



MODEL OF IMPROVING THE QUALITY OF TRAINING OF FUTURE ENGINEERING TEACHERS

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Abstract.

Relevance: improvement of the system of professional training of future specialists is impossible without the introduction of information technology, new approaches to measuring the quality of the educational process, innovative diagnostic methods, as well as the use of training models as a necessary prerequisite for the competence of the graduate.

Purpose: a theoretical model of improving the quality of specialists' training, which corresponds to the author's vision of solving this problem is developed and substantiated. Its use is shown in the educational process to improve the quality of training of future engineering teachers.

Methods: theoretical; empirical (praximetric (study and analysis of work plans, training programs for future engineering teachers, tools and methods of pedagogical diagnostics, test tasks and methods of their use); the idea of cybernetic method (model «black box») is used.

Results: the possibilities of pedagogical diagnostics as a technology that contributes to improving the quality of training of students of engineering and pedagogical universities are clarified; the theoretical (structural) model of improving the quality of training of future engineering teachers is proposed and substantiated, the components of the model and the requirements for its development are identified and described, the system of evaluation and quality control of learning outcomes in the higher education institutions has been improved. The evaluation of the quality of professional training of future specialists has been carried out in accordance with the developed «theoretical» and «mathematical» models, without which it is impossible to solve the issue of quality management of the educational process. The article focuses on the «theoretical» model of training. The study proposes an approach to modeling based on the concept of cognition «black box» and specifies the principles of the model, on which the process of training of future professionals is based on.

Conclusions: it has been theoretically proved that the proposed 'theoretical' model of improving the quality of training is the part of the fundamental training of engineering teachers, has a practical and applied nature, and also provides a clear algorithm for effective improvement of the quality of the educational process.

Keywords: *quality of training, engineering teacher, pedagogical diagnostics, innovative methods of diagnosis, scientific management of the educational process, theoretical model of quality of training of specialists.*

Introduction. Modern requirements for the training of specialists and the provision of the education quality were caused by the rapid development of the scientific and technological revolution, the rapid renewal of knowledge, and the increase in the volume of scientific and scientific-technical information. Today, as never before, there is a need for highly qualified specialists who have high-quality general scientific and professional training, capable of independent creative work. One of the components of the system of training the highly qualified

specialists is the development of a model for improving the quality of specialists' training, which becomes a system-forming factor in determining the content of education, forms and methods, innovative pedagogical technologies as well as the learning outcome as an indicator of education quality. Currently, researchers and scientists are turning to the creation of models for the training of future professionals, but the most complex and undeveloped theoretical problems include: inconsistency of the conceptual appa-

ratus; lack of reasonable uniform criteria and indicators for assessing the effectiveness and quality of the educational process; difficulties in determining the overall quality development strategy; bias in assessing the real achievements of students; lack of effective tools for comprehensive diagnosis of the effectiveness of the educational process with information about the state of the pedagogical process and the level of training of its participants; difficulties in scientific management of the quality of specialists' training. This necessitated the development and improvement of a theoretical model to improve the quality of specialists' training using methods of pedagogical diagnosis.

Sources. A large number of scientific works is devoted to the study of the problem of providing, improving and evaluating the quality of education in higher education; among them there are the works of V. Andrushchenko, V. Bilokopitov, J. Bolyubash, L. Gorbunov, G. Yelnikova, M. Zgupovsky, V. Kremen, V. Luhovyi, O. Lyashenko, M. Mykhalchenko, C. Nikolaenko, V. Ognevyuk, N. Seleznyova, M. Stepko, L. Spodin, A. Subbetto, Y. Tatura, G. Tsekmistepova and others. The outlined problem is at the center of scientific research and foreign researchers: K. Ingenkamp, K. Kuder, K. Pearson, P. Rulon, M. Richadson, Harvey L. (Harvey and Green, 1993, pp. 9-34), Parri J. (2006, pp. 107-111).

To achieve the goals and objectives of the study, theoretical methods (analysis, synthesis, generalization and systematization of basic principles for identifying the state of the problem; analysis of tools and methods of pedagogical diagnosis; modeling method for developing a 'theoretical' model) are used.

The article aims to develop and substantiate a theoretical model of improving the quality of specialists' training, which corresponds to the author's vision of solving this problem. Its use is shown in the educational process to improve the training of future engineering teachers.

Methods: theoretical (analysis, synthesis, generalization and systematization of basic principles for identifying the problem of scientific quality management of specialists' training; analysis of tools and methods of pedagogical diagnostics, test tasks and methods of their use; modeling method for developing a «theoretical» model); empirical (praximetric (study and analysis of work plans, training programs for future engineering teachers, tools and methods of pedagogical diagnostics, test tasks and methods of their use); the idea of the cybernetic method is used) (model «black box»)

Results and discussion. The issue of creating models for the training of future specialists is considered by researchers mostly at the general level. But, this is not enough, in terms of active use of information technologies in the educational process. The necessity to model the process of improving the quality of training of future professionals is determined by the need for practice of vocational education in building this process, identifying its basic components, monitoring its results, obtaining information on opportunities for its improvement (Lukianenko and Antoniuk red., 2018).

The terms «model», «modeling» are considered in pedagogical science by such researchers as V. Afanasyev, V. Venikov, I. Novik, S. Arkhangelsky, N. Kuzmina, V. Shtoff and others. Problems of models of pedagogical processes were studied by Yu. Vaskov, O. Vynoslavska, N. Talyzin, L. Serman and others. We mean under the model, in a broad sense, a mentally or practically created structure that reproduces a fragment of reality in simplified and visual forms. In a narrower sense, the model is either a specific image of the object under study, which reflects the actual or expected properties, structure, etc., or another object that actually exists alongside the one under study, and is similar to it in some properties or structural features. Thus, the model is a kind of universal research tool.

In our opinion, the approach to modeling is original in the works of American scientists (T. Toffoli and N. Margolus), who believe that: “Science has not benefited much from models that are subject to our desires. We want to have models that have a defiant character; models that have their own mind. We want to get more from models than we have invested in them” (Toffoli and Margolus, 1985). Summarizing and analyzing the given statement, we believe that it is not just «a language figure», but an important approach to modeling. Summarizing the above, the study was based on the concept of building a model of specialists' training that would work more effectively than today's models. Such a model should be clear and understandable to all interested parties (employers, the state, parents, students) and show clear guidelines for achieving high quality training of future professionals. The study of the issue of the construction of «models for improving the quality of training of future professionals» is of particular importance for the research. In our investigation, first of all, we will analyze the concept of «specialists' training model». In the field of higher school pedagogy, the model of training specialists of higher education institutions is considered to be a clear, detailed, scientifically sound set of minimum

positive personality traits of a professional, which should be possessed by each graduate (Stolyarenko, 2002).

In fact, the model of specialists embodies the objective requirements for training, and the compliance of the graduate with them is a necessary requirement for his success in professional activity and life. We share the point of view of the scientist V. Slastenin (red. 2004), who proposes to take into account personal and professional-pedagogical qualities in the model of training; psychological and pedagogical training; methodical training in the specialty, the scope and content of special training. In the study, we have relied on the scientific views of N. Talyzina (1987), who believed that the problem of the training model was key to determining the content of curricula and educational programs. The description of the model of the specialist by the researcher is carried out through the selection of typical tasks to be solved by the future specialist. In constructing our model, we took the phasing (as a basis) proposed by E. Smirnova (1977), which consisted of the following elements: selection of the main parameters of the model first at the hypothetical and then at the research levels; selection, design, standardization and debugging of a set of techniques for model formation; development of methodical bases for the forecast and their realization at creation of concrete model.

Modern researchers agree that the model of training should be prognostic, i.e. not only to record the current state of specialists, but to contain information about its future form. This made it possible to provide advanced training of specialists in the higher education institutions. We believe that the development of such a model will clarify the objectives

of training the future professionals, adjust curricula and educational programs, choose comprehensive methods and tools to assess the effectiveness of the educational process, as well as to make management decisions of a corrective nature.

Thus, consideration of theoretical and practical experience in developing models of future professionals has allowed to enrich the scientific thesaurus with a new concept «model for improving the quality of training of future professionals», understood as a scientifically sound, detailed described algorithm for training the future professionals at the present stage using innovative diagnostic tools and statistical-mathematical methods for predicting the expected changes in form of the educational achievements of these specialists.

The originality of our approach to constructing a theoretical model to improve the quality of specialists' training is that the algorithm of the model is based on the concept of cognition «black box» (black box). This toolkit has excellent opportunities to study the processes and phenomena occurring in education. We define the concept of the model as «black box».

«Black box» is a term used to denote a system whose mechanism of operation is unknown or is accepted as unknown. Such systems usually have 'input' to enter information and «output» to display work performance. The state of the outputs usually functionally depends on the state of the inputs. The model includes what is essential to achieve the goal (purpose of the model) (Chervak-Smerichko, 2015, p. 249). A clear example that demonstrates the approach to building a model based on the concept of cognition «black box» is shown in Fig. 1.

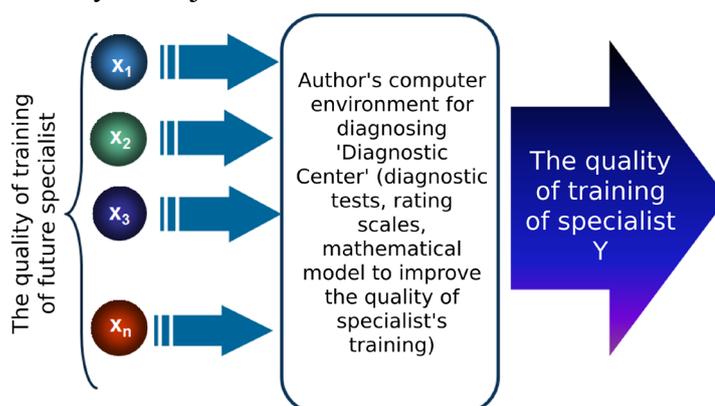


Fig. 1. Graphic model 'black box' to improve the quality of training of future specialists

But, we emphasize that such a model, despite the external simplicity and lack of information about the interior of the system, is not a trivial task. If we formalize the 'black box' model to the limit, we arrive at the task of two sets $X = \{x_1, x_2, \dots, x_n\}$ and Y

of input and output variables between which no relationship is known. As a rule, the output variable is a dependent variable, and the input variables are independent variables, i.e. Y is a function and x_1, x_2, \dots, x_n – the arguments of this function. The

main task solved by this model is to determine which parameters mainly affect (the quality of specialists' training) and assess this impact. In our study, when compiling the model, which is based on the concept of cognition «black box» (see Fig. 1), we proceeded from the understanding that the input parameters will be considered as control effects on the quality of specialists' training, and the value of the output – the solution question: *How to improve the quality of training of specialists?* (reaction to the action of input parameters), in other words, with the help of such a design it is possible to solve the problem of determining the initial level of quality of specialists' training «at the entrance» and what it should be and what this specialist is capable of «at the exit». Thus, this approach to modeling opens new opportunities for scientific management of the educational process of higher education. Thus, the primary task of the study is a clear justification of the parameters of the model for measuring the quality of training of future engineering teachers (list of inputs of the model) (Yefremova, 2011, p. 111).

In order to find out which parameters will be «embedded» in the model, it is not enough just to theoretically substantiate them, it is necessary to study them statistically for a long time. In our case, this problem is solved by statistical and mathematical methods: factor analysis and correlation regression analysis. To successfully solve the problems of the study, we formulate the principles on which the process of constructing a model for improving the quality of specialists' training should be based.

1) *The principle of purposefulness.* This principle involves the choice of methods, forms and means of pedagogical diagnostics in order to ensure the required level of training of future professionals with a clear definition of the main parametric characteristics (quality indicators, evaluation criteria, levels).

2) *The principle of scientific validity.* The main content of the principle of scientific validity is the requirement that the training of specialists should be carried out on the basis of the application of scientific methods and approaches. In our study, the implementation of this principle is achieved using a constructed mathematical model.

3) *The principle of improvement and extensibility.* This principle lies in the ability to quickly improve and expand the functional possibilities of the model by increasing the number and quality of model parameters. The presence of such characteristics will increase the adequacy of the constructed model.

4) *The principle of objectivity.* The principle of objectivity requires obtaining objective and reliable information about the progress and results of assessing the academic performance of students. This is realized with the help of developed diagnostic tests, questionnaires and the constructed mathematical model. The author's computer environment «Diagnostic Center» is used as a tool for pedagogical diagnostics and interpretation of its results.

5) *The principle of systemacity and continuity.* This principle emphasizes the importance of regular implementation of diagnostic activities to measure the quality of specialists' training and make management decisions of a corrective nature. Requirement that ensures the implementation of this principle: this process requires systematic work throughout the training period of future engineering teachers.

6) *The principle of efficiency, flexibility, mobility.* The ability of the model is to respond to changing requests of participants in the educational process and in the shortest possible time to adjust to another similar task.

7) *The principle of diagnostic and prognostic orientation.* Forecasting is an integral part of the management of the educational process of the higher education institutions. This principle presupposes that, in the course of pedagogical diagnostics, information should be obtained, which will allow to build a perspective strategy of quality development and an optimal plan of the process of training the future specialists. At the same time, the effectiveness of training of future specialists and the work of the university as a whole depends on the effective forecasts. In our study, this principle is carried out due to the obtained values of the coefficients of elasticity of the constructed correlation-regression model.

All the above principles are interrelated, interdependent and form the basis for building the model to improve the quality of training of future professionals. Based on the analysis of scientific sources, we have identified such components of the model to improve the quality of training of future engineering teachers as: purpose, content, principles of modeling, methods, tools and forms of diagnosis, stages of implementation, levels and results of the model and etc. The model shown in Fig. 2, is represented by a set of components of its target, technological and effective units. We will describe, in detail, the components of the model, starting with the main principles of the target unit.

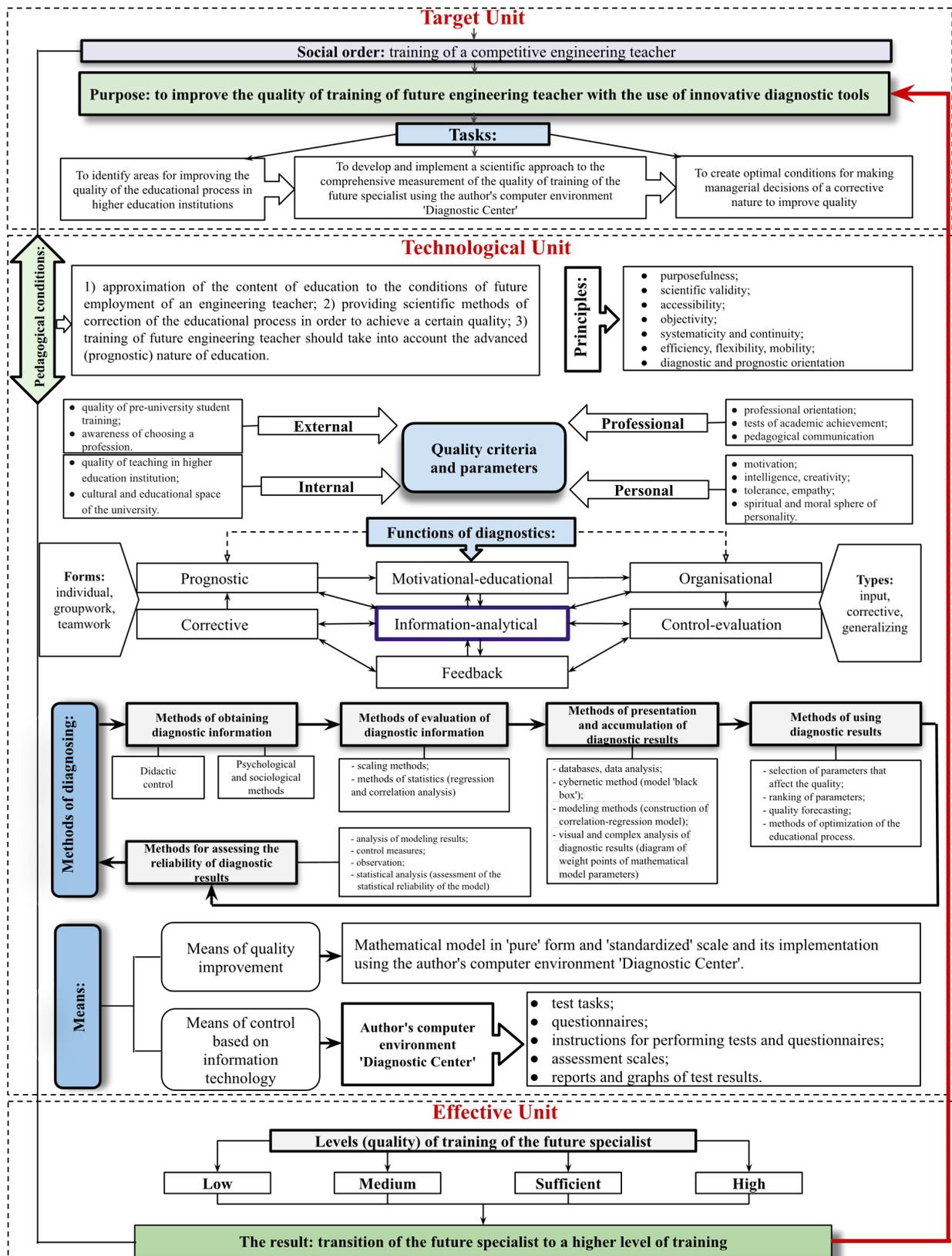


Fig. 2. Theoretical (structural) model of improving the quality of training of future engineering teachers

The target unit is determined by the purpose and objectives of quality training of future professionals. Whereas one of the main priorities of modernization of higher professional education is to ensure the quality of specialists' training, the given goal and objectives are the result of studying and analyzing the current state of professional training of *Professional Pedagogics*/2(21)'2020

future engineering teachers and identifying effective ways to improve quality. Based on this, the purpose of the model is to improve the quality of training of the future engineering teacher with the use of innovative diagnostic tools. The implementation of the above goal involves the following tasks: 1) to identify

tify areas for improving the quality of the educational process in higher education; 2) to develop and implement a scientific approach to comprehensive measurement of the quality of training of future professionals using the author's computer environment «Diagnostic Center»; 3) to create optimal conditions for making managerial decisions of a corrective nature to improve quality.

The technological unit provides an innovative approach to quality management of the educational process and contains a scientifically sound and orderly set of forms, methods and functions of pedagogical diagnostics, principles and means of quality improvement, which allow to implement the tasks of this model. This unit also includes a reasonable selection of quality criteria and parameters that, in accordance with higher education standards, are able to provide quality training to future engineering teachers. It is known that the stability of measurement results depends on the chosen method of pedagogical diagnostics. We propose to actively use the following groups of methods of pedagogical diagnostics according to the classification of O. Yefremova: methods of obtaining diagnostic information; methods of evaluating diagnostic information; methods of presentation and accumulation of diagnostic results; methods of using diagnostic results and methods of assessing the reliability of diagnostic results. The key methods in the proposed model have been statistical and mathematical methods (regression and correlation analysis), and the idea of a cybernetic method (black box model) has been used. In our opinion, these methods allow to assess fully, objectively and reliably, the level of training of future engineering teachers and provide a choice of the best (optimal) ways and methods of solving problems of quality management of the educational process. However, it is very difficult to implement such a model by traditional means, as the set of characteristics and indicators included in the model is too diverse. Therefore, to overcome the difficulties in solving this problem, new approaches are used, which are based on the introduction of the author's computer environment «Diagnostic Center» and regression and correlation analysis. Practice shows that it is more appropriate to use the pedagogical diagnosis in three stages: input, corrective and generalized control.

The effective unit reflects a clear idea of achieving the planned quality of training of future engineering teachers, which is determined by scientifically sound levels and forecasts. It also contains

the effectiveness of the quality management system, the effectiveness of the conducted adjustment of management activities and the degree of achievement of the purpose and objectives of the diagnosis. In other words, the effective unit of the model is the expected result as a high level of quality of training at this stage.

Conclusions. The proposed theoretical model is an attempt to improve the quality of training of future engineering teachers. It clearly indicates an action plan to improve quality, helps to systematize the research process and answers the questions: «HOW is the high quality achieved?», «WHAT are the prospects?». The model meets the requirements for the quality of training of modern specialists in the specialty 015 Vocational Education (Computer Technology), is an integral part of the fundamental training of engineering teachers and also has a prognostic and practical orientation. In further research, we will focus on the experimental verification of the theoretical model using the author's computer environment «Diagnostic Center» and the mathematical model.

In conclusion, we would like to emphasize that, today, vocational education is increasingly faced with new challenges due to the growth of digital technologies and mechanisms for remote diagnosis. It is on the verge of the birth of a new type of specialists. In order to keep up with the times, it is not enough for high school teachers to update curricula and content, it is necessary to introduce artificial intelligence technologies, teach and evaluate the results of training students on new platforms / new tools and do it innovatively. In our opinion, it is interesting to know what requirements will be imposed on the engineering teacher in 5-10 years, what level of competencies this specialist must have in the future to perform his work competently (moreover, the demands made for these specialists may not match in the future). The conducted study does not cover all aspects of the voiced problem. The promising areas of further research include the introduction of artificial intelligence to optimize the procedures for comprehensive quality diagnosis, which will allow teachers of higher education institutions to focus more on improving quality without wasting time on long-term diagnosis; to measure quality with high accuracy for more exact diagnosis and to use effective methods of correction; to predict the dynamics of the quality of specialists' training; to promote the development of new models of training future specialists in the short and long term, etc.

List of references

- Єфремова, О. В., 2011. Побудова математичної моделі якості професійної підготовки фахівців інженерно-педагогічного профілю. *Нові технології навчання*, 68, с. 111-115.
- Ефремов, О. Ю., 2001. *Методы психолого-педагогической диагностики в деятельности преподавателя ВУЗа*. СПб: ВУС.
- Лук'яненко, Д. Г. та Антонюк, Л.Л. ред., 2019. *Конкурентні моделі управління якістю вищої освіти у XXI столітті*: монографія. Київ: КНЕУ.
- Сластенин, В. А. ред., 2004. *Педагогика профессионального образования*. М. : Издат. Центр „Академия”.
- Смирнова, Е. Э., 1977. *Пути формирования модели специалиста с высшим образованием*. Л. : Изд. Ленинград. Ун-та.
- Столяренко, А. М., 2002. *Психология и педагогика*. М. : ЮНИТИ-ДАНА.
- Талызина, Н. Ф., Печенюк, Н. Г. и Хохловский, Л. Б., 1987. *Пути разработки профиля специалиста*. Саратов : Изд-во Саратов. ун-та.
- Тоффоли, Т. и Марголус, Н., 1985. *Машины клеточных автоматов*. М. : Мир.
- Червак-Смерічко, О. Ю., 2015. Математичне моделювання в економіці: моделювання і системний аналіз. *Науковий вісник Ужгородського університету*. Серія : Економіка, 2, с. 246-252. [online] Доступно: <http://nbuv.gov.ua/UJRN/Nvuuec_2015_2_43> [Дата звернення 10 Вересень 2020].
- Harvey, L. and Green, D., 1993. Defining quality. *Assessment & Evaluation in Higher Education*, 18(1), pp. 9-34. DOI: <https://doi.org/10.1080/0260293930180102>
- Parri, J., 2006. Quality in Higher Education. *Management*, 2 (11), pp. 107-111.

Translated & Transliterated

- Yefremova, O. V., 2011. Pobudova matematychnoi modeli yakosti profesiinoi pidhotovky fakhivtsiv inzhenerno-pedahohichnoho profilu [Construction of mathematical models of quality professional training of engineering pedagogical specialists]. *Novi tekhnolohii navchannia [New learning technologies]*, 68, s. 111-115, [in Ukrainian].
- Yefremov O. Yu., 2001. *Metody psikhologo-pedagogicheskoy diagnostiki v deyatel'nosti prepodavatelya VVUZa [Methods of psychological and pedagogical diagnostics in the activities of a university teacher]*. SPb: VUS, [in Russian].
- Lukianenko, D. H. ta Antoniuk, L. L. red., 2019. *Konkurentni modeli upravlinnia yakistiu vyshchoi osvity [Competitive quality management models of higher education]*: kolektyvna monohrafiia. Kyiv: KNEU, [in Ukrainian].
- Slastenin, V. A. red., 2004. *Pedagogika professionalnogo obrazovaniya [Pedagogy of vocational education]*. Moskva: Akademiya, [in Russian].
- Smirnova, E. E., 1977. *Puti formirovaniya modeli spetsialista s vysshim obrazovaniyem [Ways of forming a model of a specialist with higher education]*. Leningrad: Izd. Leningrad. un-ta, [in Russian].
- Stolyarenko, A. M., 2002. *Psikhologiya i pedagogika [Psychology and pedagogy]*. Moskva: YuNITI-DANA, [in Russian].
- Talyzina, N. F., Pechenyuk, N. G. and Khokhlovskiy, L. B., 1987. *Puti razrabotki profilya spetsialista [Ways to develop a specialist profile]*. Saratov: Izd-vo Saratov. un-ta, [in Russian].
- Toffoli, T. and Margolus, N., 1985. *Mashiny kletochnykh avtomatov [Cellular automata machines]*. Moskva: Mir, [in Russian].
- Chervak-Smerichko, O. Yu., 2015. Matematychno modeliuвання v ekonomitsi: modeliuвання i systemnyi analiz [Mathematical modeling in economics: modeling and systems analysis]. *Naukovyi visnyk Uzhhorodskoho universytetu. Serii: Ekonomika [Scientific Bulletin of Uzhhorod University. Series: Economics]*, 2, s. 246-252. [online] Dostupno: http://nbuv.gov.ua/UJRN/Nvuuec_2015_2_43 [Data zvernennia 10 Veresen 2020], [in Ukrainian].
- Harvey, L. and Green, D., 1993. Defining quality. *Assessment & Evaluation in Higher Education*, 18(1), pp. 9-34. DOI: <https://doi.org/10.1080/0260293930180102>
- Parri, J., 2006. Quality in Higher Education. *Management*, 2 (11), pp. 107-111.

Модель підвищення якості підготовки майбутніх інженерів-педагогів

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Реферат

Актуальність: вдосконалення системи професійної підготовки майбутніх фахівців неможливо без упровадження інформаційних технологій, нових підходів до вимірювання якості освітнього процесу, інноваційних методів діагностування, а також використання моделей підготовки фахівців як необхідній передумови компетентності випускника.

Мета: розроблено і обґрунтовано теоретичну модель підвищення якості підготовки фахівців, яка відповідає авторському баченню розв'язання цього питання, а також показано її використання в освітньому процесі для підвищення якості підготовки майбутніх інженерів-педагогів.

Методи: теоретичні; емпіричні (праксиметричні (вивчення та аналіз робочих планів, програм підготовки майбутніх інженерів-педагогів, засобів і методів педагогічної діагностики, тестових завдань і методик їх використання); використано ідею кібернетичного метода (модель «чорна скринька»).

Результати: з'ясовано можливості педагогічної діагностики як технології, що сприяє підвищенню якості підготовки студентів інженерно-педагогічного вишу; запропоновано та обґрунтовано теоретичну (структурну) модель підвищення якості підготовки майбутнього інженера-педагога, визначено і описано компоненти моделі та вимоги до її розробки, вдосконалено систему оцінювання і контролю якості результатів навчання у ЗВО. Реалізація оцінювання якості професійної підготовки майбутніх фахівців здійснювалася відповідно до розроблених «теоретичної» та «математичної» моделей, без яких неможливо розв'язати питання управління якістю освітнього процесу. У статті основну увагу і приділено розгляду «теоретичної» моделі підготовки фахівців. У дослідженні запропоновано підхід до моделювання, заснований на концепції пізнання «чорний ящик» та конкретизовано принципи моделі, на яких базується процес професійної підготовки майбутніх фахівців.

Висновки: теоретично доведено, що запропонована «теоретична» модель підвищення якості підготовки фахівців є складовою частиною фундаментальної підготовки інженерів-педагогів, має практично-прикладний характер, а також дає чіткий алгоритм для ефективного вдосконалення якості освітнього процесу.

Ключові слова: *якість підготовки, інженер-педагог, педагогічна діагностика, інноваційні методи діагностування, наукове управління освітнім процесом, теоретична модель якості підготовки фахівців.*

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