Providing the Fundamentalisation of Operations Research Learning Using MAXIMA System

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Abstract. In the article, the problems of using the systems of computer mathematics (SCM) as a tool to provide the fundamental component of operations research learning and students research activities support are considered. The role of SCM in the process of bachelors of informatics training and special aspects of pedagogical applications of these systems in the "Operations research" study is defined. The analysis of the basic concepts of the fundamentalisation of education and in particular the basic concepts of the fundamentalisation of informatics disciplines learning is summarized. The attempt to distinguish explicitly and specify the fundamental concepts in the content of "Operation research" learning is made. The method of "Operation research" study using Maxima system as a tool to support the basic concepts learning and an investigation is approved. The results of the pedagogical experiment on MAXIMA application to support the fundamental component of learning in the course of "Operation research" study and the analysis of its results are reported.

Keywords: "Operations research", MAXIMA, learning tools, fundamentalsation of learning, informatics disciplines, learning environment, educational university.

1 Introduction

1.1 Research objectives

In course of information society formation as scientific and technological progress is currently enhancing, there is a challenge for an educational system to provide training of specialists for their immediate inclusion in the technological processes at the production level. After all, it is impossible to predict accurately at the time of enrollment at the university the state of the art of technological achievements that could be reached at the moment of graduation [14].

The way out of this critical situation in the education system is in the fundamentalization of education, which is due to the orientation of the education system to create holistic, generalized knowledge that would be the core of all the knowledge acquired by the student, which would unite the knowledge gained during the training process into a single system [11].

According to V. G. Kinelev, the purpose of fundamental education is to create favourable conditions for the development of flexible and multifaceted scientific thinking, various ways of perceiving reality, the formation of an internal need for self-realization and self-education throughout life [4].

Over time, the rapidly growing amount of diverse information leads to "the need for their adequate structuring and reflection in the disciplines. Mathematics and informatics disciplines play an important role in the process of mastering some of the most basic knowledge that is the basis for the formation of general and professional culture, rapid adaptation to new professions, specialities and specializations " [3].

The aim of the article is the justification of Maxima system use of in the process of "Operations research" learning in a pedagogical university as a toll for fundamentalisation of learning and providing investigative approach through the analysis of the basic concepts in the course of study.

1.2 Problem statement

The role of fundamental knowledge in modern scientific studies is mentioned in the works of many authors regarding the foundations of classical science. In particular, B.G. Kuznetsov notes that the style of physical thinking radically changed in the twentieth century. In particular, he mentions the loss of uniqueness, the erosion of the content of classical physical concepts in their relativistic interpretation [5]. “According to many scientists, in our time it is impossible to say where physics ends and technology begins, where mathematics ends and physics begins” [14], notes L. S. Khizhnyakova. This has a significant impact on the development of teaching methods in many disciplines.

In many studies, the fundamentalisation of education is associated with equal access to education. It is also considered as a "fundamentally-knowledgeable" frame of personality development, provides systematic knowledge, holistic perception of the world and the person in it, the creation of a basis for professional culture and mastery [10], [12], [12].

Nowadays it becomes necessary to form not only specific but also generalized knowledge and skills. Such knowledge and skills, formed in the process of a certain discipline study, are then available for the use in the course of the other disciplines study or for other professional activities [1], [2], [9]. The fundamentalisation of education is facilitated by the consideration and use of interdisciplinary relations, the research work of teachers and students at the intersection of basic and applied sciences [12].

1.3 The Research Methods

In the course of the study, the scientific and methodological foundations of using the Maxima system are substantiated and analyzed for the unchallenged fundamentalisation of the training of computer science disciplines for computer specialist. The study is based on the methods of theoretical analysis, generalization and systematization of scientific facts about the pedagogical processes and phenomena, methods of system analysis and modelling, pedagogical observations and generalization of pedagogical experience, as well as the results of the pedagogical experiment. The study was carried out in the framework of the implementation of the planned research undertaken in the Institute of Information Technologies and Learning Tools of NAES of Ukraine and the Department of Informatics and Computing Mathematics of the Drohobych Ivan Franko State Pedagogical University.

Such interdisciplinary methods and procedures are used in informatics as analysis and synthesis, induction and deduction, visualization and formalization, algorithmization and programming, informative-logical, mathematical and computer modelling, program management, expert evaluation, identification and others. It is necessary to acquire them in complex, otherwise, there is not a sufficient level of mastering the material of informatics disciplines.

2 The Research Results

The combination of education and science is a condition for the modernization of the education system, the main factor for further development should be provided by the fundamental education, the intensification of scientific research in higher educational institutions, research institutions [13].

S. O. Semerikov, determining the fundamentalisation of education by the totality of interrelated functions (methodological, vocational, developmental, prognostic, integrative), determines the appropriate ways to provide the educational process with fundamental components [12]:

- saturation of the content of higher education with systemic theoretical knowledge, fundamental theories, concepts, ideas;
- the dominance of research methods of teaching, creative activity, integration of ideas and methods of science, teaching and scientific creativity;
- self-development of a student as a subject of mobile educational, professional and research activities.

In the process of computer science specialists training in fundamental disciplines, it is necessary to attribute primarily philosophical, informatics and natural-mathematical, as well as professional and practical training disciplines. Along with the relevant knowledge, the opportunity to study professionally oriented disciplines should be provided, so the fundamental knowledge that is the most basic and stable in time provide the possibility of further professional growth of a specialist [12], [13].

The essential feature of the fundamental disciplines is that in the process of study the mechanisms of cognition and the basics of understanding the processes and phenomena of the world are formed. The pragmatic necessity of applying a certain mathematical apparatus or understanding the essence of a certain physical effect when performing a professional task requires additional study of mathematical and natural disciplines.

Fundamental learning provides the theoretical foundations of the speciality following the requirements for the level of theoretical training of a teacher of the corresponding profile and is based on the latest achievements of science [6].

According to M. I. Zhaldak, the use of modern ICTs plays an important role in the fundamentalisation of knowledge, a comprehensive and thorough study of the domain, the formation of knowledge necessary for a valid explanation of cause-effect relationships of the processes and phenomena studied. Fundamental knowledge is important for applied research, and the needs of everyday practical activity of people cause and stimulate the corresponding cognitive activity, aimed at the disclosure of laws of a fundamental nature [16].

Higher education in informatics is largely based, as before, on the foundations of an accumulative model of new knowledge, when skills are formed to solve standard professional tasks, act in known situations [10].

We consider the organization of information and educational space at universities as the basis for fundamental teaching of mathematics and computer science, while the task is not the formation of pragmatic, highly specialized knowledge, but methodologically important, invariant knowledge, based on a holistic perception of the world, intellectual development of personality being able to be adapted to rapidly changing socio-economic and other general processes. The fundamentalisation of informatics specialists training is based on the emphasis in the content of instruction on philosophical and mathematical foundations of educational disciplines. The practical implementation of this process in the preparation of future specialists in computer science should be carried out using computer mathematics systems that arise through supporting the teaching of mathematical and computer sciences, by combining the theoretical and applied components of student training, strengthening the professional orientation of their education and the implementation of inter subject communications [12], [15], [16].

By the fundamentalisation of informatics disciplines learning, we understand the selection of the basic concepts, fundamental theoretical principles, concepts, ideas underlying the system-forming knowledge and skills in the field of mathematical and informatics disciplines, the implementation of interdisciplinary communications, providing a competency-based approach to improve the level of training students, their full-fledged activities in the information society [15].

An analysis of the basic concepts of the fundamentalisation of education is summarized in Table 1.

In the process of teaching first-year students of speciality 014 Secondary Education (Informatics), Ivan Franko Drogobych State Pedagogical University revealed their conscious orientation for work in the field of computer science. Most of them feel confident when working with popular software environments and quickly perform typical operations. But the need to deviate from the usual technological schemes causes difficulties. The experience of introduction of the systems of computer mathematics (in particular, MAXIMA) into the learning process obtained during the educational experiment that had been conducted in Ivan Franko Drogobych State Pedagogical University in 2016 was disseminated into the learning process of the several educational institutions of Ukraine (Ternopil Volodymyr Hnatiuk National Pedagogical University, Kryvyi Rig National University, Kherson State University and others) [15].

Table 1. Analysis to understand fundamental

Fundamental	large, strong, stable, deep, basic, main (Ozhegov SI)
Fundamental knowledge	stable and universal general theoretical knowledge, the content of which is noted by generalization, structuredness, in which the internal-no and external connections of various subject areas are revealed, based on which the person's ability is formed to learn new knowledge, to navigate problems (a tool to achieve scientific competencies) (Laptiev V.V.) [6].
Fundamental preparation	strengthened interconnections of theoretical and practical training of a specialist for professional activity, aimed at the formation of a holistic scientific picture of the world, at the individual and professional development of a student, together provide a high level of education (S. Semerikov) [1210].
Fundamentalization of education	a qualitative change in higher education based on the principle of fundamentality, the introduction of theories of a high degree of generalization, with increased information capacity and universal applicability into the educational process (A. Rostovtseva).
Fundamentalization of informatics education	improving the quality of the fundamental preparation of the student, his system-forming and invariant knowledge and skills in the field of computer science, makes it possible to form the qualities of thinking necessary for full-fledged activity in the information society, for the dynamic adaptation of a person to this society, for the formation of the internal need for continuous self-development and self-education, accounting for corresponding changes in the content of academic disciplines and the methodology for the implementation of the educational process (S. Semerikov) [12].
Fundamentalization of informatics training	the selection in the content of the discipline of basic concepts, fundamental theoretical principles, concepts, ideas underlying system-forming knowledge and skills in the field of mathematical and informatics disciplines, the implementation of intersubject communications, providing a competency-based approach to improve the students' level of training, their full-fledged activity in the information society (Shyshkina M.P., Kohut U.P.) [14].

The learner begin to iterate through the available actions to obtain the desired result. The reason for this is the lack of knowledge of those fundamental theoretical and technical principles on which these environments are built. And as a result, the system construction of a new algorithm is practically impossible.

There is a shift in the content of knowledge to the technological side. This is the fact that in real information processes it is objectively difficult to distinguish explicitly and specific fundamental components. The training of mathematical and computer science disciplines as fundamental can be carried out as follows:

- for any level of education, a system of fundamental theoretical principles, concepts, methods and means is being developed, which are studied in this discipline and successfully assimilated. According to such a system, the boundaries of fundamental knowledge for a chosen level are determined;
- the system of each level is used as the basis for the system of the next level and is supplemented by new components and theoretical justifications of previous components;
- the study of each theoretical component is necessarily accompanied by its practical use in the most accessible form. In this case, the student will understand not only the content of the component but the fact that knowledge of the theoretical foundations of computer science is very important for solving practical problems will be obvious. It is very important to show the existence and ways of using the fundamental components of knowledge in modern computer programs and technologies. In this case, the material will be better absorbed.

In mathematical and computer science disciplines three components must be presented in unity: scientific, technical and technological. But they are implemented differently depending on the level and goals of training. At each level, a place must be found for fundamental knowledge.

The role of the fundamental component is often underestimated. In pedagogical practice, training will be introduced primarily in the technological direction. The methods and techniques used are theoretically substantiated and not analyzed. Students have a poor understanding of the fundamental component of computer science courses compared to mathematics and physics. This is because in real information processes it is objectively difficult to identify, clearly and characterize specific fundamental components. At the same time, fundamental concepts play a key role in the process of fundamentalisation of training, which is also closely related to the basic concepts of related disciplines.

In computer science, such interdisciplinary methods and procedures are used as analysis and synthesis, induction and deduction, visualization and formalization, algorithmization and programming, information-logical, mathematical and computer modelling, program management, expert evaluation, identification and others [12]. They must be mastered comprehensively, otherwise, there will not be a sufficient level of mastery of the material of information disciplines. All this testifies in favour of fundamentality of the content of the training.

At the same time, fundamental concepts play a key role in the process of fundamentalisation of education, which is also closely related to the basic concepts of related disciplines.

For example, the fundamental concepts of an algorithm and operation are closely related to the concept of a function, which can be associated with an operation, the implementation of which implements this function. Considering the concept of algorithm and operation only from the procedural side, that is, as a prescription characterizing the transformation that must be performed, the process side of this concept remains aside. Then the algorithm acts as a process for solving a specific problem, the result of which is a solution. This concept acquires applied to content in solving problems arising in practice. At the same time, excessive bias towards the applied application of the algorithm does not contribute to understanding its relationship with the mathematical foundations of this theory.

Therefore, the selection of the fundamental concepts of informatics disciplines, their awareness and consolidation of the experience of research activities is an integrable component of the organization of training, the creation of intersubject communications, the formation of a holistic system of knowledge and ideas among students about both the theoretical basis and the ways of applying the acquired knowledge in practice.

It is the relationship with the mathematical foundations that are an essential factor in the fundamentalisation of the teaching of information disciplines. In particular, a possible reason for misunderstanding in many cases is that it is not possible in the right sense to consider the relationship between the various aspects of solving the problem - constructing an analytical relationship, and based on the mathematical laws governing the description of the phenomenon, the very phenomenon that a computer program implements are obtained. Using a computer program, you can simulate the dynamics of the system or the manifestation of a phenomenon.

In various disciplines consider modelling various phenomena. In this sense, it is advisable to focus further attention on one of the disciplines where it would be possible to demonstrate the advantages of a systematic approach. For this, the discipline "Operations Research" was chosen, which later became the subject of an experimental study.

Operations research is the theory of using scientific quantitative methods to make the best decisions in various fields of human activity. This science gives objective, quantitative recommendations for managing targeted human actions.

The following fundamental concepts arise in the study of operations: an operation, a system, a model, modelling, a systematic approach, a task, an optimality criterion (quality, efficiency), as well as closely related concepts of a method, procedure, function, in general form the fundamental core of learning mathematics - of general and informatics disciplines. Besides, the so-called fundamental algorithms (methods) play an important role in the content of training in the study of operations, which must be mastered when solving a certain set of classical problems: resource allocation problems (transport problem, assignment problem) network planning problem; the task of choosing a route (the travelling salesman problem) problems of game theory.

By the example of teaching this discipline, one can demonstrate the relationship of mathematical methods and the implementation of the corresponding operations and algorithms with the visualization of results, which reflect the relationship of certain objects and their properties. Based on the curriculum of the course "Operations Research" for the specialities 014 Secondary Education (Informatics) of the Drogobych State Pedagogical University, the fundamentalisation of operations research training can be generalized as follows (Fig. 1).

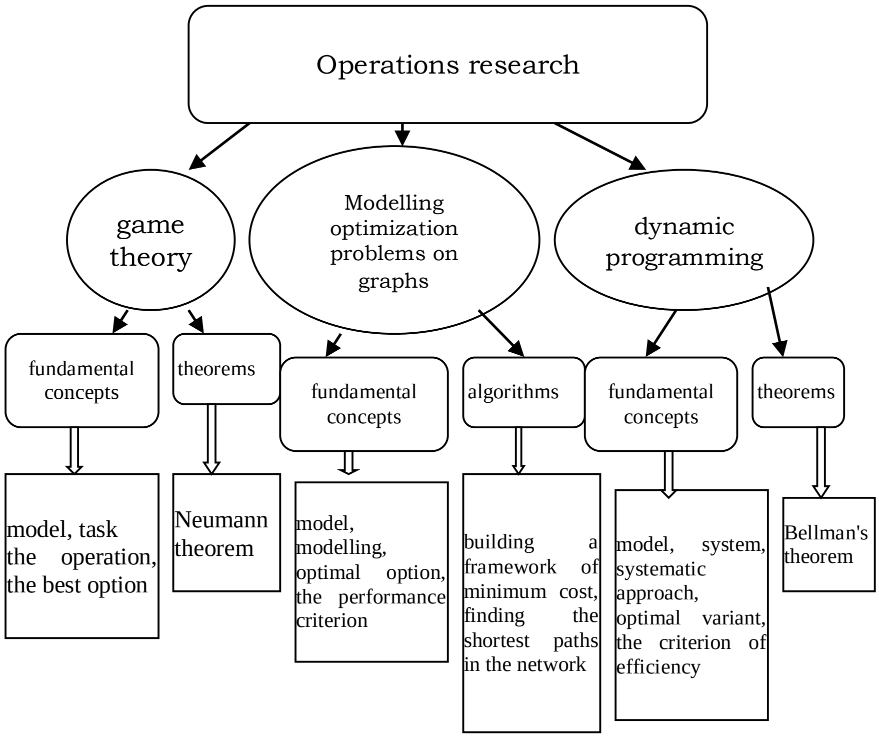

Fig. 1. Fundamental concepts of operations research

To uncover the essence of the problems that arise in the search for the advantages of using ICT in teaching operations research, we need to consider the concept of an educational task.

The training task is aimed at mastering a certain mode of action, while the practical task is to obtain the result contained in the task condition. When solving any of these problems, the subject acquires certain knowledge, but it is the educational tasks that have an exceptional impact on the functioning and development of educational activity [7].

By the example of training in the study of operations, one can demonstrate the relationship of mathematical methods and the implementation of their corresponding operations and algorithms with the visualization of results, which reflect the relationship of certain objects and their properties. This relationship is reflected in the model of the educational task "Operations Research".

The model of using the training task with “Operational Research” (Fig. 2.) reflects the interconnection of fundamental concepts, mathematical method, fundamental algorithm, algorithm and operations that are implemented in the process of solving. This shows the role of fundamental concepts as an integrative component of the training “Operational Research”.

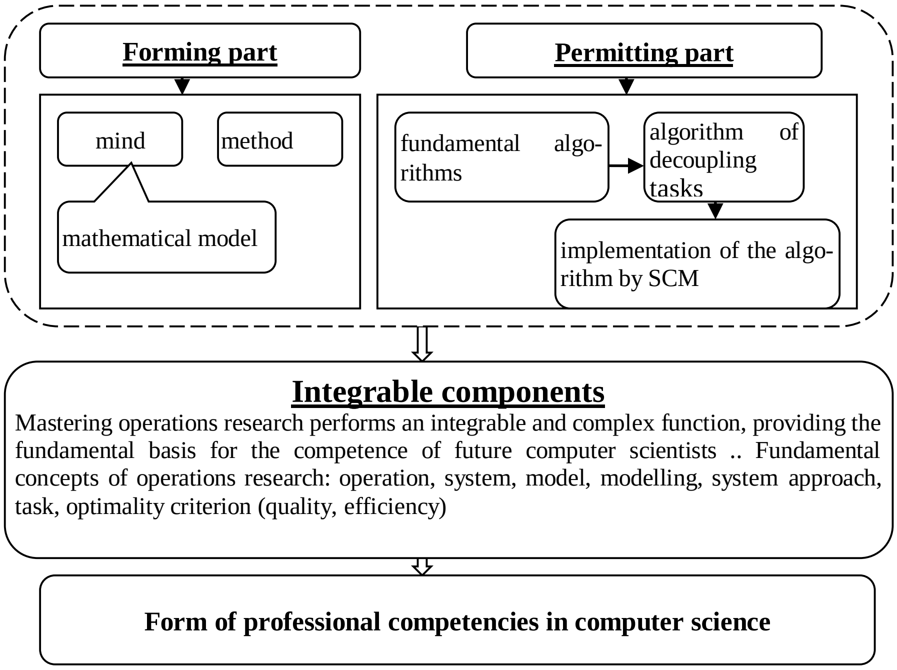

Fig. 2. The model of primary tasks with the previous operation

The use of ICT, in particular SCM as a means of training, is associated with problems of increasing the level of fundamental training of future specialists in computer science:

- combination of theoretical, applied and practical aspects;
- presentations in a systematic form of theoretical information about methods and the main provisions of decision theory, computer mathematics systems and the formation of practical skills for their application to solving real practical problems;
- deepening students' knowledge on issues related to the study of the effectiveness of solving applied problems using computer mathematics systems, analysis and interpretation of the results;
- development of the algorithmic style of students' thinking through the development of algorithms and their software implementation;
- the formation of students' skills of independent work with theoretical material and computer mathematics systems.

Correctly selected tasks of professional orientation for laboratory work enable the teacher to use SCM as a means to ensure inter subject communications between computer science and mathematics. The foundation is laid for the formation of ICT competencies [15].

For each laboratory lesson, individual task options have been developed that are divided into three difficulty levels. The difficulty level of the assignment for completion is selected by the student. The task of the first level of complexity corresponds to the reproductive level of assimilation of knowledge and is evaluated by a small (up to 5 points) number of points. To solve problems of the second level of complexity, the heuristic nature of the intellectual activity is required; tasks are estimated by the average (up to 15 points) number of points. The third level of complexity includes tasks that require a creative approach. The tasks are formulated in such a way that for their solution it is necessary to have elements of divergent thinking. Divergent thinking is usually inherent in creative individuals, inclined to create new combinations of those elements, others use only the usual way. With the successful completion of tasks of this level, the student deserves the most (up to 20 points) number of points. Thus, differentiation of training is implemented, the student sees the results of his work and can evaluate the objectivity and accuracy of rating points [15].

The most important element of laboratory studies in the course "Operations Research" appropriately selected tasks. Tasks are given to students taking into account the fundamentals of the theory presented at the lecture. As a rule, in a laboratory lesson, the main attention is paid to the formation of specific abilities and skills, based on which the content of students 'activity is determined - solving problems, graphic works, clarifying categories and concepts of the studied discipline. When analyzing tasks with students, the teacher should pay special attention to the formation of abilities to comprehend and understand the material on the topic.

Considering the system of individual tasks for laboratory work, as well as tasks for the practical protection of modules, one should analyze the problems and advantages of using such tasks. When preparing tasks, you should carefully approach the determination of the level of difficulty. This can only be helped by the teacher's experience, his ability to identify key points in the training material, and understanding the relationship of the tasks with other disciplines. Also important is the question of the relationship of difficulty levels in one task. For laboratory work, it is more appropriate to set tasks where the fulfilment of tasks of a higher level of complexity is possible provided that the tasks of the previous level of complexity are completed. Otherwise, students often overestimate their capabilities, take on complex tasks immediately, cannot complete them, and they don't have enough time to complete simple tasks. Thus, they do not gain those rating points that they could gain by correctly assessing their capabilities. It is advisable to use tasks of different difficulty levels when conducting modular controls and exam tickets, where you need to cover all the training material.

Each laboratory work is accompanied by a list of questions for self-examination and several tasks to perform during students' independent work. The main task is to form practical skills for future specialists in formalizing tasks and solving them using SCM tools.

On the advantages of a system of multi-level individual tasks, the accuracy and objectivity of the assessment come to the fore here. The classical four-point student competency assessment system, despite its usual simplicity, had some drawbacks regarding the objectivity of assessment. A 100-point rating system gives greater accuracy in the assessment, but here the problem arises of ensuring this accuracy - what maximum error can a teacher make when setting rating points. Differentiation of the complexity of tasks, and accordingly the number of points for their implementation, allows to some extent to ensure acceptable accuracy and objectivity of the assessment.

Differentiation of the rating of students is also carried out according to a disciplinary indicator. It would be wrong to give equal scores to students who complete the curriculum on time and to those who, for no good reason, are significantly late. In this case, students, although successfully, did the laboratory work on time, passed the module control, etc., receive only 1 point for the control element, regardless of the level of complexity of the tasks performed.

Table 2 shows an example of a variant for determining the semester rating of student performance.

Table 2. Scores ratings per semester

Form of control	Number of points	Number of control measures per semester	Total points
Attending classes	1	10	10
Performing laboratory work 1st level of difficulty 2nd level of difficulty 3rd level of difficulty	 0,5 1,5 2	 10 10 10	 5 15 20
Writing a report for each laboratory work	1	10	10
Practical protection of each laboratory work	1	10	10
test	30	1	30
Total for completing tasks: *1st level of difficulty* *2nd level of difficulty* *3rd level of difficulty*			 65 80 100

3 Implementation and Evaluation

The results of the pedagogical experiment on the use of Maxima system in the process of "Operations research" teaching.

During 2016-2019 the experimental research has been conducted. During the experiment, the SCM MAXIMA was implemented in the process of "Operations research" teaching concerning the students of the Institute of Physics, Mathematics, Economics and Information Technology of the Drohobych Ivan Franco State Pedagogical University (education and qualification level "Bachelor", for the specialities 014 Secondary Education (Informatics). In the experiment, the specially worked out methodology of "Operations research" teaching using Maxima system was tested. In the experiment, on his forming stage, 50 students participated. The experiment confirmed the research hypothesis concerning the increase of the level of professional competences development in the process of studies according to the worked out methodology. It also showed that using cloud technology students can achieve greater access to the means of research activities (it is possible to attain expansion of access to research activity facilities).

In the experiment, they involved both the local version of the system, installed on the student computer desktop and the cloud-based version that was posted on the virtual desktop.

Results formative stage of the pedagogical experiment in the control and experimental groups and comparative histogram distribution educational achievements students on the results of the final exam discipline "Operations Research" is shown in Fig. 3.

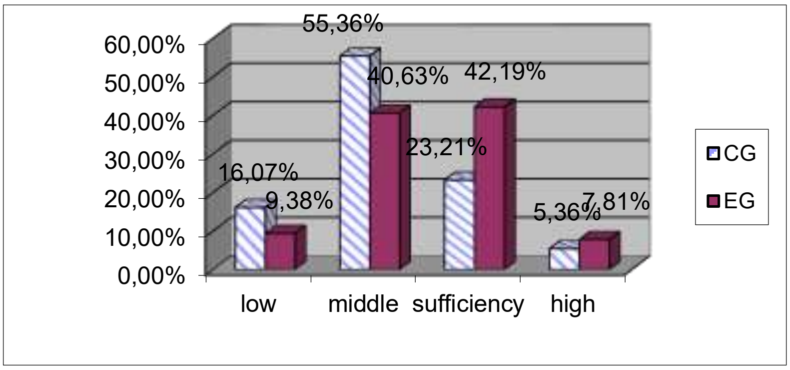

Fig. 3. A comparison of educational achievements of students on the results of final control the course "Operations Research" after the forming stage of the experiment

Processing of the experiment results and evaluation of the efficiency of the developed technique was carried out by methods of mathematical statistics [15]. The objective of the experiment was to identify differences in the distribution of certain characteristic (the level of formation of individual components of professional competence) comparing two empirical distributions according to the χ 2 - Pearson criterion, λ – Kolmogorov-Smirnov criterion [15].

χ2 - Pearson criterion. The samples in the study are random and independent. The measurement scale is C = 7 categories (1-39, 40-59, 60-66, 67-74, 75-81, 82-89, 90-100). The number of the degree of freedom v = C – 2 = 5.

The null hypothesis H0: the distribution of the estimates for the student residual knowledge concerning the use of systems of computer mathematics in the control (n1 = 56) and experimental samples (n2 = 64) to the forming stage of the experiment do not differ (i = 0, 1, …, 6).

Q1i – number of participants in the control group who scored i points;

Q2i – number of participants in the experimental group who scored i points.

Alternative hypothesis H1: the distribution of the estimates for the student residual knowledge concerning the use of systems of computer mathematics in the control (n1 = 56) and experimental samples (n2 = 64) to the forming stage of the experiment differ (i = 0, 1, …, 6).

The value of χ2 is calculated according to the formula

$$T_{\exp} = \frac{1}{n_1 n_2} \sum_{i=0}^{C-1} \frac{(n_1 Q_{2i} - n_2 Q_{1i})^2}{Q_{1i} + Q_{2i}} \quad (1)$$

The results of calculating statistics of these samples are given in the Table. 3.

Table 3. The calculation of the χ2 for the control and experimental groups before the forming experiment

I	Q1i	Q2i	S12i
0 (F)	0	0	0
1 (FX)	28	36	3136,00
2 (E)	36	38	1674,38
3 (D)	18	24	3510,86
4 (C)	16	18	30,12
5 (B)	10	6	23104,00
6 (A)	4	6	2560,00
T			2,372723

From the table of values, χ2 for the level of significance α=0,05 and number of degrees of freedom of v = C – 2 = 5 determine the critical value of statistics of Tcritical = 11,07.

Since the obtained value Texp< Tcritical (2,372723< 11,07) does not fall in the critical region [χ2, +∞], this suggests that before the forming stage of the experiment the level of students' residual knowledge concerning SCM using in the control and experimental groups do not differ significantly.

The level of students knowledge on the course "Operations research" as well as professional disciplines was checked according to the results of complex state examination to justify the influence of methodology of SCM using as "Operations research" teaching tools on the increase of the level of some components of professional competence.

Null hypothesis H0: distribution of students estimations on "Operations research" in the control (n1 = 56) and experimental samples (n2 = 64) after the formative forming stage of the experiment do not differ (i = 0, 1, …, 6).

Q1i – number of participants in the control group who scored i points;

Q2i – number of participants in the experimental group who scored i points.

Alternative hypothesis H1: distribution of students estimations on "Operations research" in the control (n1 = 56) and experimental samples (n2 = 64) after the formative forming stage of the experiment differ (i = 0, 1, …, 6).

The calculation results of the statistics of these samples are given in Table 4.

The calculation of χ2 criterion for the experimental and control samples after conducting the formative stage of the experiment showed that Texp >Tcritical (30,20408> 11,07). This is the reason for rejecting the null hypothesis.

The acceptance of the alternative hypothesis suggests that these samples have statistically significant differences, i.e., the experimental method is more effective than the traditional one.

Table 4. Calculation of $\chi 2$ for the control and experimental groups after the formative experiment on the course "Operations research"

I	Q1i	Q2i	S12i
0 (F)	0	0	0
1 (FX)	18	12	30720,00
2 (E)	50	22	215168,00
3 (D)	12	30	79213,71
4 (C)	14	34	84672,00
5 (B)	12	20	15488,00
6 (A)	6	10	7744,00
T			30,20408

Taking into account that in the experimental groups the training of students was performed according to the developed methodology, it can be assumed that this contributed to the achievement of better results. Therefore, it is possible to speak of experimental confirmation of the hypotheses.

Summarizing, we conclude that the pedagogical experiment confirmed the hypothesis of the study. Analysis of the results indicates the increase in the level of formation of individual components of professional competence using the developed methodical system and, consequently, its effectiveness.

4 Conclusions and Prospects for Further Research

SCM implementation in the process of teachers training and also the process of computer science professionals training provides an opportunity to intensify the educational-cognitive activity of students, assists to development of their creative abilities, mathematical intuition and skills of research activities realization. SCM systematic using contributes to students attitude toward a computer as to the means of solving professional problems. Such students gain more knowledge not only in mathematical disciplines but also in computer science. As a rule, they have no psychological barrier to using sophisticated software tools. On the contrary, they are attracted by the programs created at a high professional level, and they notice the unique application possibilities of such systems. SCM is an environment for learning tools projecting and, consequently, can be used for the creation of innovative pedagogical technologies.

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