; cooperation with a subject matter expert or methodologist promoted increased operationalization of their professional knowledge.

Currently, the initial methodological prerequisites for the study are: 1) development of interdisciplinary pedagogical university students training content in the field of methodology using AI methods with a focus on their practical application to solve professional education issues in general and in the context of the educational process of intellectual, educational environments; 2) changing the nature of the educational process due to the engagement of students in active interdisciplinary and synergistic activities in the process of performing specially designed integrated professionally oriented tasks involving the use of AI methods; 3) training of future teachers to work in intelligent educational environments, including by fulfillment of tasks on their expert training system knowledge base construction. First-year master's students of the Herzen State Pedagogical University of Russia and Ammosov North-Eastern Federal University (NEFU) and attendees of the St. Petersburg Center for Evaluation of Quality of Education and Information Technologies have been selected as a study subject. The experiment involved 65 teachers and 294 master's students.

Each year, the master's students who completed the study of Information Technologies in Professional Activities discipline and refresher courses students who completed Information Technologies and E-Learning in Teaching School Subjects program were asked to answer the question: do you believe that tasks for expert training system KB construction enhance your professional development and your efficient training in solving tasks in professional activity?

The method of mathematical statistics — time series analysis — was used to study the trend of students' attitudes towards tasks for construction and development of knowledge bases in

preparing future teachers for efficient, professional activity. A statistical description of the development of the studied pedagogical process in time using time series has been made (Table 1). The obtained series of observations with the values of the studied indicator was put in chronological order (the variable t is the time parameter increases from 2010 to 2018). The levels of the series were obtained as a result of an annual survey among students of the State Pedagogical University of Russia and NEFU.

The master's students of two universities and refresher courses attendees who purposefully performed tasks for construction and development of expert training systems knowledge bases participated in the study. Both categories of students were asked to answer the question: To what extent do tasks for construction and development of expert training systems knowledge bases affect the development of students' willingness to carry out these types of professional teacher activities? The evaluation was made on a 10-point scale. The hypothesis was verified that the correlation between the profiles of master's students and refresher students statistically significantly differs from zero (that is, the opinions of master's students and refresher students on the studied question are similar). In order to process the results, the Spearman's rank correlation method was used for the case when the groups with the same values are found in both compared series.

4. Results

On the grounds of theoretical analysis and study of trends in the development of modern Russian education, the expediency of applying the teaching methods based on the construction of expert training system knowledge database by students has been proved. Master's students and attendees of refresher courses for teachers acted as students.

Its efficient application in the educational process is confirmed by specific results obtained upon experimental data processing. The results of surveys by year are presented in Table 1.

Table 1
Survey Results

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018
number of answers	31	28	32	34	45	52	34	45	58

The obtained moment time series satisfies the requirements that are imposed on the initial information for sampling by the indicated method. Namely: the levels of series are equidistant from each other; levels of series are comparable; time series has a sufficient length; no observations are missing in the time series; time series levels do not contain abnormal values.

After the analysis of the initial information for compliance with the requirements, the calculations and evaluation of development dynamics indicators were carried out. A model was developed for predicting interest in studying and applying the methods for ETS KB construction in order to improve the professional training of future teachers.

In the coordinate system Yt0t, where Yt is the number of students who responded positively to studying AI, t is the serial number of the year. Figure 1 shows the dynamics of positive responses to the question of the feasibility of ETS KB construction by students.

Figure 1
Dynamics of positive responses
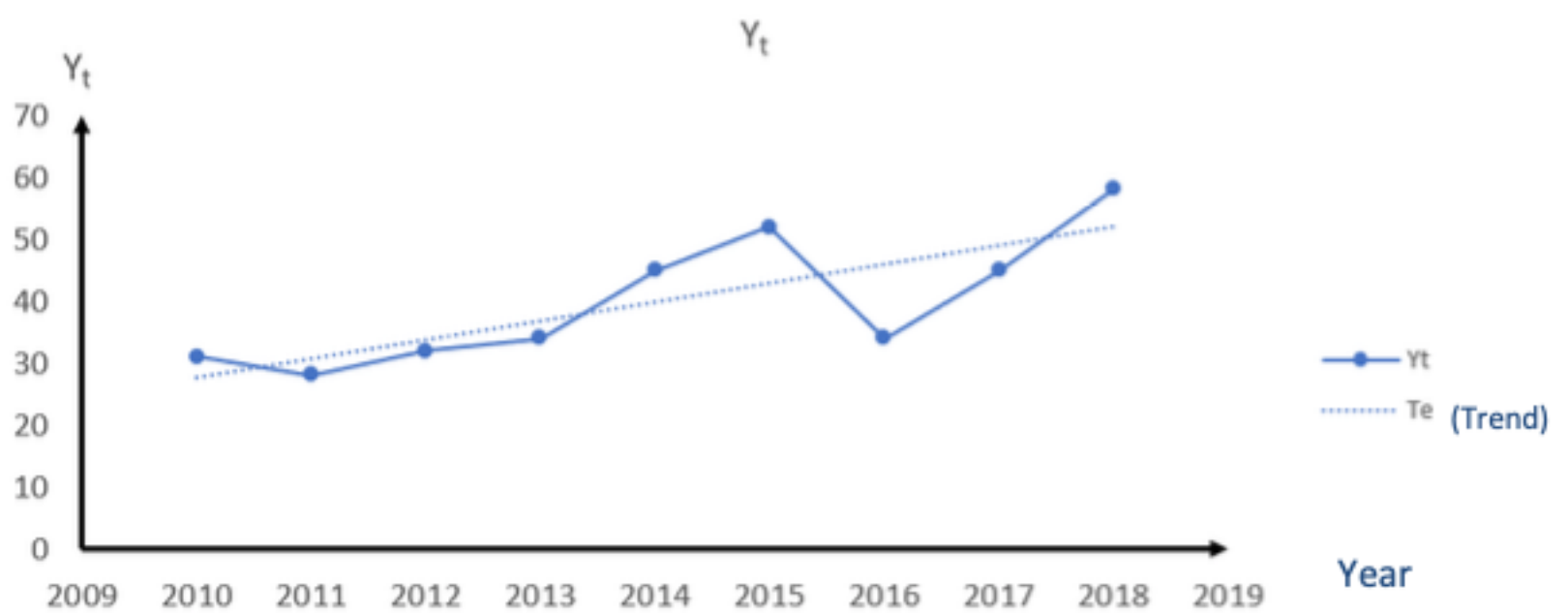
Next, the autocorrelation coefficient of the first-order levels of series was identified by the formula:

$$r_t = \frac{\sum\limits_{t=2}^{n}\left(Y_t - \overline{Y_1}\right)\cdot\left(Y_{t-2} - \overline{Y_2}\right)}{\sum\limits_{t=2}^{n}\left(Y_t - \overline{Y_1}\right)^2 \cdot \sum\limits_{t=2}^{n}\left(Y_{t-1} - \overline{Y_2}\right)^2} = 0.4554,$$

where $\quad\overline{Y_1} = \dfrac{\sum\limits_{t=2}^{n} Y_t}{n-1}\quad$ and $\quad\overline{Y_2} = \dfrac{\sum\limits_{t=2}^{n} Y_{t-1}}{n-1}$

The obtained value of the autocorrelation coefficient and the graphic image of the time series allow concluding that the interest shows a tendency close to linear. Therefore, a linear function can be used to model its trend.

$$y = a + bt$$

In order to calculate the parameters of the linear trend a and b, the least squares method was used, and the following system was solved:

$$\begin{cases} na + b\sum t = \sum Y \\ a\sum t + b\sum t^2 = \sum Yt \end{cases}$$

Using formulas derived from the system, the parameters were found:

$$b = \frac{\overline{Yt} - \overline{Y}\cdot\overline{t}}{\overline{t^2} - \overline{t}^2} \quad \text{and} \quad a = \overline{Y} - b\overline{t}$$

As a result, the following trend was obtained

$$Yt = 24.81 + 3.02t$$

This confirms the results of the experiment conducted with master's students of two

universities and refresher students. On average, annually the number of students who believe that the fulfillment of tasks for ETS KB construction promotes professional development and efficient preparation for solving professional tasks, increased by three people.

In the course of study, average values were obtained for each type of new educational activities in the experiment group of master's students and refresher students. Then the ranking was made, where the unit of measurement was one rank, and the maximum value was 18 ranks. The ranking results are shown in Table 2.

The following hypotheses were verified:

H0: The correlation between the opinion of master's students and refresher students is no different from zero.

H1: The correlation between the opinion of master's students and refresher students is statistically significantly different from zero.

Since there are groups with the same values in both compared series of answers, identical Ta and Tb ranks corrections were made before calculating the rank correlation coefficient:

$$T_a = \sum (a^3 - a)/12$$

$$T_b = \sum (b^3 - b)/12$$

To calculate the empirical value of the rs Spearman correlation coefficient, the formula was

$$r_s = 1 - \frac{6 \cdot \sum d^2 + T_a + T_b}{N \cdot (N^2 - 1)}$$

The critical values of rs when n = 18 were determined as per the table of critical values of the sample coefficient of ranks correlation:

$$r_{s\,кр} = \begin{cases} 0.47 \ (p \leq 0.05) \\ 0.60 \ (p \leq 0.01) \end{cases}$$

$$r_{s\,вып} > r_{s\,кр} \ (p \leq 0.05).$$

Table 2
Rank indicators of properties of educational activities types

Types of activity	Evaluation of master's students	Evaluation of refresher students	d2
analysis of the multivariance and alternativeness of decisions made by experts	1	2	1
highlighting the essential in the knowledge	2	8.5	42.25
the acquisition of knowledge from expert and professionals using various methods	3	13.5	110.25
planning of educational process	4	12	64
ability to structure students' subject knowledge	5	5	0

learning the principles of building the students' knowledge structure	6	3	9
studying the implementation of interdisciplinary knowledge synthesis in practice	7	8.5	2.25
studying adaptive technologies of educational contents teaching	8	6	4
ability to master various professional methods and types of work	9	7	4
modeling various situations	10	10	0
build interpersonal and business relationships, interact with the professional environment	11	1	100
independent acquisition of knowledge as a result of the use of traditional and modern sources of knowledge	12.5	15	6.25
teaching knowledge	12.5	11	2.25
planning and implementation of research activities	14	16	4
formation of a knowledge system on the studied subject	15	4	121
identification of the main aspects in the subject area under consideration, their comprehensive analysis, and synthesis	16	18	4
mastering the school planning process methods;	17	13.5	12.25
consideration of student´s psychological qualities in the arrangement of the educational process	18	17	1

Hypothesis H0 is rejected. The correlation between the opinion of master's students and refresher students is statistically significant and is positive at the 5% significance level.

The most significant results include: 1) development of fundamentally new content of Information Technology in Professional Activities discipline for Pedagogical Education master's students and Information Technology and E-learning in Teaching School Subjects refresher program for teachers; 2) development and successful implementation of teaching methods based on the involvement of students in the educational process by solving teaching objectives using methods applied in KB development. The content is adapted to the teacher's professional activity in the changing conditions of teaching and learning in intellectual, educational environments; filled with theoretical and practical issues of using AI technologies, methods and tools relevant for education.

5. Discussion

Modern education is focused on developing human abilities, not on forming specific knowledge and skills. This changed the philosophical and methodological basis for forming knowledge, the methods of its production, and its broadcasting. Educational establishments now try to focus on developing students' abilities to work with knowledge and to practice effective methods for the teachers to teach this fundamentally different kind of activity for both teacher and student. In this respect, particular attention should be paid to pedagogical universities. This is consistent with the decree on "the national goals and strategic objectives

of the development of the Russian Federation for the period up to 2024".

According to the Decree, it is necessary 1) to ensure "the modernization of vocational education, including the use of adaptive, practice-oriented, and flexible educational programs"; 2) the introduction of new teaching methods and educational technologies at the levels of the primary general and secondary general education, to ensure an increase in their involvement in the educational process (Decree, 2018). The deficient research on these issues for both pedagogy and methodology make them relevant and practically significant for bringing about innovative developments in the modes of professional development of teachers to enable them to work in a new paradigm—the knowledge-generation paradigm. The article is devoted to one of these developments. In the process of research, it is recommended that undergraduates and students of advanced training courses should act as knowledge engineers in the design and development of a knowledge base as the primary structural element of an "Expert Training System." The work was carried out under the paradigm of developing an Expert System based on action. The students as knowledge engineers analyzed, synthesized, and found ways to present in a computer not only subject knowledge but also additional information related to the structure of the educational process. They were interested in the semantic structure of the educational activities of the student and the teacher, taking into account the dynamics of the development of the educational process; interrelation of educational activities, modeled for organizing the full-fledged mastering of knowledge; multivariate scenarios for the achievement of learning objectives, taking into account adaptation to the level of training and learning of the student. That is, they were engaged in modeling subject areas (within the framework of a methodological problem to be solved) based on meta-procedures for working with knowledge about knowledge. The development of useful e-learning resources with intellectual elements that imitates the learning process in dynamics requires the use of existing knowledge about human problem-solving mechanisms and puts the creator of such systems in front of the need to expand their field of knowledge with new knowledge from various subject areas: knowledge of a specific subject area, pedagogy, psychology, teaching methods of the relevant academic discipline, gnoseology, linguistics, methodology, etc. The very formulation of the task of creating a knowledge base is focused on the interdisciplinary synthesis of knowledge. As a result, fragmented, unstructured knowledge based on interconnection and coordinated use (as part of solving a methodological problem) forms new knowledge structures with a higher level of development of their carrier (student). The development of the student appears to the developer of the knowledge base in dynamics. This is modeling various options for organizing knowledge in the knowledge base, in developing various scenarios of learning activities, taking into account their adaptation to the user system, modeling the student's and teacher's activities through their analysis and synthesis. Obtained earlier subject knowledge is the basis for its development. In this regard, the authors can talk about the evolution of the student from his existing knowledge to the knowledge arising through the development of a knowledge base. The variety and multivariance of solving educational tasks are achieved by studying various alternative approaches to organizing and conducting the educational process. To this end, undergraduates and refresher students studied the experience of work of experts in subject areas, got acquainted with alternative solutions to the same educational or methodological problem, and analyzed various ways of deploying the thoughts of experts and the multiplicity of their decisions. That is, the students learned the variants of nonlinearity in solving single-type tasks. Representatives of the Russian synergetic school emphasize (The Concept, 2017) that it is non-linearity that provides excellent opportunities for adaptation. The authors can assume that the activities of the students in the process of working with experts adapts them to the teaching profession, developing divergent thinking; that is, the ability to identify diverse approaches to solving the task, developing them and identifying the original.

6. Conclusion

The result of the study shows that successful training and retraining of teachers for implementing activities in a changing professional and learning environment requires focus

in performing updated professional activities. Such activities require an interdisciplinary synthesis of their knowledge and practical skills, the ability to develop models of possible ways to develop students, understanding and the didactically correct use of students' self-completion and self-organization mechanisms. To this end, a practical methodology has been developed for training future teachers (undergraduates enrolled in the direction of "pedagogical education") and working teachers, aiming to develop mental and practical activities that ensure the consistent use of knowledge from various subject areas to effectively solve professional tasks and adapt to the rapidly changing needs of modern society. The methodology is based on interdisciplinary synthesis, which presumes an organic combination of knowledge, practical actions, forms, methods, and means used in the educational process to provide a specialist with the required professional qualities, and on the unity of their pedagogical goals. This was considered a methodological basis and technological means for innovative educational activities. The analysis and generalization of students' teaching activities at stages of designing and creating a knowledge base of expert training systems showed that they master the strategy of forming a system of knowledge, skills, and abilities of students in the subject being studied; methods of self-organization and self-development through the studied subject; nonlinear technology organization of the educational process; options for the practical implementation of the learning openness principle. This corresponds to a highly productive level of teacher activity.

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