# Heuristic Teaching Methods Of Professional Junior Bachelors In Software Engineering

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**Abstract:** The article theoretically substantiates the methods of heuristic training of professional bachelors in software engineering. The historical aspect of the origin of heuristics is realized. Scientific and methodological literature on this issue is analyzed. The main definitions of the heuristic learning theory are revealed. The meaning of the concepts: "heuristics", "heuristic learning" is specified. The main methods and techniques of professional junior bachelors' readiness formation of in software engineering for heuristic activity in the process of professional training are indicated. The application of heuristic methods of professional junior bachelors in software engineering is argued. The solution of many problems of different CAS and systems of automation of mathematical calculations is defined. The specificity of professional disciplines in the IT field is directly related to abstraction, algorithmic modeling and database structures. The study of educational and methodological literature on the topic of graduation work and the development of existing experience of teachers on this topic and its use in their activities, gave the opportunity to determine the main directions of further work and use the results of this study. preparation of future bachelors of software engineering. The expected pedagogical effect from the use of epy heuristic activities is stated: increasing the motivation of professional junior bachelors in software engineering to heuristic activities; increasing their interest in self-development and self-improvement.

**Keywords:** heuristic methods, heuristic methods, heuristic training, professional bachelors in software engineering.

## 1. Introduction

The relevance of this study is due to several factors. First, the change of generations, the ephemerality of events and the development of technology require from professional bachelors in 121 "Software Engineering" to use theoretical and fundamental knowledge, skills and abilities to succeed in solving complex specialized problems and "practical problems during professional activity in the field of computer science and information technology, computer technology and modern technologies of design and programming of information systems" [9], possession of integrated competence.

Secondly, the formation of professional competencies will enable professional junior bachelors in software engineering to realize both personal goals and the demands of society.

Thirdly, self-development, self-knowledge, self-discipline and the culture of heuristic thinking are the key to self-realization in professional activities [3].

The subject of this work is ecologically embedded in the modern concept of education, the main purpose of which is the comprehensive development of the individual, which should be characterized by: motivation for development, communication skills, professional skills, competence (technical and behavioral). The purpose of professional activity of professional junior bachelors in software

engineering is not mastering the information system and, thus, the basics of science, but the formation of abilities to perform heuristic activities. Information occupies a structural unit in the overall purpose of professional activity only until a certain point, and then this information should be widely used in practice as a means of regulating the heuristic activities of professional junior bachelors in software engineering [7].

## 2. Analysis Of Recent Research And Publications

Issues of heuristic learning organization were studied by domestic and foreign scientists: in psychology (G. Bush, V. Krutetsky, A. Luk, V. Pushkin), philosophy (A. Bransky, A. Kudryashov, V. Mantatov and others), engineering, technology, cybernetics and pedagogy (P. Kapterev, V. Andreev, A. Khutorsky). A. Khutorsky is considered to be the developer of the original scientific and pedagogical concept of heuristic learning [10]. Its development is a heuristic learning technology, which is based on individuality in the creative self-realization of students with the collective study of subjects.

The analysis of the works of the above authors confirms that the heuristic approach is based on the psychology of creative thinking, the procedure for finding something new, an attempt to formalize creative activity. Based on the definition of the formation of heuristic activities according to O. Skafa [8], in the formation of professionally-oriented heuristic activities of bachelors in engineering software, we will understand new educational products and new personal qualities of the future specialist, his ability to consciously act in a situation of choice, to set and achieve their own goals, to act productively both during training and in future professional activities.

The purpose of the article is to concentrate the main achievements of methodical support of junior bachelors' preparation in software engineering for heuristic activities for further use of the obtained essences in the formation of creative thinking, heuristic skills, algorithmic techniques. According to the purpose the following tasks of the article are defined:
- to analyze the history of heuristics;
- to clarify the content of interrelated basic concepts;
- to substantiate the methods and techniques of forming the readiness of professional bachelors in software engineering for heuristic activities in the process of professional training.

The term "heuristics" is primarily associated with the ancient Greek scholar Socrates (469-399 BC), who built his own system of learning based on the use of special questions, the so-called "dialogues" of Socrates. The method (mayevtics) is that the correct questions to the opponent or student "force" the latter to draw their own conclusions and conclusions, to learn something new. Socrates' famous saying "I know I know nothing" is the initial heuristic formula of his teaching system. On the other hand, everyone knows that this is another scientist who loudly shouted "Eureka!". This term translated from Greek ("heureka") means "I found!", Which Archimedes announced his discoveries, "insight" – a sudden guess, insight, enlightenment, insight into something [5]

In the third century AD the mathematician Pope of Alexandria wrote The Art of Problem Solving. He summarized the work of ancient mathematicians and showed how to solve problems that can not be solved using mathematical and logical techniques. He called this method "heuristics". In Book 3 of the Science of Learning, the Czech mathematician Bernard Bolzano (1781–1848) wrote about 14 techniques, which he called the "art of discovery". In modern interpretation, they would look like this [2]:
- ask questions clearly;
- specify the boundaries of the study;
- establish the correspondence of the questions with the available knowledge;
- develop a combination of subtasks and choose methods for solving them;
- withdraw solutions from the arsenal of knowledge, if possible;
- put forward a hypothesis by direct and indirect induction;
- combine techniques;
- compare the solution with known knowledge;
- check the correctness of all logical inferences;
- check the correctness of all definitions and judgments used;
- express all concepts using the appropriate signs;
- strive to form visual images of the objects of the problem;
- logically formulate the result;
- evaluate all pros and cons of the result;
- solve the problem as carefully as possible.

The tasks that a person must be able to solve in the course of their activities are extremely multifaceted. It is impossible to teach in the process of learning to solve all the problems that may arise in life: their number is almost immeasurable. At the same time, students should be given the opportunity to show a diverse approach to solving problems, to prepare so that in the future they will be able to solve a variety of open general scientific and professional problems. This can be done by helping professional bachelors in software engineering to acquire skills of independent search for patterns, acquainting them with fairly general universal methods and techniques of independent purposeful search for solutions, ie heuristic techniques [2].

Consider the pedagogical aspect of the application of heuristics. In the general sense, heuristics is "the science of creativity and creative activity of people in order to obtain new results in the field" [10]. Heuristics is also a "process of finding a new product of activity", so the purpose of heuristics is to study the methods, techniques and rules for discovering and finding a solution to a problem.

A. Khutorsky separates the concept of "heuristics" and "didactic heuristics", recognizing the latter as a "theory of learning" that defines a system of goals, patterns, principles, content, technology, forms, methods and tools that ensure self–realization and educational development of teachers and students. the process of creating educational products in the areas of knowledge and activities they study. Analyzing the educational aspect of heuristics, we clarify the meaning of the concept – "heuristic learning" as learning, the purpose of which is to construct the student's own meaning, goals and content of education, as well as the process of its organization, diagnosis and awareness.

There is also the concept of "degree of creativity", the

essence of which A. Khutorsky defines as the definition of the teacher after the initial diagnosis of bachelors' knowledge of engineering software subjective and objective novelty of the created educational product [10].

In the history of related mathematical education there are many examples of building a system of heuristic learning by such outstanding scientists and mathematicians as R. Descartes, G. Leibniz, D. Poya [6] and others. According to O. Skafa [8], the basis for the formation of a system of heuristic techniques is based on five interrelated components: goals, content, methods, organizational forms and teaching aids that have heuristic components. Therefore, we believe that professional junior bachelors in software engineering need to give an example of adjusting learning objectives, which will promote better learning and the formation of skills to determine heuristic learning objectives.

Heuristic skills can be implemented in the process of obtaining knowledge obtained on the basis of logical processing and transformation of certain information using existing knowledge, intuition, insight and heuristic methods of mental activity, the quality of which is an indicator of their assimilation.

Thus, in the concept of heuristic learning, there is a system of interrelated basic concepts. There are many of them, which causes difficulties in understanding. Therefore, there is a methodological need to schematize all educational material.

Heuristic methods of mental activity include:
– analysis based on synthesis – knowledge of new aspects, qualities and properties of the studied objects, by including these objects in the system of connections and relationships in which these new properties can be detected;
– comparison – mental action, which establishes similar (comparisons) and different (contrasts) qualities and properties of certain objects and phenomena;
– abstraction – a mental action aimed at identifying in objects and objects essential for this study properties and imaginary distraction from insignificant;
– generalization – a mental action aimed at identifying a significant common property that belongs to the set of objects that unite them;
– systematization – the reception of mental activity, in the process of which the studied objects are arranged in a certain system on the basis of a general principle;
– classification – the assignment of individual objects or phenomena to the appropriate genus or class;
– analogy – a mental action aimed at gaining new knowledge about the properties, characteristics, relationships of objects and phenomena being studied, on the basis of partial similarity with other objects or phenomena;
– "summarizing" and "drawing conclusions" – a method of mental action required in solving problems, formulating concepts and proving inferences.

The main stages of formation of methods of heuristic activity are allocated:
– awareness of the problem, the solution of which requires the use of a certain technique;
– awareness of the need to master this technique;
– mastering the content of the reception, the sequence of relevant operations;
– performing exercises aimed at working out the operational staff of the reception;
– self-control over the level of mastery of the reception;
– use of reception in standard and non-standard situations;
– deepening and generalization of reception.

Techniques of heuristic activities are divided into general and special. The general methods include those used in the study of various subjects, and the special – techniques used only in the study of a particular discipline, such as computer science.

The sequence of formation of methods of heuristic activity of bachelors in engineering of lost software has the form [1]:
- creation of a problem situation;
- disclosure of the essence and significance of the reception;
- allocation of operational staff;
- separate testing of operations;
- generalization of operations and drawing up indicative bases of activity;
- transfer of admission to new educational material.

Heuristic learning is based on a number of psychological and pedagogical laws with the corresponding principles.

The first law and the corresponding principle of co-creation in the process of solving a creative task, where the group leader, based on a democratic style of communication, encouraging imagination, unexpected associations, stimulates the emergence of original ideas and acts as a co-author. And the more developed the ability of the leader to cooperate and co-create, the more effective, other things being equal, the solution of creative tasks. The second law and the corresponding principle of trust in each other's creative forces and abilities. All participants are on equal terms: with a joke, a successful remark, the leader encourages the slightest initiative of the members of the creative team.

The third law and the principle of using the optimal combination of intuitive and logical. In terms of generating ideas, it is optimal to weaken the activity of logical thinking and encourage intuition. This is greatly facilitated by such rules as the prohibition of criticism, delayed logical and critical analysis of generated ideas. A friendly psychological microclimate creates conditions for freedom, activates intuition and imagination.

The importance of the heuristic question method is to use the collection of additional information in a problem situation or to organize information in the process of solving a creative problem. Heuristic questions were widely used in his scientific and practical work by the ancient Roman philosopher Quintilian. He recommended that all major politicians, in order to gather complete information about any event, ask themselves seven key (heuristic) questions and answer them: who? what? why? where? what? how? When?

The advantage of the method of "heuristic questions" is its simplicity and efficiency for solving any problem. Heuristic questions especially develop intuition of thinking. Disadvantages and limitations: it does not give particularly original ideas and solutions and, like other heuristic methods, does not guarantee absolute success in solving creative tasks.

The peculiarity of the method of "multidimensional matrices" among researchers and inventors is also known as the method of "morphological box" or the method of "morphological analysis" is to solve creative problems, namely, very often another combination of known elements (devices, processes, ideas, etc.) or combination of the known with the unknown, the matrix method allows you to do it not by trial and error, but purposefully and systematically. Thus, the method of "multidimensional matrices" is based on the principle of systematic analysis of new connections and relationships that are manifested in the process of matrix analysis of the research problem. It allows you to solve complex creative problems and find many new, unexpected, original ideas. Disadvantages and limitations: even when solving problems of medium difficulty in the matrix can be hundreds of solutions, the choice of which is optimal is difficult.

The method of "free associations" is that in the process of creating associations, extraordinary relationships are established between the components of the problem and elements of the outside world, including components of past creative experience of persons involved in collective problem solving. As a result of the process of creating new associative connections, a creative idea of solving the problem arises.

The method of inversion is one of the heuristic methods of creative activity, focused on finding ideas for solving creative problems in new, unexpected directions, often contrary to traditional views and beliefs, which are dictated by formal logic and common sense.

The inversion method is based on regularity and according to the principle of dualism, dialectical unity and optimal use of opposite (direct and inverse) procedures of creative thinking: analysis and synthesis, logical and intuitive, static and dynamic characteristics of the object, external and internal sides of the object. If you can not solve the problem from start to finish, then try to solve it from start to finish, etc.

The undoubted advantage of the inversion method is that it allows to develop the dialectic of thinking, to find a way out of a seemingly hopeless situation, to find original, unexpected solutions to different levels of complexity and difficulty of creative tasks. Its disadvantage is that it requires a fairly high level of creativity, basic knowledge, skills and experience.

The method of empathy, which means identifying one person with another in order to mentally put yourself in the position or situation of another. It is no coincidence that empathy (personal analogy) in solving a creative task is understood as the identification of a person with an object, a process. When using the method of empathy, the object is given the feelings, emotions of man: the indexation of purpose, functions, capabilities, pros and cons, such as identifying the machine and their own. It's as if a person is merging with an object.

Thus, the method of empathy (personal analogy) is based on the principle of replacing the object under study, the process with others. With this in mind, the method of empathy is one of the heuristic methods of solving creative problems, which is based on the process of empathy, ie identification with object and subject of creative activity, understanding the functions of the subject based on "use" in the image of the invention. attributed to personal feelings, emotions, ability to

see, hear, reason, etc.

To some extent, the method of organized strategies helps to overcome the inertia of thinking. In the method of organized strategies, one of the main psychological barriers to solving creative tasks is the inertia of thinking and the inability of the decisive to go, abandon the most traditional way and find a new approach, direction in the search for solutions. To choose the right direction of the strategy of finding the idea of the solution should avoid the fear of losing the main more original strategy, the idea. At the heart of this method are the principles of: self-government of the individual in choosing new strategies for solving creative problems; reproduction of an object, subject, process from different positions and a new point of view.

Scientists have introduced a system of characteristics of creative thinking that can be diagnosed and developed in the process of learning mathematics: non-standard, unconventional thinking (characterizes the openness and ability to create); divergence of thinking (characterizes the range of creativity); heuristic thinking (characterizes the specifics of the creative process); efficiency of thinking (characterizes the effectiveness of creative activity); intellectual activity (the presence of the subject of the driving forces of creativity). Using various methods, techniques and teaching aids, the teacher directs the cognitive processes of students, brings them in line with the objectives of creative thinking. The main task is to organize the cognitive activity of bachelors in engineering software so that it is the most rational and productive, so that the study material is assimilated by them deeply, firmly and consciously. An effective way to encourage bachelors in engineering software to think creatively is to ask the right questions. It is advisable to ask more often about what the student is doing, why he is doing it exactly, why his action is correct. It is recommended to ask such questions not only in cases where an error is made, but constantly, teaching bachelors in software engineering to a detailed explanation and justification. Questions about the activity of bachelors in engineering software are effective in terms of their productivity, compliance with the tasks. You need to ask: about the reasons (Why? How? Who?); delve into the answer (Why not? What will change if…?); look for alternative theories (Is there another possibility? Where else has something like this been used? What does intuition suggest?)

Different CAS and mathematical computing automation systems are used to solve many problems. But these systems require only input and selection of the mode of operation, which immediately gives the answer. With these systems, you can solve problems without knowing the theoretical basis. Excel has a wide arsenal of tools for solving problems of probability theory and mathematical statistics, which are necessary for the formation of mathematical competencies of future programmers. For example, we use educational and methodological instructions that help to understand the work with the software.

1. On the toolbar select "Insert function";
2. In the window appeared, select the category "Statistical" and the function "EXP.RASP";
3. Fill in the arguments of the function "EXP.RASP";
4. Record the result.

5. There is a value of the function "EXP.RASP" for x = 1/3, equal to 0.632.

6. Similarly, the value of the function "EXP.RASP" for x = 1/2, equal to 0.736.

7. There is a value of the function "EXP.RASP" for x from 1/2 to 1/3, equal to 0.104.

The specifics of professional disciplines in the IT field are directly related to abstraction, algorithmic modeling and database structures. Information and computer technology is evolving at a very rapid pace: generations of hardware and software are changing their predecessors more often than users are gaining the skills to work with them. This situation is ambiguous for IT students.

On the one hand, you need to learn the basic components, on the other – there are already many ready-made applications, programs and other tools that allow you to create quality products without penetrating into the essence of processes and logic of their construction.

Students of the specialty "Software Engineering" are offered several programming languages to study. And sometimes there are questions about the logic of building logical constructions of code written in different languages. Tables of comparisons of basic structures, which students fill in individually, but more often during the group work, can be used to resolve misunderstandings.

For example, to compare programming languages, we offer a type of work: find the main differences and determine which programming language copes with the task the best. Consider the results of a comparison of Python and Pascal programming languages as an example.

A) Simple syntax and low login threshold. Python uses indents instead of punctuation and keywords to denote a block. One-line programs cannot be run in Python. This reduces the size and increases the ease of perception of the code. Let's compare the syntax of the loop with the premise (Table 1).

*Table 1. Simple syntax and low login threshold*

| Pascal | Python |
|---|---|
| while s + n < 150 do | while s + n < 150: |
| begin | s = s + 15 |
| s := s + 15; | n = n - 5 |
| n := n - 5 | print(n) |
| end; | |
| writeln(n) | |

B) Dynamic typing. This means that the variable is associated with its type directly at the time of assignment, ie there is no need to declare it in advance (Table 2).

*Table 2. Dynamic typing*

| Pascal | Python |
|---|---|
| var s, n: integer; | s = 0 |
| begin | n = 75 |
| s := 0; | |
| n := 75; | |
| end. | |
| n = 75 | |

C) Conciseness of the code. One of the advantages of Python is the compactness of the code. For example, if you need to swap variables, it will look like this in these two languages (Table 3).

*Table 3. Conciseness of the code*

| Pascal | Python |
|---|---|
| c := a; | a, b = b, a |
| a := b; | |
| b := c; | |

D) High-level data types:

Python is a high-level language, so it has built-in high-level data types. Such as dynamic arrays (lists) and dictionaries.

In Python, we can work with each element separately. Here is an example of filling an array with the same values. We see that the code in Python is more concise (Table 4).

*Table 4. High-level data types*

| Pascal | Python |
|---|---|
| const n = 100; | n = 100 |
| var a: array[0..n - 1] of integer; | a = [0] * n |
| for i := 0 to n - 1 do | |
| a[i] := 0; | |

In this way a higher level of understanding of the algorithms structure is achieved and the skills of finding differences and determining the advantages of each language are formed, which will inevitably affect the quality of professional training of future programmers.

The theory of solving inventive problems (TSIP) [4] is the achievement of the creative level of human development, which is the highest result of pedagogical technologies. It is TSIP that promotes the effective development of technical creativity of the individual. This theory was substantiated in 1946 by science fiction writer and researcher Heinrich Altshuller [1]. TSIP was used to solve inventive problems in technical systems in various fields, such as business, science, pedagogy, literature, art. The implementation of TSIP is successful in educational institutions of Ukraine: Kyiv, Odesa, Poltava, Rivne, Luhansk, Kharkiv and others. In the city of Odesa there is a laboratory "TSIP-pedagogy of Ukraine" under the leadership of M. Meerovich and L. Shraginova.

In our study, the essence of technology is focused on the development of systems thinking of professional junior bachelors in software engineering, their creativity and abilities. Its task: to teach to solve professional problems of different levels of complexity with inventive content. During the classes, TSIP methods were used: focal objects, brainstorming, synectics, modeling, etc. Moreover, to form the ability to heuristic activities and develop the creative qualities of junior bachelors in software engineering used methods: the development of creative imagination, the theory of creative personality, the theory of creative teams. For example, methods of creative imagination help to reduce psychological inertia in solving non-standard creative tasks.

TSIP as a technology for the development of creative imagination has a diverse set of methods of fantasizing, for example: the use of science fiction sources for the development of heuristic activities; step design; synthesis of non-traditional fantastic ideas; the method of hidden properties of the object; associations; trend method; onlooking;

situational tasks. All the methods of mental activity a person uses throughout life, which affects his awareness of the new to establish new connections and generalizations. TSIP-pedagogy aims to form creative thinking and the formation of creative bachelors in engineering software, prepared to address non-standard situations in various fields.

So the advantages of heuristic learning are:
- increasing the level of assimilation of new educational material;
- increasing the role of independence in the educational process, increasing initiative and creativity;
- formation of positive internal motivation in the process of finding solutions to atypical situational problems;
- strengthening interpersonal relationships for adaptation and involvement in interaction in the group organization of activities;
- increase self-esteem, which allows self-realization in professional activities.

## 3. Conclusion

The expected pedagogical effect from the use of heuristic techniques is stated:
- increase the motivation of professional junior bachelors in software engineering to heuristic activities;
- increasing their interest in self-development and self-improvement;
- promoting the formation of integrated competence;
- the ability to use theoretical and fundamental knowledge, skills and abilities to successfully solve specialized problems and professional non-standard situations in professional activities in the field of computer science and information technology, computer technology and modern design technologies and information systems programming [9].

Heuristic techniques in teaching bachelors in software engineering are an excellent method of developing not only the skills to solve specialized problems and tasks in future professional activities, but also will be useful for solving a wide range of open life problems.

In the process of training IT specialists, difficulties often arise in their understanding of some program issues. One of the effective methodological tools that helps to clearly clarify and consolidate the practical mastery of these issues are individual and group heuristic techniques.

The study of educational and methodological literature on the topic of graduation work and elaboration of existing experience of teachers working on this topic and use it in their activities, gave the opportunity to determine the main directions for further work and use the results of this study in training future bachelors in software engineering.

Areas and topics that are closely related to the research require further development: the creation of methodological support for the formation of heuristic activities of professional junior bachelors in software engineering.

## References

[1] Altshuller G.S., Vertkin I.M. How to become a genius: Life strategy of creative personality. Minsk: Belarus, 1994. 480 p.

[2] Vashchenko G.G. General teaching methods: a textbook for teachers. K.: Ukrainian Publishing Community, 1997. 441 c.

[3] Liubarets V.V. Theory and practice of professional training of future managers of socio-cultural activities in the information-educational environment: author's ref. dis... doc. ped. Science: 13.00.04; National Pedagogical University named after M.Drahomanov. Kyiv, 2019. 46 p.

[4] Makridina L.O. Technologies of creativity TSIP. School management. 2003. №32. Pp. 12–26.

[5] Panova S.O. Teaching the content line "Heuristic teaching of mathematics" during the professional training of future teachers of mathematics. Bulletin of Psychology and Pedagogy; Borys Hrinchenko Pedagogical Institute of Kyiv University. Human Institute. 2016–2017. Vip. 18. URL: http://www.psyh.kiev.ua.

[6] Poya D. How to solve the problem, M: "Librocom", 2010. P. 132–133.

[7] Sidorenko V.K., Lyubarets V.V. Technology of forming of professional competence on the basis of contextual learning. Bioresources and nature management. 2013. T. 5. № 1–2. P.136–143.

[8] Skafa O.I. Heuristic teaching of mathematics as a computer-oriented methodological system. Collection of scientific works of Berdyansk State Pedagogical University. Berdyansk: BSPU, 2009. №3. (Series "Pedagogical Sciences"). Pp. 73–80.

[9] Standard of professional higher education according to the educational-professional degree of professional junior bachelor in the field of knowledge 12 "Information Technologies", specialty 121 "Software Engineering". (2021). URL: mon.gov.ua.

[10] Khutorskyi A.V. Heuristic learning: Scientific school. URL: http://www.khutorskoy.ru/science/concepts/terms/heuristic_training.htm.