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EVOLUTION OF TEACHING AND LEARNING THROUGH TECHNOLOGY

ВЛИЯНИЕ ТЕХНОЛОГИЙ НА РАЗВИТИЕ ОБРАЗОВАНИЯ

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Realization of the scientific and cognitive potential of teaching university students to inverse and incorrect problems in the context of informatization of education

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Abstract. *Problem and goal*. Since the mid-50s of the 20th century, both Russian and foreign scientists began to actively conduct, and, at present, scientific research on inverse and incorrectly posed problems is being successfully carried out. Often, research on inverse and incorrect problems is carried out jointly by Russian and foreign experts. At present, the results of joint research by specialists on inverse and incorrect problems from Germany, Italy, China, Russia, Sweden, Japan and other countries are discussed at various thematic international scientific conferences and are subsequently published on the pages of scientific Russian and foreign journals. Many such publications can be found in the electronic libraries of scientific publications elibrary.ru, "CyberLeninka", in the bibliographic and abstract database "Scopus" and other bibliographic and abstract databases. The wide availability of such bibliographic and abstract electronic databases allows the teacher who teaches students inverse and incorrect problems to keep abreast of modern scientific achievements in the scientific world and to form the content of a variety of elective courses, including modern mathematical methods and approaches to researching inverse and incorrect problems. When teaching inverse and incorrect problems, the teacher must realize the goals and objectives of not only the formation of deep scientific subject knowledge in students, but also the identification of the scientific and cognitive potential of such training. *Methodology.* Realization of the scientific and cognitive potential of teaching university students inverse and incorrect problems using computer technologies. *Results.* Understanding the scientific and cognitive potential of inverse and incorrect problems, their relationship with applied aspects, the ability to use computer technologies in the study of applied problems will allow students, after graduating from an educational institution, to prove themselves as a successful specialist in applied mathematics in general, and in inverse and incorrect problems, in particular. *Conclusion.* Graduates who have acquired solid knowledge of inverse and incorrect problems, possess modern scientific methods

of their research developed by specialists from different countries of the world, understand the scientific and cognitive potential of inverse and incorrect problems, and possess the skills of independent selection of effective information technologies for solving applied mathematical problems will successfully work in research organizations and independently conduct applied research.

Keywords: scientific potential, cognitive potential, teaching, university students, inverse problems, incorrect problems, computer technologies, informatization of education, applied mathematics

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Реализация научно-познавательного потенциала обучения студентов вузов обратным и некорректным задачам в условиях информатизации образования

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Аннотация. *Проблема и цель.* С середины 50-х гг. XX века как российскими, так и зарубежными учеными стали активно проводиться научные исследования обратных и некорректно поставленных задач, которые успешно продолжаются в настоящее время. Нередко исследования обратных и некорректных задач проводятся совместно российскими и зарубежными специалистами из Германии, Италии, Китая, Швеции, Японии и других стран. Сегодня результаты этих исследований обсуждаются на различных тематических международных научных конференциях и в дальнейшем публикуются на страницах научных российских и зарубежных журналов. Со многими публикациями можно ознакомиться в электронных библиотеках научных публикаций elibrary.ru, «КиберЛенинка», в библиографической и реферативной базе данных Scopus и др. Широкая доступность таких библиографических и реферативных электронных баз позволяет преподавателю, который обучает студентов обратным и некорректным задачам, быть в курсе современных научных достижений в научном мире и сформировать содержание разнообразных курсов по выбору, включающее современные математические методы и подходы к исследованиям обратных и некорректных задач. При обучении обратным и некорректным задачам преподавателем должны реализовываться цели и задачи не только формирования у студентов глубоких научных предметных знаний, но и выявления научно-познавательного потенциала такого обучения. *Методология.* Реализация научно-познавательного потенциала обучения студентов вузов обратным и некорректным задачам осуществлялась через использование компьютерных технологий. *Результаты.* Понимание научно-познавательного потенциала обратных и некорректных задач, их взаимосвязи с прикладными аспектами, умение использовать компьютерные технологии при исследовании прикладных задач позволит студентам после окончания обучения в учебном заведении проявить себя успешным специалистом по прикладной математике в целом и по обратным и некорректным задачам в частности. *Заключение.* Выпускники, получив-

шие прочные знания по обратным и некорректным задачам, владеющие современными научными методами их исследования, разработанными специалистами разных стран мира, понимающие научно-познавательный потенциал обратных и некорректных задач, владеющие навыками самостоятельного выбора эффективных информационных технологий для решения прикладных математических задач, успешно будут работать в научно-исследовательских организациях и самостоятельно проводить прикладные научные исследования.

Ключевые слова: научно-познавательный потенциал, обучение, студенты вузов, обратные задачи, некорректные задачи, компьютерные технологии, информатизация образования, прикладная математика

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Problem statement. Inverse and incorrect problems have long attracted researchers from many countries. For example, in the 19th century, in engineering, astronomy, physics and other scientific fields, applied mathematical problems were already formulated, which are inverse and incorrect problems.

The need to study inverse and incorrectly posed problems is initiated by the provision of high-quality calculation results, taking into account the inevitable errors in setting the coefficients and parameters of the mathematical model.

The implementation of non-destructive testing and diagnostics of objects, determination of the location or shape of objects, reconstruction of images, identification of cause-and-effect relationships of the processes and phenomena under study lead to the need to solve inverse and incorrect problems. Inverse and incorrect problems often arise in geophysics, chemistry, biology, economics, industry, medical tomography, and many other scientific fields. Solving inverse and incorrect problems can provide new information, replacing direct measurements. This is especially important in cases of inaccessibility or inaccessibility of the studied objects, processes and phenomena. These can be the deep layers of the Earth, the bottom of the world's oceans, objects in outer space, etc.

We note the following most important inverse and incorrect problems.

1. Inverse problems of finding the unknown boundary of a figure. Such applied problems appear in the theory of equilibrium figures of a rotating fluid.

2. Inverse problems of geophysics about the discovery of minerals using graviometric data.

3. Inverse spectral problems of finding the scattering potential from spectral data, etc.

4. Inverse problems of optimal control, which are used in engineering.

5. Incorrect problems of synthesis of optimal control systems.

6. Incorrect problems of calculating the eigenvalues of systems of linear homogeneous equations.

7. Incorrect problems for integral equations of the first kind, which appear, for example, in problems of processing the readings of physical instruments, continuation of stationary fields.

Scientists from many countries have made a significant contribution to the development of the theory of inverse and incorrect problems. We note such authors as Zh. Hadamar, A.S. Alekseev, V.A. Ambartsumyan, Y.M. Berezansky, G. Borg, I.M. Gelfand, N.B. Ilyinsky, S.G. Krein, M.M. Lavrentiev, E.M. Landis, B.M. Levitan, V.A. Marchenko, P.S. Novikov, A.I. Prilepko, I.M. Rapoport, V.G. Romanov, A.A. Samarsky, L.N. Sretensky, V.N. Strakhov, A.N. Tikhonov, L.D. Fadeev, L.A. Khalfin, G. Gerglotz, H. Cordes, A.J. Douglas, D.W. Fox, T. Gallie, F. Joxn, M.H. Protter, E. Wichert, N. Wiener.

Further development of inverse and incorrect problems is found in the works of Russian and foreign authors. Among them are V.Ya. Arsenin, A.V. Baev, A.B. Bakushinsky, N.Ya. Beznoshchenko, Yu.A. Belov, A.L. Buchheim, V.V. Vasin, V.K. Ivanov, A.Sh. Lyubanova, R.G. Novikov, Yu.P. Petrov, S.V. Polyntseva, V.G. Romanov, V.S. Sizikov, R.V. Sorokin, V.P. Tanana, I.V. Frolenkov, V.A. Yurko, A.G. Yagola, R. Arcangeli, Y.M. Chen, H. Engl, S. Falleta, C.W. Groetsch, M. Grasselli, M. Hanke, G. Monegato, L. Scuderi, O.N. Strand and other authors [1–12].

Currently, using the great potential of world science, numerous applied research is being carried out. A special place in applied research is occupied by hard-to-reach and inaccessible objects, processes and phenomena of various nature and their cause-and-effect relationships, which can be effectively and mobilely studied using mathematical models of inverse and incorrect problems.

In many Russian universities, students are taught a variety of elective courses, the content of which includes modern methods for solving inverse and incorrect mathematical problems. At the same time, computer technologies are widely used in such training.

Research of many Russian and foreign authors makes a significant contribution to the informatization of higher education mathematical education. Among them E.R. Alekseev, I.V. Belenkova, V.V. Grinshkun, D.P. Goloskokov, E.A. Dakher, E. Kovacheva, M.N. Kirsanov, E.V. Klimenko, E. Kovacheva, T.G. Kuzmichev, J. Lavonen, M.P. Lapchik, I.V. Levchenko, I.V. Maruseva, S.N. Medvedeva, D.E. Penny, E.A. Ryabukhina, Yu.Yu. Tarasevich, E.K Henner, J. Hughes, Ch.G. Edwards and other authors [13–18].

Reverse and incorrectly posed tasks have not only universality, but also a scientific and cognitive potential that allows one to acquire new scientific information about the properties of objects, processes and phenomena of various natures that are difficult to access and inaccessible to humans. Obviously, when teaching inverse and incorrect problems, the teacher realizes the goals and objectives of not only the formation of deep scientific subject knowledge in students, but also the identification of the scientific and cognitive potential of teaching inverse and incorrect problems [1–12; 19–25].

Method of research. Of course, the developed content, which includes modern achievements of world science and takes into account the professional orientation of teaching, didactic principles, forms and methods of teaching, make a significant contribution to the effectiveness of teaching students inverse and in-

correct problems. At the same time, it is obvious that a specialist in this field with scientific and pedagogical experience of work at a university should act as a teacher of inverse and incorrect problems. Such a teacher is able to teach students in the study of inverse and incorrect problems to implement important principles of the study of inverse and incorrect problems: interdisciplinary approach, structural, functional and dynamic unity, multilevel, cause-and-effect relationships; to reveal the scientific and cognitive potential of teaching inverse and incorrect problems.

Conducting classes with students on inverse and incorrect problems, it is advisable for the teacher to:

– to integrate natural science and humanitarian knowledge that will help students to form fundamental knowledge on inverse and incorrect problems, in applied mathematics, computational mathematics, to comprehend the epistemological aspects of inverse and incorrect problems, humanitarian, scientific and educational, scientific and cognitive potential of teaching inverse and incorrect problems;

– to implement such pedagogical technologies that allow students to develop mathematical creativity, develop a scientific worldview, acquire professional competencies, skills and abilities to successfully research a variety of inverse and incorrect problems with the subsequent analysis of scientific results and logical conclusions about the new scientific information received;

– correctly use computer technologies in classrooms, with the help of which it is possible, in the course of presenting educational material, to demonstrate to students the formulations of mathematical definitions, lemmas, theorems, tables, diagrams, function graphs, surface graphs, drawings, audio and video materials of an educational and scientific nature;

– to identify the scientific and cognitive potential of teaching inverse and incorrect tasks, which clearly demonstrates to students the need and effectiveness of inverse and incorrect problems in the study of the surrounding world (water space, earthly environment, air space, outer space, industry, economy, agriculture, other spheres of human activity).

Results and discussion. In the classroom, students study a variety of approaches and methods for solving inverse and incorrect problems, learn to conduct a logical analysis of mathematical statements of inverse and incorrect problems. Such research work helps students, if appropriate, transform a given mathematical problem into a form that is convenient for research. Moreover, in the future, after such scientific research, students come to understand and comprehend the effectiveness of the study of processes and phenomena using mathematical modeling.

In the classroom, students are taught to use environmental and health-preserving technologies in applied research on the example of using inverse and incorrect problems. As a result, students gain useful experience in analyzing the new information received about the objects, processes and phenomena under study, and form new scientific knowledge about the world around them. A developed scientific worldview helps students to understand the relationship of inverse and incorrect problems to theory, experiment and philosophy – the main methods of cognition of researchers; to comprehend the humanitarian value of mathematical models of inverse and incorrect problems.

The process of studying many inverse and incorrectly posed problems is laborious due to their nonlinearity, which creates mathematical difficulties in finding a solution and, in the future, proving the correctness of the problem.

Students master such effective mathematical methods as the method of selecting solutions for ill-posed problems, the method of quasi-inversion, the method of operator equations, the Tikhonov regularization method, the compact solution method, the Fourier method, the Laplace transform method, the method of characteristics, the method of scales in Banach spaces, the Sobolev method, etc. other mathematical methods.

Computer technologies help students overcome some mathematical difficulties, such as routine mathematical transformations, finding a solution to a scientific problem, visualizing the solution obtained, and the final scientific analysis of the results of solving a problem. Using computer technologies, students gain experience in mobile research of inverse and incorrect problems, realize the huge potential of computer technologies in solving various applied mathematical problems.

To teach inverse and incorrectly posed problems, it is necessary to involve specialists in inverse and incorrect problems who know modern computer technologies and have experience in their application. It is from such specialists that students can gain solid scientific knowledge on inverse and incorrect problems, but also learn from them the valuable experience of choosing and using the most effective computer technologies for the study of such specific non-standard applied mathematical problems. It is such specialists who can realize the scientific and cognitive potential of teaching inverse and incorrectly posed tasks.

Students can gain valuable experience in mastering deep subject scientific knowledge in the field of inverse and incorrectly posed tasks when they are involved in the performance of final qualification works on inverse and incorrect problems in which computer technologies are supposed to be used. A useful activity for students may also be the study, at the request of the teacher, of scientific work on the opposite or incorrectly posed problems, in which computer technologies are used. And, further to discuss with him the scientific result set forth in the scientific work. It is important to emphasize here that the student, while studying scientific work, master the scientific style of presenting material, which is much more difficult than the style of presenting educational material in textbooks and problem books.

The opportunity to find the required scientific article for students can be provided, for example, by electronic bibliographic and abstract databases of scientific libraries elibrary.ru, “CyberLeninka”, “Scopus”.

In the future, this can develop the student’s motivation for the subsequent study of the theory of inverse and incorrectly posed problems in the master’s and postgraduate studies and play an important role in choosing a future profession in the field of applied mathematics.

When teaching students inverse and incorrect problems, attention is paid to approximate methods for their solution. Students develop the skills and abilities of finding approximate solutions to inverse and incorrect problems using the methods of computational mathematics. They master finite-difference methods, variational methods, optimization methods, methods for solving stationary problems in math-

ematical physics, methods for solving non-stationary problems in mathematical physics.

In the classroom, students master the techniques and technologies for the correct use of computer technologies in the search for approximate solutions to inverse and incorrectly posed problems. Students are convinced that modern computer technologies are able not only to quickly find an approximate solution to the desired mathematical problem, but also to visualize it in a form convenient for the researcher. This can be, for example, a graphic image, a table, a diagram, etc., which allows you to visually conduct a scientific analysis, and, if necessary, to carry out a new computational experiment in a mobile manner.

Conclusion. Understanding the scientific and cognitive potential of inverse and incorrect problems, its relationship with applied aspects, the ability to use computer technology to research a variety of atypical applied problems will allow students to be successful researchers.

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