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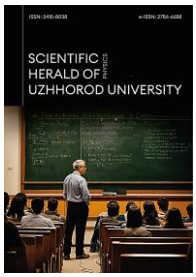

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Theoretical and practical bases of application of parallel computing when solving problems of the numerical method in the educational process

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Abstract

Relevance. The rapid development of the information society highlights the need for high-quality training of computer specialists in Kazakhstan's higher education institutions. Establishing a modern system for teaching numerical methods and parallel computing is crucial for preparing future specialists to be competitive in the evolving labor market.

Purpose. The research aims to justify the need for a methodological system to develop the readiness of future computer specialists in Kazakhstan's higher education institutions. This system is essential for ensuring their ability to use parallel computing to solve numerical methods problems.

Methodology. The study involved analysing, comparing, systematising, classifying, and generalising theoretical data, as well as using questionnaires to evaluate opinions on the research level and the significance of the problems studied. The practical stage included preparing and implementing experiment materials, and evaluating results using mathematical statistics to verify the relevance of the author's methodology.

Results. During the experiment the content of the concepts "willingness of the future specialist to use parallel computing in solving problems of numerical methods", "hardware technologies of software computing", and "software technologies of parallel computing" is defined. The signs and features of developing future specialists' willingness to use parallel computing in solving numerical methods problems are revealed. A methodology for this development was created and implemented. During experimental research at Nazarbayev University (Astana), a methodological toolkit was developed to enhance specialists' readiness for parallel computing. This toolkit includes the implementation of components, criteria, and indicators of readiness, along with selected methods for their development.

Conclusions. The research results identify key areas for improving the methodology for developing future specialists' readiness to apply parallel computing in solving numerical methods problems. This involves enhancing the components of students' willingness to engage in such activities. The practical value of the work lies in the creation of a methodological system to improve the training of students and future computer technology specialists in Kazakhstan's higher education institutions.

Keywords: informatisation of society; computer technologies; engineering education; professional training; methodological tools.

Introduction

The rapid development of scientific and technological progress in Kazakhstan activates the processes of growth of the volume of knowledge required by specialists for quality work in the conditions of modern information society. Thus, the development of the information culture of future computer specialists is the most urgent task set before the higher education of Kazakhstan in today's conditions [1]. The relevance of the indicated problems is conditioned upon the strengthening of the process of

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computerisation in society, the intensity of the development of educational services and the implementation of information exchange in all spheres of life. There is a need to introduce computer technologies in the educational process of training future computer specialists, wide introduction of progressive information technologies and development based on new strategies designed to expand the forms of self-education and individualisation of the learning process.

In modern conditions, there is a rapid decrease in the number of hours for learning computer science in institutions of higher education in Kazakhstan. Considering this situation, there is a need to introduce special courses in the educational process of training specialists who specialise in computer science [2]. Due to the emergence of multi-core architectures and the increasing availability of processing resources, parallel and distributed computing has a special role in the software industry. Thus, it is for this reason that computer engineering professionals must improve the skills needed to learn and practice the full potential of new computer systems. However, the process of conventional teaching of programming, namely, the basics of parallel and distributed computing in higher education institutions of Kazakhstan should be considered as a subject with a high level of complexity, which is recommended to be taught in optional classes [3; 4].

F. Sametova et al. [5], exploring the issues of linguistic analysis of massive data processing in computer graphics tasks, concluded that it is necessary to actively use software and hardware tools that allow performing calculations in a very limited period. Researchers state the fact that the possibility of increasing the performance of hardware by increasing the frequency of packing density of logic elements on the crystal has expired. The development of approaches based on multiprocessor construction of computer systems and the development of parallel programming principles become actual. These approaches are based on the parallel system structure, contributing to the development of the theory of parallel computing, which is in interrelation with the process of optimisation of computer calculations and establishment of distributed computing systems.

The process of development of higher education in Kazakhstan requires an increase in the curricula of integrative courses to develop interdisciplinary links during the training of highly qualified specialists. Among such courses, preference should be assigned to the integration of mathematics with computer science. The question of the activation of cognitive activity of students in the process of teaching using parallel calculations while solving problems of numerical methods becomes urgent [6]. In scientific works, R.M.V. Pidaparti and A.V. Hudli [7] actively explored the issues of methodical foundations for the development of the cognitive activity of future specialists in the application of parallel computing while solving problems of numerical methods in the educational process. During the conducted research it was established that in the process of teaching the course "Parallel and Distributed Computing" there is a need to simultaneously learn computational algorithms, considering the specific features of their software implementation in the conditions of shortage of teaching time.

The purpose of the research – theoretical and practical substantiation of the application basics of parallel computing in the process of solving problems of numerical methods in the educational process of training future specialists in higher educational institutions of Kazakhstan. In the process of the conducted research the following tasks are highlighted:

1. Justification of theoretical and practical bases of application of parallel computing in solving problems of numerical methods in the educational process.
2. Finding ways to apply parallel computing in solving problems of numerical methods in the educational process.
3. Design of the system of methodical means of developing the willingness of future specialists to use parallel computing in solving numerical methods problems in the educational process.

The problem of the research is the substantiation of theoretical and practical bases of application of parallel calculations in solving problems of numerical methods in the process of training future specialists in higher educational institutions of Kazakhstan. The solution to this problem will contribute to the effective design of professional competencies of future specialists, the development of their professionally important qualities for competitiveness in the labour market, and the solution of urgent problems and challenges of the socio-economic development of the country.

Materials and Methods

The presented research was conducted in two stages: theoretical (analysis, comparison, systematisation, questionnaire, classification, generalisation of theoretical data to evaluate the authors' opinions regarding the level of research and to determine the significance of the researched problems) and practical (preparation of the experiment materials and its implementation, evaluation of the results using mathematical statistics methods to verify the relevance of the presented author's methodology). The main methods in the process of experimental research were intended to explore the problems of developing the willingness of a future specialist to apply parallel computing in solving problems of numerical methods in higher education institutions of Kazakhstan. The research of problems of introduction of methodical means of the examined willingness development was theoretically implemented. The methods used at this stage were the following: analysis, comparison, systematisation, survey, and modelling. The mentioned methods were used to identify the input level of future specialist's willingness to apply parallel computing in solving problems of numerical methods.

The practical stage consisted of experimental research, which was conducted at Nazarbayev University (Astana). To ensure the representativeness and reliability of the sample, the specific features of the development of experimental groups, age and gender of respondents were determined. The control-research array was developed by pairwise selection. The condition was considered that at the end of the selection, the number of the experimental group met the requirements of representativeness. The experiment involved 60 applicants for higher education.

The control group included 28 respondents, and the experimental group included 32 participants.

The experiment was conducted during the academic years 2022-2023. In the process of the experimental research, 15 women and 45 men were identified among the applicants of education who were involved in the experiment. The diagnostics of the effectiveness of the system of methodical means of developing the willingness of a future specialist to apply parallel calculations in solving problems of numerical methods in the conditions of the educational process of the university was conducted. The following components and criteria of preparedness were identified in the course of conducting the determining experiment, namely: motivational (motivation-value), cognitive-action (knowledge-operational), subjective (reflexive). In addition, indicators such as: motivation to learn professional competencies, acquiring skills of analysing the obtained information using parallel calculations while solving tasks of numerical methods, ability to perform reflection.

The levels of readiness of a future specialist to the application of parallel computing in solving problems of numerical methods, fixed at the average and low level, have been determined. At the formative stage of the experiment, the verification of the identified components of readiness of a future specialist to the application of parallel computing in solving problems of numerical methods was conducted. To increase the level of readiness of a future specialist to use parallel computing in solving problems of numerical methods, a system of methodical means was developed. It included author's questionnaires and clarifying interviews, which were used during the determination of readiness levels at the establishing stage of the experiment. A special course "Models and methods of parallel computing" was developed, which included interactive methods, digital and multimedia technologies, hypertext and Internet technologies, technologies of virtual information space, cloud technologies, Web technologies, telecommunication technologies, SMART-technologies. The presented special course and methods were implemented at the formative stage of the experiment to develop the identified components of readiness.

After the end of the experiment, the obtained results were analysed, summarised, conclusions were drawn and prospects for further research on the outlined subject were substantiated.

Results

One of the most important problems of higher education in the field of automated systems software and computer engineering in Kazakhstan is the need for an urgent solution to the issues of developing the readiness of future specialists to solve problems of numerical methods in the process of applying parallel computing [8]. Firstly, there is insufficient development of professional competencies necessary for future specialists in the field of computer engineering and information technologies. Secondly, there is inadequate practical training for master's graduates, and a low level of financing for the development of modern material and technical bases in higher education institutions and enterprises. Lastly, there is insufficient involvement of specialists with practical work experience and relevant qualifications in teaching.

However, the research determines that the special courses offered for the applicants of higher education in Kazakhstan on the speciality "Computer Engineering" are based on such an approach in teaching numerous methods as specialised mathematical libraries, which in the conditions of modernity are a product of the evolution of procedural programming and have limited opportunities for further development. The question of providing a favourable computer environment for the specialists of the speciality "Computer Engineering" is rather complicated and necessary to be solved. Such an environment should include a flexible model of knowledge and scientific information representation, as convenient and functional means for content filling, viewing, and information search. The research proves that while working in a favourable computer-based educational environment, a future specialist will be able to develop productive forms of thinking, and acquire skills in using a variety of computer graphics tools, using artificial intelligence [9].

The main purpose of parallel programming is to accelerate the process of application work and data processing. Parallel programming has found its application in industries where it is necessary to process a large data set or perform the calculation process in a short period. The research identifies the following approaches to implement parallel programming namely multithreaded, distributed, asynchronous, functional and graphics processing unit (GPU) programming. The purpose of the experimental research was:

– to identify the level of readiness of future specialists to solve problems of numerical methods in the process of application of parallel computing;

– to analyse and identify the techniques that are used in solving numerical methods problems in the implementation of parallel computing in the educational process;

– to clarify the ways and methodical system of solving the problems of numerical methods in the implementation of parallel computing in the educational process.

The following objectives accompanied the process of achieving the purpose:

1. Determination of components and levels of readiness of future specialists to solve problems of numerical methods in the process of application of parallel computing.
2. Clarification of ways and methodological techniques of readiness of future specialists to solve problems of numerical methods in the process of application of parallel computing.
3. Verification of the effectiveness of the developed methodology using methods of mathematical statistics.

To determine the level of readiness of future specialists to solve problems of numerical methods in the process of application of parallel computing, components and indicators to them are allocated.

Motivational (motivation-value) component consists of purposes, motives, needs, values and professional interests. The essence of the motivational criterion is the implementation of a system of motives and needs in the organisation of the process of parallel calculations in solving problems of numerical methods using digital technologies, encouraging learning based on autonomy,

and stimulating and supporting the activity of students at a specific level. The motivational criterion is designed to reflect students' attitudes towards the learning process. It aims to leverage digital learning tools to enhance knowledge assimilation, increase motivation to engage in professional tasks, foster self-development through research activities, stimulate interest in purposeful communication, and promote the use of digital technologies. Students' motivation is accompanied by utilitarian-practical motives and acquires personal significance, which can turn the purposes and tasks outlined by the teacher into internal needs.

Cognitive-operational (knowledge-operational) component is manifested in the presence of knowledge: general professional, professional, special, methodical; skills and abilities to their implementation in practice. The defined criterion reflects didactic and methodical knowledge of solving problems of numerical methods in the process of application of parallel computing, and forms, methods, types of digital technologies and patterns of their use in the educational process in the implementation of training students of the speciality of computer engineering. The criterion implies the development of general academic and subject competencies and the identification of ways to manage such processes.

Subjective (reflexive) component is manifested in the ability to analyse psychological features and professional abilities, to predict and control the results of their activities, the ability to mobilise their potential, creative energy, the ability to self-expression, self-development and self-improvement. The criterion reflects the level of the respondents' ability to solve problems of numerical methods in the process of applying parallel calculations in the process of professional training.

The following indicators of the examined readiness were identified: motivation to master professional competencies, acquisition of skills to analyse the received information using parallel calculations during the solution of numerical methods tasks, and ability to perform reflection. In addition, a set of adapted methods of studying the levels of development of the considered definition at different stages of the experiment was designed in the course of the establishing stage of the experiment. The sample size was 60 bachelors of Nazarbayev University (Astana), studying in the speciality "Computer Engineering". The control group included 28 respondents, and the experimental group included 32 respondents, including 15 women and 45 men.

At the establishing stage of the experiment, the literature on the problem of research was analysed, and the best practices in the methodology of parallel computing application were explored. Object-oriented software was selected to support parallel computing courses in the educational process. The contingent of participants was also determined, and individual levels of development of the considered definition at different stages of the experiment were diagnosed. The identified levels in the process of the establishing experiment were clarified and corrected during the research.

Comparative analysis of the scientific base on the research problems involves systematising, classifying, and generalising theoretical data. It includes modeling and generalising the methodology for training future specialists in computer technologies. Additionally, it determines the components of readiness among future specialists to apply parallel computing in solving numerical method problems within the educational process. These components encompass motivational, cognitive-activity, and subjective aspects. The logic of the research required exploring the readiness of future specialists to solve problems of numerical methods in the process of applying parallel computing. For this purpose, a questionnaire survey of bachelors was conducted. The results of the questionnaire survey allow making conclusions about the levels of development of the indicated components of readiness. As a result of the experiment, it was found that the level of students' cognitive activity during the learning of the course of numerical methods is on average and low position. The results of the questioning are presented in Figure 1.

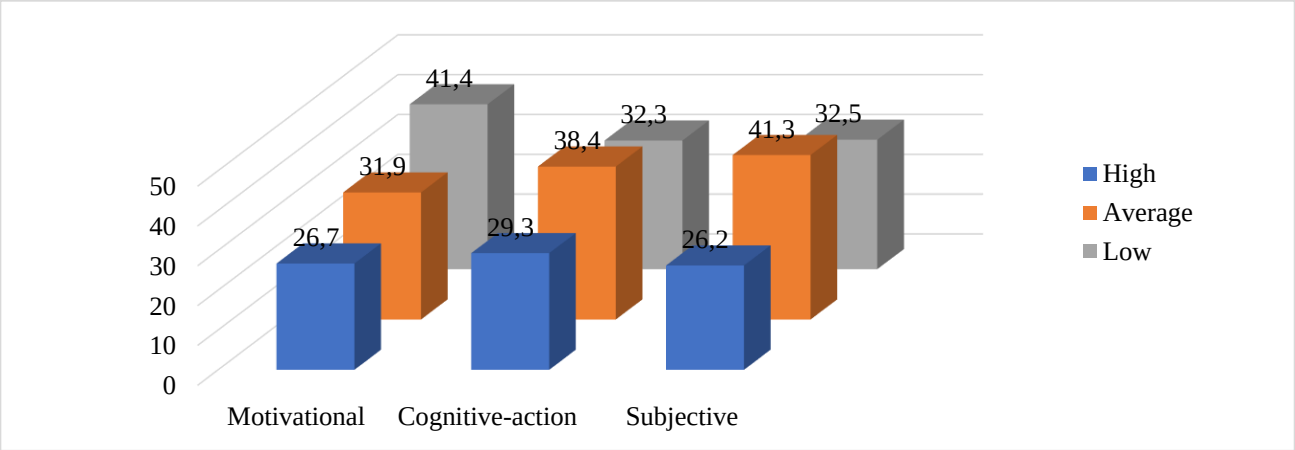

Figure 1. Results of diagnostics of levels of components' development of readiness of future specialists to solve problems of numerical methods in the process of application of parallel calculations in the control group

Source: compiled by the authors.

To increase the level of readiness of future specialists to solve problems of numerical methods in the process of application of parallel calculations the educational stage of the experiment was conducted. The purpose was to check

the effectiveness of the proposed methodology of application of parallel calculations in solving problems of numerical methods in the educational process. During the experiment, the features of theoretical and practical foundations of parallel computing applications in solving numerical method problems are reflected in the current curriculum of the Numerical Methods course at Nazarbayev University. Methodical recommendations for conducting independent work on "Parallel and distributive calculations" are also delineated. Furthermore, programs for regression analysis of experimental data based on these foundations are developed. The author's questionnaires and clarifying interviews were used to determine the features of design and development of the motivational component of students' readiness of future specialists to solve problems of numerical methods in the process of application of parallel calculations. They also helped to determine the degree of motivation, and the desire for self-development and self-improvement.

The implementation of the content criterion consists of determining the available knowledge, including types, ways, methods and techniques that affect the organisation of the process of solving problems of numerical methods in the application of parallel computing, the implementation of ways to optimise and intensify them using digital technologies. Diagnostics of the levels of organisation of future specialists' readiness to solve problems of numerical methods in the process of application of parallel computing by the substantive criterion is proposed to be based on the methodology of problem questions posing. The implementation of the operational criterion consists of imparting to future specialists the skills of using techniques and methods of solving problems of numerical methods in the process of parallel computing using digital learning technologies.

The methodology of diagnostics of the operational criterion consists in the development of the author's special course "Models and methods of parallel computing". It included interactive methods. digital and multimedia technologies, hypertext and Internet technologies, technologies of virtual information space, cloud technologies, Web technologies, telecommunication technologies, and Smart-technologies. The development of the content of the tasks was based on the principle of complex differentiation for groups of students and is based on the implementation of indicators of the readiness of future specialists to solve problems of numerical methods in the process of applying parallel computing.

During the determination of levels of readiness of future specialists to solve problems of numerical methods in the process of application of parallel calculations the attention is emphasised on the levels, namely: high, average and low. To exclude randomness in assessing the levels of the examined readiness in conflict issues, there was a need to conduct an interview. During the interview the applicants should answer questions and perform tasks, according to the results of which conclusions can be drawn about the level of development of each component of readiness. The obtained results of the data at the founding stage of the experiment are presented in Figure 2.

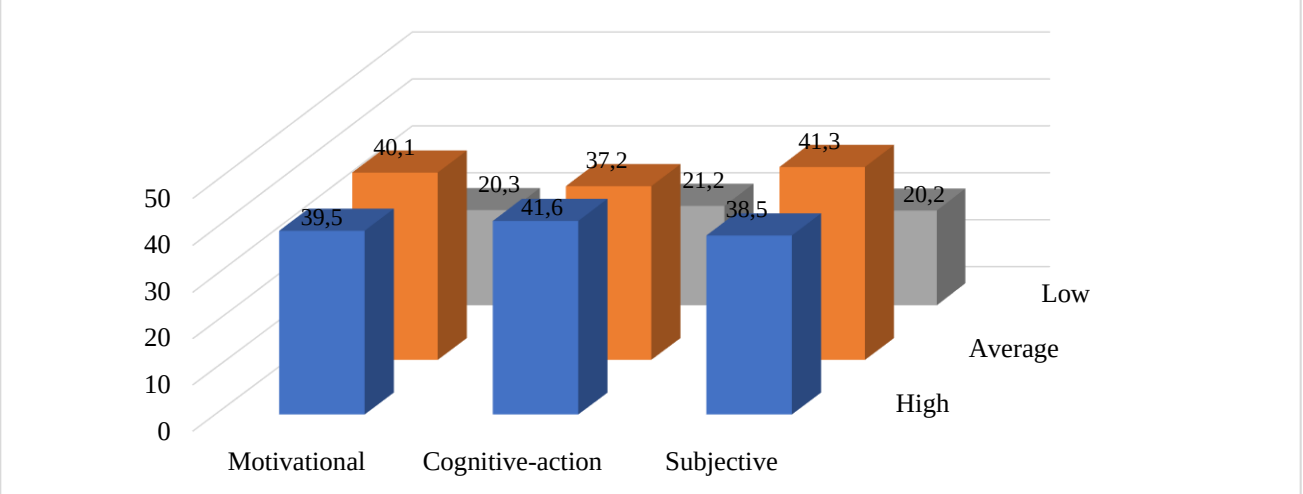

Figure 2. Results of diagnostics of levels of components' development of readiness of future specialists to solve problems of numerical methods in the process of application of parallel calculations in the experimental group

Source: compiled by the authors.

Analysis of the results of the experimental research and evaluation of the effectiveness of the proposed methodology of parallel computing in solving problems of numerical methods was performed using the methods of mathematical statistics. In the research, the samples are random, independent and subject to the standard law of distribution. The experimental data were processed by Pearson's criterion x2. In the process of processing the experimental data, no significant differences were found in the experimental and control samples at the stage of the establishing experiment. However, differences in the experimental and control samples, and differences in the control sample before the formative experiment and after its implementation are noted. The accepted alternative hypothesis states that the samples have statistically significant differences, which indicates the effectiveness of the experimental methodology compared to the traditional one.

In the process of experimental research, it was established that the ability to perform parallel calculations in solving problems of numerical methods in the educational process of training specialists in computer

engineering speciality plays an important role in their future professional activity. Considering the requirements of the modern labour market in Kazakhstan, the necessary specialists are capable of active thinking, self-criticism and creativity. Using modern methods of parallel computing requires specialists both activity and ability to search for new solutions, and development of skills to independently set and perform new professional and social tasks, to be capable of quick adaptation and work in changing conditions, confidence and responsibility. From the perspective of further research, it is possible to overcome the difficulties in identifying one-sidedness in the problems of holistic representation of the results of the quality of education.

Based on the experimental research, it is proved that the readiness of future specialists to solve problems of numerical methods in the process of parallel computing is an essential component of the professionalism of a computer specialist. Improvement of the system of training specialists in the area of computer engineering forms their ability to implement effective practical activity, provides a creative approach to solving professional problems, and possession of labour culture. As a result of the conducted experimental research the methodology of improvement of the process of application of parallel calculations in solving problems of numerical methods in the educational process in higher educational institutions of Kazakhstan has been developed, introduced and tested.

Discussion

The requirement of modern information society is the training of highly qualified specialists capable of active use of computer technologies in their professional activity, in particular, specialists of engineering and computer specialities, as the welfare and economic power of Kazakhstan society depends on them. Thus, one of the ways to improve the training of such specialists is the maximum use of computer technologies, in particular, using parallel computing in solving problems of numerical methods in the educational process.

The context of the implementation of data processing based on the principle of sequence requires computer technology to increase performance. This problem should be solved by developing the principles of parallel information processing. In the context of the indicated problematic researchers recommend to use of new computer architectures based on parallel data processing. Nowadays in the field of computer engineering in Kazakhstan, the principles of parallelism in computing devices are actively used, among which preference is given to cluster systems and multi-core personal computers. The development of progress in computer engineering has led to the active development of corresponding software [10].

N. Law et al. [11], exploring the training of computer engineering professionals, found that the training of such professionals requires improvement as computer hardware and programmes improve in the marketplace. The research supports the findings of the works presented and highlights the contradictions between:

– existing requirements on the labour market regarding the level of professional training of specialists in the field of computer engineering and the quality of their training;

– society's need for computer scientists and the insufficient level of their professional training;

– outdated approaches to training a computer science specialist and the need for such specialists on the labour market;

– necessity of professional knowledge development by means of computer technologies and insufficient design of training methodology.

With the rapid development of the introduction of the latest computer technologies, there is a need to improve the training of future specialists in the field of computer engineering. The establishment of new generation software is the reason for the dynamic development and use of parallel computing models, which in their theoretical and practical basis become widespread and penetrate numerous aspects of architecture and programming tools of modern computer systems. Using network technologies and Internet means, operating systems and application software in modern conditions are based on the concepts of parallel and distributed computations. Appearance and rapid spreading of new generation programming languages, in particular, Java and C++ have defined a new trend in the research of programming problems of multiplatform distributed and parallel applications. Therefore, specialists in engineering or programming need to master the concepts and tools of multiprocessing and parallel programming to improve the efficiency and reliability of computing [10].

N. Giacaman and O. Sinnen [12], exploring the issues of professional training of future software engineers in the field of parallel computing, concluded that the subject of parallel computing has a special place in their professional training in the educational programmes of the first (bachelor) level of specialties of the branch of knowledge "Information Technologies". The authors' opinion is supported that in the process of learning the discipline "Parallel and Distributed Computing" students should have competencies in algorithmisation, object-oriented programming, operating systems, computer circuitry and computer architecture.

Based on numerous studies by scientists R. Wesselink et al. [13] and B. Zhekibayeva et al. [14] it is determined that the process of solving tasks of practical content in the field of science and technology requires the implementation of high-quality and fast computing. Tasks with a large amount of input data require processing of significant sizes of information. The research supports the opinion of colleagues that numerous tasks, in particular, those requiring the analysis of space information, monitoring the functioning of enterprises and organisations that are vast in their volume, and banks with large sizes of information inputs, require optimal decision-making in real-time. Thus, there is a need to improve the existing and develop new approaches to the organisation and execution of computations using high-performance computing systems.

Y. Ko et al. [15] are inclined to the opinion that the most modern way to optimise the computational process is data parallelisation for its further implementation on parallel architecture systems. The researchers proved that using parallel methods and algorithms can be implemented through the introduction of universal and special-purpose computing facilities. Concerning the results obtained in this research using the proposed approach can be correct,

namely since in the conditions of modernity the development of universal computing systems is performed by four main areas, namely: vector-conveyor, Symmetric Multi-Processing (SMP), Massively Parallel Processing (MPP), and clusters. A typical example of SMP-systems are modern multicore processors by Intel (Core Duo, Core 2Duo).

K. Kurt and M. Pehlivan [16], conducting research regarding parallel execution of arithmetic and logical operations and expressions, noted that in this case using parallel methods for solving digital filtering problems becomes important. Regarding the results obtained in this research, using the proposed approach may be correct. Namely, to solve problems of this type is optimal speed and memory utilisation parallel-conveyor algorithm for solving a one-dimensional problem of digital type, which is performed based on the execution of some number of recalculations of an array of variable values through motion. Based on the studies of A. Asaduzzaman et al. [17] and D.E. Marcial et al. [18] the following classification of numerical integration methods is proposed, namely: Newton-Cotes methods, spline methods, high algebraic precision methods, Monte Carlo methods.

Nowadays in Kazakhstan, the issue of training a highly qualified specialist capable of parallel computing in solving problems of numerical methods in the educational process becomes essential. Thus, to solve this problem, there is a need to develop methodological tools for the application of parallel computing [19]. In the process of implementing the saving of computational resources when applying the available parallel computing tools, hardware and software parallel computing tools are distinguished. The notion “hardware technologies of parallel computing” should be understood as a set of commands consisting of microoperations. It includes shift, addition, alignment, and normalisation, performed by separate devices after which the results are sent to the next calculator, making preparatory actions for receiving the next set of data. “Parallel Computing Programming Technologies” is a universal means of software development when performing parallel computations. Such programming system operates based on Message Passing Interface (MPI), a technology of designing systems with shared memory Open Multi-Processing (OpenMP), using parallel processing directives, Open Computing Language (OpenCL), Media Player Classic (MPC) [20]. In the process of research of readiness of future specialists of engineering and computer profile, it was established that it can be considered as a result of the training of a highly qualified specialist competitive in the labour market, possessing professional competencies and skills to act within the limits of their speciality, development of professional abilities and personal qualities according to the speciality requirements.

Thus, the working definition of the concept of “readiness of a future specialist to apply parallel computing in solving problems of numerical methods” is defined as a complex integrative new development of a future specialist who possesses personal and professional values, cognitive and praxeological abilities, reflection to plan their development in the field of computer technologies and professional adaptation. The process of implementation of parallel calculations in solving problems of numerical methods during the training of future specialists is quite multifaceted. It consists of creative perception, comprehension of lecture material while working on the lecture notes, study of literary sources and primary sources, preparation for different types of classes, independent consolidation of knowledge while performing independent work. It also includes preparation for laboratory works and methodical classes. work in scientific circles, preparation for the examination and crediting session, passing the examinations and crediting session, passing the examinations and crediting session.

Conclusions

In the course of the research, the conclusions are made that the qualitative professional training of the future specialist in the application of parallel computing in solving problems of numerical methods in higher educational institutions of Kazakhstan should be based on the system of methodical means for the implementation of which it is necessary to implement the prediction of the productive component of the content. Application of parallel calculations in solving problems of numerical methods in education requires the teacher thorough preparation, which allows them to adapt to pedagogical innovations. The research confirms that the knowledge of theoretical and practical foundations of the implementation of parallel computing in solving problems of numerical methods in education will contribute to the further expansion of professional competencies of future professionals. The results of the experiment indicate significant positive changes in the levels of development of readiness of a future specialist to apply parallel computing in solving problems of numerical methods, which proves the effectiveness of the developed system of methodological tools.

The analysis of scientific literature allowed systematising the idea about the application of parallel computing in solving problems of numerical methods and determining the main ways of developing the examined readiness. The presented methodological support for the development of future specialist’s readiness to use parallel computing in solving problems of numerical methods is defined as a professional necessity in the future activity of a computer industry specialist. Promising areas for improving the development of a future specialist’s readiness to use parallel computations in solving problems of numerical methods are designed. In the course of the experiment, it is established that the readiness levels of future specialists in the computer engineering field are in the low and average position. It is determined that such a tendency requires the establishment of the necessary methodological tools to improve the level of training of such specialists.

The research highlights motivational, cognitive-activity and subjective criteria and indicators: motivation to master professional competencies, acquisition of skills to analyse the obtained information using parallel calculations while solving tasks of numerical methods, and ability to perform reflection. The obtained data of the experimental results after the application of the proposed methodology allow concluding about the effectiveness of the implementation of methodological tools. In this regard, the policy of educational institutions of Kazakhstan should

be designed to update the methodology of training future specialists in the field of computer technologies.

Prospects for further research are designed to develop a wider range of methodological tools to develop the process of readiness of a future specialist to apply parallel computing in solving numerical methods problems. The obtained primary results require the expansion and deepening of the developed problem. Thus, the development of a wider set of scientific and methodological support will contribute to the system's knowledge about future activity, and to the development of skills and abilities to use them in practice. The data obtained as a result of the research can be considered as a tool for increasing the readiness of a future specialist to apply parallel computing in solving numerical methods problems.

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Conflict of Interest
None.

References
[1] Czech ZJ. Introduction to parallel computing. Cambridge: Cambridge University Press; 2016.
[2] Beetham H, Sharpe R. Rethinking pedagogy for a digital age: Principles and practices of design. New York: Routledge; 2019.
[3] Papavasiliou A, Oren SS, Rountree B. Applying high performance computing to transmission-constrained stochastic unit commitment for renewable energy integration. In: A.J. Conejo (Ed.), *IEEE Transactions on Power Systems* (pp. 1109-1120). New York: Institute of Electrical and Electronics Engineers; 2015.
[4] Collection of materials of the international round table on the topic: "Training of professional in the context of digitalization of education – Problems and prospects"; 2022. http://surl.li/gbayy
[5] Sametova F, Kiynova Zh, Orynkhanova G. Digital educational resources as ensuring a new quality of education. *Bull Al Farabi Kaz Nat Uni*. 2022;71(2):126-134.
[6] Miller GR. An object-oriented approach to structural analysis and design. *Comput Struct*. 1991;40(1):75-82.
[7] Pidaparti RMV, Hudli AV. Dynamic analysis of structures using object-oriented techniques. *Comput Struct*. 1993;49(1):149-156.
[8] The Strategy for development of the Republic of Kazakhstan until the year 2030; 1997. https://www.akorda.kz/en/official_documents/strategies_and_programs
[9] Sharov S, Tereshchuk S, Tereshchuk A, Kolmakova V, Yankova N. Using MOOC to learn the Python Programming Language. *Int J Emerg Technol Learn*. 2023;18(2):17-32.
[10] Musser DR, Stepanov AA. Algorithm-oriented generic libraries. *Softw Pract Exp*. 1994;24(7):623-642.
[11] Law N, Chow A, Yuen AHK. Methodological approaches to comparing pedagogical innovations using technology. *Edu Inf Technol*. 2005;10:7-20.
[12] Giacaman N, Sinnen O. Preparing the software engineer for a modern multi-core world. *J Parallel Distrib Comput*. 2018;118(1):247-263.
[13] Wesselink R, Biemans H, Gulikers J, Mulder M. Models and principles for designing competence-based curricula, teaching, learning and assessment. In: M. Mulder (Ed.), *Competence-Based Vocational and Professional Education. Technical and Vocational Education and Training: Issues, Concerns and Prospect*s (pp. 533-553). Cham: Springer; 2017.
[14] Zhekibayeva B, Kalimova A, Sarsekeyeva Z, Ossipova S, Zhukenova G. Research on integrated learning upon enhancing cognitive activity in primary school. *J Intellect Disabil Diagn Treat*. 2020;8(3):396-405.
[15] Ko Y, Burgstaller B, Scholz B. Parallel from the beginning: The case for multicore programming in the computer science undergraduate curriculum. In: T. Camp, P. Tymann, J.D. Dougherty, K. Nagel (Eds.), *SIGCSE 13: Proceedings of the 44th ACM Technical Symposium on Computer Science Education* (pp. 415-420). New York: Association for Computing Machinery; 2013.
[16] Kurt K, Pehlivan M. Integrated programs for science and mathematics: Review of related literature. *Int J Edu Math Sci Technol*. 2013;1(2):116-121.
[17] Asaduzzaman A, Asmatulu R, Rahman M. Teaching parallel programming for time-efficient computer applications. *Int J Comput Appl*. 2014;90(7):18-25.
[18] Marcial DE, Arcelo AQ, Montemayor JO, Launer MA. Digital trust in the academy: People, software and hardware. *Inf Technol Learn Tools*. 2022;89(3):178-189.
[19] Sun D, Li Y. Effectiveness of digital note-taking on students' performance in declarative, procedural and conditional knowledge learning. *Int J Emerg Technol Learn*. 2019;14(18):108-119.
[20] Knight J. Internationalization: A decade of changes and challenges. *Int High Edu.* 2008;50:8001.

Теоретичні та практичні основи застосування паралельних обчислень у розв'язуванні задач чисельного методу в навчальному процесі

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Анотація

Актуальність. Стрімкий розвиток інформаційного суспільства актуалізує необхідність якісної підготовки комп'ютерних фахівців у вищих навчальних закладах Казахстану. Створення сучасної системи навчання чисельних методів і паралельних обчислень має вирішальне значення для підготовки майбутніх спеціалістів до конкурентоспроможності на ринку праці, що розвивається.

Мета. Метою дослідження є обґрунтування необхідності методичної системи формування готовності майбутніх комп'ютерників у вищих навчальних закладах Казахстану. Ця система має важливе значення для забезпечення їхньої здатності використовувати паралельні обчислення для розв'язання задач чисельними методами.

Методологія. У дослідженні використано аналіз, порівняння, систематизацію, класифікацію та узагальнення теоретичних даних, а також анкетування для оцінки думок щодо рівня дослідження та значущості досліджуваних проблем. Практичний етап включав підготовку та впровадження експериментальних матеріалів, оцінку результатів за допомогою математичної статистики для перевірки актуальності авторської методики.

Результати. У ході експерименту визначено зміст понять "готовність майбутнього фахівця використовувати паралельні обчислення у розв'язуванні задач чисельними методами", "апаратні технології програмних обчислень", "програмні технології паралельних обчислень". Виявлено ознаки та особливості формування готовності майбутніх спеціалістів до використання паралельних обчислень при розв'язуванні задач чисельними методами. Створено та впроваджено методологію цього розвитку. Під час експериментальних досліджень в університеті Назарбаєва (Астана) розроблено методичний інструментарій для підвищення готовності фахівців до паралельних обчислень. Цей інструментарій включає реалізацію компонентів, критеріїв та індикаторів готовності разом із обраними методами їх розробки.

Висновки. Результати дослідження визначають ключові напрямки вдосконалення методології формування готовності майбутніх спеціалістів до застосування паралельних обчислень у розв'язуванні задач чисельними методами. Це передбачає посилення компонентів готовності студентів займатися такою діяльністю. Практичне значення роботи полягає в створенні методичної системи вдосконалення підготовки студентів і майбутніх фахівців з комп'ютерних технологій у вищих навчальних закладах Казахстану.

Ключові слова: інформатизація суспільства; комп'ютерні технології; інженерна освіта; професійна підготовка; методичний інструментарій.