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SCIENTIFIC-METHODOLOGICAL ASPECTS OF STUDENTS' CONCEPTS FORMATION AT A TECHNICAL UNIVERSITY

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Abstract

The current stage of the society's development is characterized by a sharp increase in the volume of scientific and technical information, an acceleration of information exchange among its producers and consumers, a reduction in the time for introducing the results of scientific research into production, and an increasingly close cooperation of all participants in research and production processes. Apparently, these trends are long-term, so they will have a significant impact on all spheres of life related to scientific and technical activities of a person, including the system of higher technical education, which must respond in a timely and adequate manner to the changed demands of society. It is becoming increasingly obvious that there is a need to solve a complex of didactic problems related to the specification of goals, the selection of content, the search for methods, forms and means of training that would prepare young professionals for professional activity in the conditions of continuous updating of professionally relevant information. The formation of a scientific concept is considered as a process of development of the level of generalization of the studied concept from the primary to the generalization of the corresponding scientific concept. The technology and methods of formation of scientific concepts in students of a technical university are presented, the corresponding methodological recommendations, sample questions and tasks at different stages of concept formation are given. The materials of the article can be useful for teachers of professional educational institutions working with students of technical training areas.

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Keywords: Scientific concept, form of thinking, assimilation of the concept, level of assimilation of the concept, learning technology

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1. Introduction

The quality of training of future engineers largely depends on the professionalism of a teacher in higher education. This is the reason why, one of the standards of the international CDIO initiative is associated with improving the pedagogical competencies of teachers. The standard identifies the main challenges for the teaching engineer: how to motivate students? What is the best way to represent diagrams and formulas? What techniques can help students memorize information better? How to communicate with students? How to form students' technical and other concepts? How to study technique, technology, etc.? (Chuchalina et al., 2011).

On the other hand, in the Russian Federation, on January 1, 2017, the Professional Standard for a teacher of vocational training, vocational education and additional vocational education was introduced. As one of the main requirements for a teacher of higher education the use of justified forms, methods of organizing the activities of students, the use of modern technical teaching aids and educational technologies during training sessions are indicated. This fully applies to the formation of scientific concepts among students.

General patterns, mechanisms, ways of forming concepts among students of different ages in pedagogical psychology and didactics have been studied in sufficient detail. However, there is some contradiction between theory and practice. This explains the lack of specific methodological developments in the study of technical disciplines and, in particular, scientific concepts in professional educational institutions.

2. Problem Statement

In this article, we consider the scientific and methodological aspects of the formation of students' scientific concepts based on the development of the level of generalization of the studied concept.

3. Research Questions

First of all, it should be noted that the concept is:

1. “The form of thinking (reflecting the essential properties, connections and relationships of objects and phenomena), the main function of which is to highlight the general by means of abstraction from features, particulars.
2. Thought, generalizing and highlighting objects and phenomena of a certain class according to the most general characteristics” (Comp et al., 2005, p. 345).

4. Purpose of the Study

The purpose of our study is to answer the question: what are the scientific and methodological aspects of the formation of scientific concepts among students of a technical university in classrooms.

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5. Research Methods

If a concept is a "form of thinking ...", "thought ...", then at a certain stage of its formation a student begins to think within the framework of the given concept content, reflecting its essential properties and connections with the help of judgments and inferences. Obviously, simple memorization and reproduction of a definition is not the result of understanding the concept. Unfortunately, some teachers do not take this important circumstance into account in their work.

Leontiev (1960, p. 161-186) notes that initially in the mind of a student there is a concept of a small level of generalization (idea of a particular subject) based on his limited experience. It is characterized from the side of its internal structure by its concrete factual connections and by its direct relation to reality. The formation of a scientific concept is a process of movement, when the primary generalization underlying the corresponding word develops, is rebuilt, i.e. rises to a new higher level and in the ideal case, finally, it turns out to coincide with the generalization that is presented in the scientific concept (Kochnev, 2017a, b). Thus, the main condition for the formation of a scientific concept is the development of primary generalization in students to generalization corresponding to a scientific concept. Therefore, we can talk about the level of generalization, and therefore about the stages of the formation of a scientific concept. In turn, the level of generalization of a scientific concept can also serve as a level of digestion of this concept. This conclusion allows us to determine the stages of formation and, accordingly, the levels of digestion of scientific concepts by students and to give them a specific characteristic.

It is known that any scientific concept is introduced through its term. The term (lat. Terminus-border, limit) is a word, phrase, which is used in a special, mainly scientific and technical meaning to define the concepts of science, art technology (Comp et al., 2005). The terms defining technical concepts include, for example, part, mechanism, machine, generator, battery, etc.

The content of the concept is the definition itself, revealing its generic (general) and specific (distinctive or essential) features. For example, for the technical concept "car", a common feature will be that it belongs to the group of transport vehicles for the carriage of goods and passengers, and an essential feature is its peculiarity of movement - on railess roads. In this case, the concept of "car" has a two-stage structure (generic concept and one essential feature). There are also more complex concepts. For example, the concept of “technological operation (a part of a technological process performed continuously at one workplace, over one or more simultaneously processed or assembled products, one or more workers) has one generic concept and three essential features.

In addition to their purpose, significant features of technical concepts can also be the features of the device of an object, its principle of operation, and the process of work. In turn, for technological concepts, essential features can be the sequence and modes of the processes, the equipment used, tools, etc.

And so, the content of any concept is determined by its general and distinctive (hereinafter referred to as essential) features.

How is the process of assimilation of scientific concepts going on? Psychologists have established that the source of a scientific concept is not sensory experience itself, but a definite action, which, by transforming objects, reveals new relationships and properties in them (Davydov et al., 1979). Consequently, these relations (connections) and properties are not detected directly by perception, but in

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the process of mental activity based on judgments and inferences. Thus, students, analyzing the operation of a belt drive, begin to understand that this transmission allows the transfer of torque from the drive shaft to the driven one. Also, students can compare gear and belt drives, find in them the general (transmission of rotational motion from one shaft to another), difference (design features, different possibilities of transmission of motion), the advantages of each transmission (transmission of motion without slipping and with the possibility of slipping of the link) ... On the basis of these judgments and inferences, in the future, the concept of a mechanism as a technical device designed to transmit or transform motion is given.

Thus, the formation of proper scientific concepts can only occur on the basis of purposeful mental actions leading to conclusions and inferences. Conclusions and inferences, in turn, arise in the mind of a student when he performs the following mental operations: comparison, juxtaposition, distinction, analysis, synthesis, assessment, generalization, etc.

The assimilation of a concept often does not occur spontaneously; thanks to their experience, students already have a certain level of generalization of the concept (primary generalization). For example, to the question "What is the reducer?" a student may answer: "It is a mechanism that transfers torque from the electric motor to the winch drum." Let's compare this level of generalization of the concept with the scientific one:

“Reducer - (from Lat. Reductor - taking back, bringing back) 1) a mechanism that is included in the drives of machines and serves to reduce the angular velocities of the driven shaft in order to increase the torque." As we can see, in this case, a student has a certain initial level of generalization about the concept being formed. He defined the generic concept (general feature) of the reducer as a mechanism. Of the three essential features, he noted only one - the transmission of torque. Such important features of the concept of "reducer" as its purpose (decrease in angular velocities) and the goal of decreasing angular velocities (increase in torque) remained unmarked. That is, the main semantic connections were not noted: what is a reducer for at all and what happens when the angular speed of the driven shaft decreases in the reducer (Chuchalina et al., 2011).

Note that the identification of the initial level of generalization of the concept is an important stage in its formation among students and a guideline for all subsequent work of a teacher and students to identify new essential features of the concept and its semantic connections.

The performance of mental operations by students is first built on the basis of substantive activity. They work with various objects, models, schemes. This allows them to form some sensory support for the formation of the concept.

When forming concepts (establishing general and essential features of a concept, connections among the properties of objects and phenomena, features of a concept, etc.), a teacher must actively manage this process by posing questions and tasks. In this regard, the experience of V.I. Reshanova is interesting; she offers a number of tasks for working on the meaning of physical concepts: to clarify the meaning of words and phrases included in the definitions; to form ideas about the different commonality of physical concepts to distinguish the less general (specific) from the more general (generic); to correlate different kinds of formulations of the same concept (Comp et al., 2005; Reshanova, 1985). So, when studying the meaning of the concept "mechanism", the following questions can be asked to clarify the meaning of words in the definition to students: What do you mean by a technical device? What does it mean to transform (transmit)

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motion? What will be the driving (driven) link in the transmission? Which concept will have a more general meaning: "technical device", "detail", "mechanism" or "machine"? Which of the presented mechanism definitions will be correct? and etc.

The formation of a complex scientific concept is a longer process. It is not limited to the framework of one lesson, but continues during the study of the topic, and in some cases - the subject as a whole. Some concepts are characterized by interdisciplinary connections.

There are two main methods of concept formation: deductive and inductive. With the deductive method, the teaching material is considered from the general to the particular. The teacher himself formulates the definition of the concept being studied, highlights the essential features in it. For each feature of a concept (phenomenon, action, object, law, etc.), students are explained its essence, functional connections of the feature with the concept are established (for example, the role of the heating process for hardening a part). objects. New concepts are given on the basis of and in close connection with the knowledge (concepts) already known to the student.

When using the inductive method, the teacher leads the students to the necessary generalizations and the formulation of the definition of the concept being studied. This becomes possible if the students have a sufficient understanding of the object under study or have received a good subject basis for its study (they observed the device, the operation of the object, used it in practice, etc.). In this case, the teacher, with the help of questions, finds out how the students comprehend the general and essential features of the concept, as far as they can characterize, substantiate. The use of the inductive method of forming concepts, as a rule, requires a longer study time, but at the same time, the mental activity of students is much higher, and knowledge becomes more solid.

The formation of students' scientific concepts can be organized both in lectures and in the process of special laboratory work. In any case, one should make wider use of the possibilities of interactive teaching methods (problem dialogue, discussion, brainstorming, case-method, etc.). In this case, students are more actively involved in the discussion of the issues being studied, come to the collective decision (Kochnev, 2017a, b; Kochnev et al., 2020a).

As mentioned above, it is important for the teacher to purposefully build the process of forming scientific concepts in students and receive feedback on how the process of assimilating these concepts is taking place (Kochnev et al., 2017, 2020b).

6. Findings

Considering the above, we will single out the main levels of assimilation of scientific concepts and give their characteristics (Table 1). These levels can also be used as a kind of stages in the formation of concepts.

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Table 1. Levels of assimilation of scientific concept and their characteristic

Level of digestion	Characteristic of the level of digestion
1.Primary generalization (students' experience	0. Determination of certain common or essential features or semantic connections
2. Generalization corresponding to the scientific concept at this stage of training	1. Determination of general and essential features of the concept, their characteristics. 2. Understanding and validation of the essential features of the concept 3. Establishment and understanding of connections among the essential features of the concept 4. Separation of essential features from non-essential
3.Application of the concept	5. Use of concepts in the situations shown by the teacher 6. Use of concepts in new situations
4. Development of the concept	7. Deepening the content of the concept. 8 Selection and understanding of the connections of this concept with other concepts at the intra-subject and inter-subject levels

7. Conclusion

The following are the sample questions and tasks at different stages of the formation of the concept of "hardening" (subject "Materials Science", topic "Heat treatment of iron-carbon alloys", the main related concepts: heat treatment, annealing, normalization, hardening, snap temper).

1. Selection of general and essential features of the concept, their characteristics:

- For what purpose are parts hardened?
- What is hardening, snap temper? What signs will they have in common, and what - essential?
- What is Heat Treatment Process? What operations does it include?
- What is heating, holding, cooling? How and with the help of what equipment are these operations carried out in production?

2. Understanding and validation of the essential features of the concept:

- What role does the diagram of the state of iron-carbon alloys play for heat treatment?
- Why are steels containing up to 0.3% carbon hardly hardened?
- What is holding needed for?
- To what temperature should the part be heated? Why?
- How does the holding time depend on the temperature and diameter of the product section?
- What structural changes occur in iron-carbon alloys during heating, holding and cooling? How do the properties of the alloys change?
- Why is it necessary to heat the part before changing the structure of the alloy?
- Why is rapid cooling of the part necessary during hardening?
- Why does steel become stronger during hardening?

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3. Establishment and understanding of connections among the essential features of the concept:

- How are heating, holding and cooling interconnected during product hardening? What do these processes have in common?
- Why is hardening a heat treatment process?

4. Separation of essential features from non-essential ones:

- Will the following definition of hardening be correct: “Hardening is a heat treatment process associated with heating, holding and cooling of the part” Why?

5. Usage of concepts in the situations shown by the teacher:

- Present graphically the hardening mode in coordinates: temperature - time.

6. Use of concepts in new situations:

- Using the state diagram of iron-carbon alloys, determine the transformations in steels St50 and U13 when the liquid solution is cooled to room temperature

7. Deepening the content of the concept:

- What are the features of isothermal, light hardening?
- What is the difference between hardening alloy steels and carbon steels?

8. Selection and understanding of the relationship of this concept with other concepts at the intra-subject and inter-subject levels:

- What is common and what is the difference between the hardening process and other types of heat treatment?
- How does heat treatment differ from chemical heat treatment?

The abovementioned questions can serve as a kind of reference point for the study of any technical concepts at the university.

Thus, the technology we offer for the formation of students' scientific concepts based on the development of the level of generalization allows the teacher to make this process purposeful and controlled. At the same time, depending on specific conditions, he can use deductive or inductive teaching methods, various interactive technologies.

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The abovementioned methodological recommendations for the formation of students' scientific concepts in 2016-2019. passed approbation and received a positive feedback on refresher courses for teachers of universities and USPO in the Vologda region.

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