RUDN Journal of Informatization in Education
2017 Vol. 14 No. 4 493—501
Вестник РУДН. Серия: Информатизация образования
http://journals.rudn.ru/informatization-education

DOI 10.22363/2312-8631-2017-14-4-493-501
UDK 378+517.9

THE DEVELOPMENT OF STUDENTS APPLIED MATHEMATICAL THINKING IN TEACHING INVERSE AND ILL-POSED PROBLEMS

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In the article the author draws the reader's attention to the fact that, while mastering the process of learning the theory and methodology of inverse and ill-posed problems, students not only form the fundamental knowledge in the field of inverse and ill-posed problems, applied and computational mathematics, mathematical modeling of processes and phenomena, but also develop one of the most important component of mathematical ability creative and applied mathematical thinking.

It is emphasized that the search for solutions to inverse and ill-posed problems, students acquire profound knowledge in such scientific fields as seismology, gravimetry, magnetometry, Geophysics, astrophysics, imaging, electrodynamics, atmospheric optics, quantum scattering theory and other scientific fields. When teaching inverse and ill-posed problems, students also learn the mathematical methods, which are not included in the content of traditional mathematics applied and computational mathematics, and can only be purchased in the teaching of special courses. Among them, spectral analysis, the method of Volterra operator equations, Sobolev method, method of scales of Banach spaces of analytic functions, the method of integral geometry, the method of tensor analysis, methods of computational mathematics and other mathematical methods.

Key words: training the inverse and ill-posed problems, applied mathematical thinking, applied mathematics, computational mathematics, student

Currently, in many Russian universities prepare highly qualified specialists in the field of applied mathematics. In the process of teaching applied mathematics, students acquire fundamental knowledge of mathematical and functional analysis, algebra and geometry, ordinary differential equations and equations of mathematical physics, numerical methods, computer technology and other subject areas, acquire skills of research of applied problems using mathematical modeling and computing experiment. As a result, these graduates in their professional activities to acquire new knowledge about the world is able to build correct mathematical models of the studied processes and applied to explore effective methods of modern world science. The presence of such graduates noted the professional qualities demonstrates their competence in the field of applied mathematics and the existence of mathematical thinking.

The study of psychological and pedagogical aspects of students' mathematical thinking devoted to the work Z.S. Akhmanova, O.Z. Artebaleno, G.I. Bavrina, T.G. Zakharova, I.I. Kuleshova, G.L. Lukankin, T.V. Myasnikova, E.J. Pantziou, E.I. Smirnov, V.N. Khudyakov and other authors (see for example, [1; 2; 6; 9; 18; 20; 21; 23; 26; 28; 29]). A certain contribution to the formation of students ' physical and mathematical

specialties of higher educational institutions applied mathematical thinking makes training inverse and ill-posed problems (see for example, [3; 7—19; 24; 27]). The content of this training is based on the theory of inverse and ill-posed — one of the areas of modern applied mathematics.

Broad interest in inverse and ill-posed problems due to their great practical importance. This research area is applied mathematics develops in the research of Y.E. Anikonov, A.V. Baev, M.I. Belishev, P.N. Vabishevich, V.V. Vasin, A.O. Vatulyan, A.V. Goncharskii, A.M. Denisov, V.K. Ivanov, S.I. Kabanikhin, M.M. Lavrent'ev, V.V. Pikalov, V.G. Romanov, V.P. Tanana, A.N. Tikhonov, A.M. Fedotov, V.A. Cheverda, V.G. Cherednichenko, V.A. Yurko and other scholars (see for example, [4; 5; 22; 24; 25; 27; 30]).

Inverse and ill-posed problems taught to students of senior courses of physical-mathematical specialties, and it is assumed that they have fundamental knowledge in many disciplines of applied and computational mathematics, as mathematical models of inverse and ill-posed problems are atypical mathematical problems, search not template solutions which involves conducting in-depth analysis of the studied physical process and its cause-and-effect relationships. In the study of mathematical models of inverse and ill-posed problems, depending on their types, types and performances, students will acquire the skills to generate new scientific knowledge about the world, about what is happening in it of physical processes and phenomena and their causal relations.

We give some examples.

1. In the study of mathematical models of inverse problems of seismology, students acquire scientific knowledge about seismology, the study of the nature of elastic vibrations of the Earth. Depending on the performances of these inverse problems, students have to analyze and use information about the properties of the sources of the elastic fields, the structure of the earth through which seismic waves propagate.

2. In the study of mathematical models of inverse problems of gravimetry and magnetometry, the students form new scientific knowledge, for example, on the characteristics of the sources observed on the Earth's surface the gravitational field on the continuation of potential fields in the direction of the sources.

3. In the study of mathematical models of inverse problems of astrophysics, students acquire scientific knowledge, for example, about the interpretation of observations of close binary systems, the motion of a pair of stars under the influence of mutual attraction, about the important characteristics of stars.

4. In the study of mathematical models of inverse problems of processing of images, students form scientific knowledge in the field of pattern recognition, reconstruction of blurred and defocused images, imaging.

5. In the study of mathematical models of inverse problems of electrodynamics, the students form scientific knowledge, for example, on the processing and interpretation of the results of measuring electromagnetic radiation produced by various objects, sources of electromagnetic fields, the forms of bodies, in which the scattering of the field inhomogeneities on the earth's environment, the synthesis of the electromagnetic field.

6. In the study of mathematical models of inverse problems of atmospheric optics, students form scientific knowledge, for example, on the physical state of the atmosphere, concentration of absorbing and scattering substances, sizes and shapes of aerosol particles,

their composition and structure, about the parameters of the fine structure of the spectrum, the intensity of the radiation.

7. In the study of mathematical models of inverse problems of determining the density of heat sources, students acquire scientific knowledge, for example, on the density of radioactive heat sources on the thermal radiation on the Earth's surface, the half-life of radioactive elements.

8. In the study of mathematical models of inverse problems for differential equations of elasticity students master scientific knowledge, for example, in the linear theory of elasticity, in particular, about the ball isotropy of perfect elasticity, of the linear dependence between stress and strain, small deformation, on the external surface and volume forces, about the natural state of the body.

When finding solutions to mathematical models of inverse and ill-posed, the students also acquire new scientific knowledge in subject areas that are not included in the content of traditional mathematics applied and computational mathematics, and can only be purchased in the teaching of special courses. For clarity, we give examples.

1. In the study of mathematical models of inverse spectral problems, students acquire scientific knowledge in the field of spectral analysis is to define operators on some of their spectral characteristics. Students were aware that such a mathematical model of the inverse problems play an important role in applications of physics, quantum mechanics, Geophysics, meteorology, electronics, elasticity theory, and other applications. In the process of solving such inverse problems, students master the method of spectral mappings the method of standard models, the method of operator transformations, and other mathematical methods.

2. In the study of mathematical models of dynamic inverse problems for hyperbolic equations, students master the idea of the method of Volterra operator equations, optimization method of linearization, a method for the treatment difference schemes and other methods. Gaining skills to operate the functional spaces to perform mathematical operations on generalized functions, linear operators. Gain experience of applying the method of Sobolev, method, scales of Banach spaces of analytic functions, methods of integral geometry methods of tensor analysis theorem C.V. Kovalevskaya theorem S. Banach and other methods and theorems in seeking solutions to such inverse problems.

3. In the study of mathematical models of inverse boundary problems of Aero-and hydrodynamics students acquire substantive scientific knowledge, for example, in the design of airfoils, which have the desired characteristics, mastering such fundamental concepts as source, vortex, flow, geometry of the profile around the profile, the flow is inhibited layers, master the methods of aerodynamic design and other methods. The students in the solution of such inverse problems master the mathematical methods of determining the shape of the profile when there is known on his circuit of the velocity distribution, methods of flow ideal fluid, methods of the theory of analytical functions and other methods.

4. In the study of mathematical models of inverse and ill-posed problems with approximate methods, students acquire in-depth scientific knowledge in the field of computational mathematics. Among such scientific knowledge — the theory of difference schemes, finite-difference methods sweep method, iterative methods, regularization

method A.N. Tikhonov, the method of the Newton-Kontorovich, gradient methods, the discrete analogue of the Volterra operator equations with partially Lipschitz-continuous kernel. Develop methods of error estimates for approximate solutions of inverse and ill-posed problems to the exact solutions and other methods. The students extensively use computer technology for implementing computational algorithms for searching approximate solutions of the inverse and ill-posed problems that demonstrate to students their efficiency and mobility in the study applied.

In the process of solutions to inverse and ill-posed problems, students gain skills to independently formulate logical conclusions of applied and humanitarian nature. It is obvious that such students are formed as fundamental scientific knowledge in inverse and ill-posed tasks, applied mathematics, computational mathematics, and developing mathematical thinking.

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Article history:
Received: 20 June, 2017
Accepted: 25 Jule, 2017

For citation:
Kornilov V.S. (2017). The development of students applied mathematical thinking in teaching inverse and Ill-Posed problems. *RUDN Journal of Informatization Education*, 14 (4), 493—501. DOI 10.22363/2312-8631-2017-14-4-493-501

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РАЗВИТИЕ У СТУДЕНТОВ ПРИКЛАДНОГО МАТЕМАТИЧЕСКОГО МЫШЛЕНИЯ ПРИ ОБУЧЕНИИ ОБРАТНЫМ И НЕКОРРЕКТНЫМ ЗАДАЧАМ

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В статье автор обращает внимание читателя на то, что, осваивая в процессе обучения теорию и методологию исследования обратных и некорректных задач, студенты не только формируют фундаментальные знания в области обратных и некорректных задач, прикладной и вычислительной математики, математического моделирования процессов и явлений, но и развивают одну из важных компонент творческих математических способностей — прикладное математическое мышление.

Подчеркивается, что при поиске решений обратных и некорректных задач студенты приобретают глубокие знания в таких научных областях, как сейсмология, гравиметрия, магнитометрия, геофизика, астрофизика, томография, электродинамика, атмосферная оптика, квантовая теория рассеяния и другие научные области. При обучении обратным и некорректным задачам студенты также осваивают математические методы, которые не входят в содержание традиционных математических дисциплин прикладной и вычислительной математики, а могут быть приобретены только в процессе преподавания специальных курсов. Среди них спектральный анализ, метод операторных уравнений Вольтерра, метод С.Л. Соболева, метод шкал банаховых пространств аналитических функций, метод интегральной геометрии, метод тензорного анализа, методы вычислительной математики и другие математические методы.

Ключевые слова: обучение обратным и некорректным задачам, прикладное математическое мышление, прикладная математика, вычислительная математика, студент

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История статьи:
Дата поступления в редакцию: 20 июня 2017
Дата принятия к печати: 25 июля 2017

Для цитирования:
Корнилов В.С. Развитие у студентов прикладного математического мышления при обучении обратным и некорректным задачам // *Вестник Российского университета дружбы народов. Серия «Информатизация образования»*. 2017. Т. 14. № 4. С. 493—501. DOI 10.22363/2312-8631-2017-14-4-493-501

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