Artículo de investigación

Influence of the functional relationship between concept, image and action on the process of solving interdisciplinary technology-oriented tasks

Влияние функциональной взаимосвязи понятия, образа и действия на процесс решения междисциплинарных технологически ориентированных задач

Influencia de la relación funcional entre concepto, imagen y acción en el proceso de resolución de tareas interdisciplinarias orientadas a la tecnología

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Abstract

This article studies the influence of the methods used by students to solve tasks on the effectiveness of the learning process based on their analysis. The study has revealed that mastering the combined method based on the functional relationship between concept, image and action in the process of solving interdisciplinary technological tasks is one of the mechanisms of effective preparation of students for professional activity in the labour market of related professions.

Аннотация

В данной статье на основе анализа используемых обучающимися способов решения задач исследуется их влияние на результативность процесса обучения. В процессе исследования выявлено, что владение комбинированным способом, основанном на функциональной взаимосвязи понятия, образа и действия, в процессе решения междисциплинарных технологических задач выступает одним из механизмов эффективной подготовки обучающихся к профессиональной деятельности в условиях появления на рынке труда смежных профессий.

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Keywords: Interdisciplinary technology-oriented tasks, functional relationship "concept – image – action", professions of the future, preparation for professional activity.

Ключевые слова: междисциплинарные технологически ориентированные задачи, функциональная взаимосвязь «понятие – образ – действие», профессии будущего, подготовка к профессиональной деятельности.

Resumen

En este artículo, basado en un análisis de los métodos utilizados por los estudiantes para resolver problemas, se investiga su influencia en la efectividad del proceso de aprendizaje. En el curso del estudio, se reveló que el dominio del método combinado, basado en la relación funcional del concepto, la imagen y la acción, en el proceso de resolución de problemas tecnológicos interdisciplinarios es uno de los mecanismos para la preparación efectiva de los estudiantes para actividades profesionales en el contexto de la aparición de profesiones relacionadas en el mercado laboral.

Palabras clave: Tareas interdisciplinarias orientadas tecnológicamente, relación funcional "concepto - imagen - acción", profesión del futuro, preparación para la actividad profesional.

Introduction

Global technologization of the economy, which requires production intellectualization and continuous innovativeness in professional activities, requires concretization of the goals of higher education. Significant factors for its renewal include the demands of labour markets and promising directions for their development, the conformity of the education quality to the requirements of state standards, as well as the needs of society for successful socialization of graduates of higher education institutions, considering their professionally important personal resources.

Due to new professions, mainly related to the emergence of the mixed economy with appropriate market infrastructure, the labour market is expecting radical changes, which actualizes the problem of the education quality caused by the relationship between different areas of human life and implies search for ways to improve it in the context of the interdisciplinary approach. The problems of transition from interdisciplinarity to transdisciplinarity are considered by the authors J. Piaget (1972), M.S. Mokii and V.S. Mokii (2014). The study by T.A Mednaya (2015) presents the aspects of the competencies, which a graduate of a higher education institution requires. The formation of interdisciplinary relationships in the learning process is shown by researchers B.I. Palamar, G.O. Vaskivska, S.P. Palamar (2017) and others.

Therefore, the goal of higher education is to increase the intellectual potential and professional level of future members of society who are able to master the achievements of technological globalization and, as a result, to help to transform the educational results of graduates of higher education institutions into an effective factor of the real labour market functioning. Thus, this goal involves solving educational tasks aimed at ensuring the interdisciplinary approach to the formation of the education system that takes into account the widest range of competency formation: from classical fundamental foundations to the latest technologies.

The following question arises: what competencies should experts have? For example, "A living systems architect is a specialist in the planning, design and creation of closed-loop technologies with the participation of genetically modified organisms and microorganisms. This professional, who is able to calculate the necessary capacity of bioreactors, develop projects for urban farms and carefully plan a waste recycling system, will be indispensable in autonomous cities" (Atlas novykh professii, 2019).

This kind of specialist needs to renew the reserve of their professionally significant personal resources, including the following:

- Systems thinking;

- Basic knowledge of programming/robotics/artificial intelligence;
- Ability to act in the conditions of uncertainty;
- Interindustry social skills in terms of understanding technologies, processes and market situation in various related and non-related industries;
- Customer focus, aimed at the ability to work with consumer's requests;
- Ability to manage projects and processes, based on a constant desire to eliminate all types of losses, which suggests involving each employee in optimizing the production process and maximizing customer orientation;
- Understanding the national and cultural context of partner countries, as well as the specifics of work in the industries of other countries;
- Ability to identify complex systems.

The acquisition of these competencies, which are in demand in the rapidly developing technological world, is possible through the solution of interdisciplinary technology-oriented tasks.

Research hypothesis: Preparation of students for professional activity is successful if the mechanism for the formation of an effective way to solve interdisciplinary technology-oriented tasks is associated with the functional relationship between concept, image and action.

Methods

As emphasized by pedagogy, task solving is a set of mental and practical operations, which are typical, on the one hand, for solving a certain type of tasks and, on the other hand, for general methods of activities of a particular person. Interdisciplinary technology-oriented tasks are based on the number of inclusions of initial interdisciplinary data in new relationship systems that have a degree of efficiency and uncertainty in finding solutions to technological situations (as defined by F.A. Zueva (2018)).
Let us give an example of a task of this type: "Determine the volume of a biogas plant for farm and biogas output. Write down the main stages of biogas production and possible products obtained at each stage. Calculate the potential energy reserve of the produced biogas (the calorific value of biogas is 22 MJ/m3) and determine the amount of natural gas that can replace the produced biogas, considering that the energy of 1 m3 of biogas is equivalent to 0.6 m3 of natural gas. Justify the reasons for the increasing demand for the use of biogas plants on farms. Plant operating conditions: material for a bioreactor (from 100 cows over 18 months old), mesophilic fermentation with a process temperature of 33°C, process duration is 15 days, material load is continuous, daily replaced by 1/15 of the fermented mass (the coefficient taking into account organic litter mass is 1.5; if necessary, use additional data from handbooks)".

The content of the task shows that its solution requires the application of knowledge in biotechnology, ecology, environmental management, microbiology, chemistry, structural and technological features of bioreactors, engineering and technological calculations. When finding solutions using interdisciplinary technology-oriented tasks, it is necessary to consider the fact that in this case, not an abstract result of the solution is studied, but, first of all, the necessary mandatory level, without which the student cannot be recommended for professional activities of certain types (Zueva, 2017).

The distinguishing of solution methods is based on the features of understanding the task and practical ways of its realization, that is, the differences between methods are determined by the specifics of the relationship between concept, image and action in the process of solving.

When analyzing the results of the study, we used a number of quantitative and qualitative indicators of successful solution of tasks. The first indicator is the speed of decision making. Slow and difficult progress in the process of solving tasks, as well as the emergence of numerous conceptual questions, delay the solution of some tasks and there is not enough time for the remaining tasks. In our opinion, the first indicator is relative, as there are cases when the solution process turns out to be correct, although lengthy. It should also be noted that not all solved tasks have correct answers, despite the length of the solution process. However, since most of the interdisciplinary technology-oriented tasks require certain speed in the solution process, the solution time is included in the key indicators when analyzing successful solutions of tasks.

The next quantitative indicator is the focus of the solution process, that is, the stages of actions leading to success and the stages of actions leading to so-called "failure". The number of pauses occurring in the activities of students should be noted as well. This refers to the pauses, indicating the presence of “deadlocks” when there are no alternative solutions (Talyzina, 1998).

Results

The indicators used for the quantitative processing of the material served as a guideline for the qualitative assessment of solution results (Table 1).

Table 1. Basic methods for solving interdisciplinary technological tasks used by students

No.	**Name of the method for solving the task and type of recommended sequence of actions (Palamar et al., 2017)**	**Description of the method for solving the task**
1	Method of preliminary practical actions	Any stage of solving the task begins with a practical action: numbers are added and subtracted, the necessary result is adjusted; the solution is based on a chaotic repetition of similar practical actions, until their random combination leads to the realization of their conformity. Only then essential features are identified and a plan appears. The work process is uneven and causes numerous pauses; a lot of time is spent on solving the task; long and unsuccessful manipulation of the same type reduces the activity and leads to a dead end solution, as a result there are many incorrect task solutions.
2	Method of preliminary theoretical actions	It starts with the development of a strategy for solving the task based on theoretical analysis: each stage begins with a theoretical assumption and a general assumption arises about how the stages of the solution should relate to each other, followed by the stages of finding the practical result of the solution. In this case, individual working methods acquire specificity depending on the main characteristics of the solution method; students often have a “fear” of a practical solution (they hesitate for a long time to put a plan in motion, due to the fact that all the features of the practical situation are not taken into account, this leads to mistakes and diffidence in successful practical actions); task performance is cyclical; the total number of manipulative actions is small, and they comply the developed strategy. The mistakes can be divided into two groups: mistakes of “template” due to the abundance of hypotheses and mistakes caused by rethinking difficulties and inability to look at the object from various points of view, including extraordinary. When using this method, specific features of practical situations are not always taken into account, therefore there are also incorrect solutions.
3	Combined method, or solution using the “concept – image – action” mechanism	The process of solving the task, starting with the idea complies with taking into account the current situation at each stage. Initial theoretical considerations can be replaced by others in the solution process. There is a double determination of the solution process. A multianalysis of situations is carried out. The students do not start any operations until they analyze all the stages and the purpose of each stage. The idea is constantly being corrected by the analysis of the practical situation. The student discovers a great flexibility in the choice of solution means. In the process of action and their correlation with ideas and intentions, the students find a feature of the task that allows to direct the solution in a right way, the so-called “guiding sign”. There are few deadlock situations and the students quickly find a way out of themselves. Incorrect solutions are rare.

As noted above, during manipulation, students often look for a feature in the task that would allow them to choose the right direction for the solution. In our opinion, P.M. Yakobson (1998) clearly identified these phenomena as “guiding signs”, which are really important for making the right decision.

It should be emphasized that none of the features of the task is a guiding sign if students act using the first two methods. This is clear enough since when using the first method associated with the prevalence of practical manipulative actions, there is no clear concept and the solution emerges spontaneously. The absence of analysis carried out from any particular point of view does not allow to detect a guiding sign. In the second method, the conditions for this detection increase as there is a concept, but since it is very abstract and not aimed at finding specific features of the task, a guiding sign cannot be detected. Therefore, only constant appealing to the features of the task created in the solution process makes a guiding sign one of the effective ways to solve the task.

It is necessary to focus more specifically on the situational elements considered in the process of solving tasks. Firstly, this consideration is associated with the fact that a test subject takes practical actions only after the features of the task become more or less clear. Secondly, the consideration of the situational elements is expressed in the fact that any difficulty in solving the task is caused not by simple manipulation (as in the first method), not by stereotyped actions according to a once developed theoretical scheme (as in the second method), but by rethinking situations.

In the process of solving, students often encounter deadlocks. This means that the usual methods of solving tasks, often based on personal experience, have been exhausted. As a rule, in the first and second methods, the teacher has to show the way out, while the combined method allows solving the task without assistance.

In the study, such qualitative indicators as the originality of the solution and the optimal solution are taken into account. If a task suggests multiple answers, then it is necessary to choose one variant. However, students mainly give one answer or several equivalent answers, among which it is rather difficult to choose the optimal one. With regard to originality, it should be noted that the ideas of some students differ in their originality but are not always completed.

The study has shown the following: in the process of solving tasks, 80% of students use the method of preliminary practical actions, 15% – the method of preliminary theoretical actions and only 5% – the combined method, which indicates the low functional relationship between concept, image and action in the solution process.

Discussion

The initial steps in mastering the algorithm for solving interdisciplinary technology-oriented tasks are usually associated with a significant number of mistakes, so the results of the first exercises in solving tasks are variable. However, the reproduction of various technology-oriented situations contributes to the extraction of interdisciplinary knowledge for a relationship system in a specific practical application in the process of coordinating concept, image and action: accurate and selective analysis of technological situation; reproduction in memory of practical conclusions, as well as making possible to respond to signals and make corrections and changes in the process of applying the methods based on theoretical knowledge, with which a successful solution of tasks is possible. These provisions are consistent with the theory of the indicative basis of action, the construct of which was created by P.Ya. Galperin (1985) in the framework of the concept of step-by-step formation of mental actions, showing that in variable situations, the main life task becomes an adequate orientation in the significant elements of the action field in their significant relationships.

It should be noted that with a sufficiently large number of works related to the interdisciplinary approach, there are few studies aimed at identifying the functional relationship between concept, image and action in the process of solving tasks as an effective mechanism for preparing future specialists for professional activity, which makes it difficult to conduct a comparative analysis of study performance in the context of this approach.

Conclusion

In this study, the analysis of the features of methods for solving interdisciplinary technology-oriented tasks by students showed the formation of the relationship between concept, image and action, as well as their dynamics.

The consideration of situational elements in the process of solving tasks revealed the following:

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- Mainly, students use the method of preliminary practical or theoretical actions;
- When using the method of preliminary practical actions, an excessive generality of the considered concepts is noticeable, which does not lead to a specific solution;
- When using the method of preliminary theoretical actions, mistakes can occur due to the abundance of the developed hypotheses not tested in practice, as well as the inability to consider the object from different points of view and the difficulty of rethinking;
- Presented results of completed tasks are not distinguished by their individual uniqueness – answers mostly belong to the same type;
- The combined method, selection of the optimal solution and originality are not sufficiently developed.

The aforementioned leads to the conclusion that the mechanisms for accumulating experience in solving tasks using the combined method are specially developed interdisciplinary technology-oriented tasks. The criterion for identifying the degree of the structural complexity of tasks is an increase in the number of inclusions of the initial interdisciplinary data in new relationship systems, both horizontally and vertically. Some tasks are selected according to the effective assessment of teaching students about thinking methods.

The solution is based on a purposeful and repeatedly conducted under the guidance of the teacher repetition of the studied practical actions and methods, aimed at consistent improvement and conscious use of the combined action method in the course of mastering professional competencies.

The solution of interdisciplinary technology-oriented tasks is carried out according to a certain system when each previous task prepares the performance of the next task and the next task contributes to learning new material and helps to consolidate the previous material, that is, it has elements of the new and previously studied material. However, the conceptual and terminological apparatus of the educational material of the discipline is first studied to solve each of these tasks. Then a coordinate system is set that disperses these terms into related disciplines. The ability to link these concepts in the process of solving tasks, including those requiring speed in solving (Zueva, 2019), is formed based on the refinement of the relationship between the used terms and the logic of their relationship.

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