UDC 378.14 DOI: https://doi.org/10.64076/iedc251023.11

Engineering in technological education of schoolchildren in Ukraine

Anatolii Ivanchuk
Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Vinnytsia
https://orcid.org/0000-0002-6996-1403

Abstract. *The approach of Japanese researchers to the organization of the process of forming the foundations of engineering in schoolchildren is described. It is established that they consider engineering as a design process taking into account the imposed restrictions. It is found that Japanese researchers use a broad understanding of the design process as a problem-solving activity. It is proposed to link technical problems with the context of three basic technical phenomena in the drives of technological machines. It is assumed that the design activity of schoolchildren in the search for technical solutions as a means of solving technical problems will create didactic conditions for the formation of technical thinking as the basis of their technical competence. It is specified that the technical competence of schoolchildren will be machine-learning in nature.*
Keywords: *educational branch "Technology", engineering, technical phenomena in the drive of technological machines, educational technical problems, technical thinking of schoolchildren, technical competence of schoolchildren.*

In the standard of basic secondary education of Ukraine, one of the eleven basic competencies of secondary education students is competence in the field of natural sciences, engineering and technology [1]. Its technical and technological components should be formed by the educational branch "Technology" when schoolchildren study the educational subject of the same name "Technology". However, in practice, this competence takes the form of design and technological competence and "dissolves" in it, and the technical component actually disappears. That is, the technological thinking of schoolchildren as the basis of technological competence is structurally different from the technical thinking of schoolchildren as the basis of their technical competence. This is explained by the fact that the technological and technical thinking of schoolchildren is formed according to different logical schemes, in particular: need → goal → method of achieving the goal → product; technical object → principle of action → useful function. On the other hand, if we assume that any production technology is the scientific basis of the corresponding technological process, and the technological process is implemented on a production line, where it is important to know the essence of the implemented technological operations (useful functions of technological machines), and not the principle of operation of these technological machines, then the subject of technical thinking of schoolchildren disappears. Thus, there is an urgent need to determine the ways of forming technical thinking of schoolchildren in the educational field of "Technology".

S. Yamazaki considered the possibility of forming technical thinking of schoolchildren in the process of mastering the basics of engineering with the aim of self-determination regarding further professional training in the engineering specialty and in the context of sustainable development goals [4]. As a working concept of engineering, S. Yamazaki used the interpretation of W. Wulf as a design process taking into account the imposed restrictions [3]. However, in this definition, the design process was considered more broadly, compared to the one adopted in Ukraine (design for the manufacture of a product), as a method of solving practical problems. This, at first glance, small nuance contains great methodological potential. In our opinion, it provides flexibility to thinking and allows us to consider not only traditional technological problems, but also closely related technical problems. In other words, this nuance or approach justifies the need to find a methodology for forming technical thinking of Ukrainian schoolchildren in the process of studying the subject "Technology".

Japanese researchers believed that the foundations of engineering in schoolchildren can be formed only with the help of the constructivist theory of learning [4]. In particular, K. Kubota gave the following characteristics to the constructivist theory of learning: students construct their knowledge in the process of solving a technical problem; the relevance of the acquired technical knowledge only in a specific context; interaction between students in the process of solving a technical problem contributes to the process of mastering technical [5]. However, when using the constructivist theory of learning to form technical thinking in schoolchildren, according to Japanese researchers, the didactic problem of determining the level of educational value of the essence of the type of technical problem solved remains unresolved [4]. Therefore, there is a difficulty in determining the criteria and indicators of the educational value of the processes of solving educational technical problems by schoolchildren.

The purpose of the study is to substantiate the approach to the study of engineering in the process of mastering the subject "Technology" by students of general secondary education in Ukraine.

For us, the following judgments of Japanese researchers will be valuable tips for developing a methodology for forming technical thinking in schoolchildren in the process of studying the subject "Technology": 1) the design process in a broad sense is associated with solving practical problems; 2) a broad understanding of technology consists in studying methods for using structural materials, energy, and information. Using these tips, it is possible to change the subject of studying technological machines by schoolchildren as processors of a useful function (performers of technological operations in technological processes) to the subject of studying the principle of operation of technological machines by schoolchildren (how a technological machine performs its useful function). Accordingly, it is necessary to develop a system of educational technical problems and corresponding educational technical tasks related to the principle of operation of technological machines and consider the activities of schoolchildren as a process of designing a technical solution that will solve a technical

problem. It will also be appropriate to talk about the technology of converting mechanical energy of rotational motion in the principle of operation of technological machines, since technical problems will be solved using this technology, which will have all the formal features of any technology for manufacturing material objects. We solved the problem of defining generalized machine-science knowledge by substantiating its carrier - the drive of a technological machine [2]. Generalized machine-science knowledge, in turn, is associated with a comprehensive study of three basic technical phenomena in the drives of any technological machine - this is the transmission of mechanical motion in space over a distance; changing the kinematic parameters of mechanical motion along the length of the kinematic chain of the drive of the technological machine and changing the power parameters of mechanical motion along the length of the kinematic chain of the drive of the technological machine.

Thus, the use of the concept of "engineering" in a broad sense will allow organizing the educational process in the educational field of "Technology" so that the subject of study of secondary school students will be educational technical problems related to the drives of technological machines, and the process of solving them using technical solutions will form technical thinking as the basis of their technical competence. In our opinion, further research should be focused on determining the criteria and indicators of the educational value of the processes of solving technical problems related to the drives of technological machines.

References

1. Zatverdzheno standart bazovoi serednoi osvity: Kabmin ukhvalyv dokument (2020). [The standard of basic secondary education has been approved: the Cabinet of Ministers adopted the document]. Vseosvita. URL: https://vseosvita.ua/c/news/post/30055 [in Ukrainian].

2. Ivanchuk, A., Zuziak,T., Marushchak, O., Matviichuk, A., & Solovei, V. (2021). Training pre-service technology teachers to develop schoolchildren's technical literacy. Problems of Education in the 21st Century, *79*(4), 554–567. https://doi.org/10.33225/pec/21.79.554 [in English].

3. Wulf, W. A. (1998). Diversity in Engineering. *The Bridge. 28 (4)*, 8–13. https://www.nae.edu/7488/DiversityinEngineering [in English].

4. 山崎貞登. (2020). STEM, STEAM, エンジニアリング教育概念の比較教育からの論点整理 [Points at Issues Arrangements from Comparative Education about Concepts of STEM, STEAM and Engineering Education]. *日本産業技術教育学会誌*, *62*(3), 197–207. URL: https://www.jstage.jst.go.jp/article/jjste/62/3/62_197/_pdf [in Japan].

5. 久保田賢. (2000). 構成主義パラダイムと学習環境デザイン [Constructivist paradigm and learning environment design]. *(No Title)*. https://doi.org/10.11501/13884801 [in Japan].