Technological culture of future engineers in the context of modern socio-economic development of the society

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Abstract: At present, the technological stage of the development of society is intended to establish the priority of the method over the result of activity. Therefore, society needs a comprehensive approach to the choice of intellectual and material ways of its activities from the mass of alternative options and to the evaluation of its results. In this vein, technological culture is a value aspect of modern and future education. It is characterized by multidimensionality, creative character and includes not only production, but also sociocultural aspects. Technological culture includes such personal qualities of a person, which allow technologically competently to solve any problems from the fields of activity of the engineer. In addition, creative solutions of social and economic problems depend on the degree of formation of character and qualities that characterize the future orientation of the personality of future specialists. Therefore, technical universities are faced with the task of developing the qualifications of university graduates in the professional sphere, creating conditions for the development of such personal qualities as creative self-development, humanitarian and technical outlook, intellectual maturity, responsibility. In the existing practice of teaching specialized technical disciplines, the process of introducing the fundamentals of technological culture, unfortunately, is sometimes very difficult. In these cases, it is necessary to overcome the inertia of technocratic thinking and the lack of understanding of the importance of the idea of developing a technological culture and the personal properties and qualities that are significant for it.

1. Introduction
At present, the technological stage of social development is intended to establish the priority of the activity method over the activity result. Therefore, society should use an integrated approach in choosing its intellectual and material activity methods from the variety of alternative options and in the evaluation of its results.

Along these lines, technological culture is a value dimension of modern and future education. The formation of students’ technological culture assumes mastering by them the system of methods and means of transforming activity on the creation of material and spiritual values.

Historically, the dynamics of the “engineer” concept reflects the change in the requirements on the content of engineering activity. Thus, the first engineers were in parallel artists and architects, alchemists and doctors, advisers in fortification and artillery.
In the psyche of modern society, the concept of "engineer" is polysemous. He is a creator of the new engineering and technology, a projector, a researcher, a technologist, a designer, a production manager. Even such concepts appear as gene and social engineering, which indicate the expansion of ideas about engineering activities.

In the presence of economic reforms in Russia, need for a new technical level of industrial development, integration of Russian economy into the world system, the role of the engineer in modern society is being re-evaluated. The nature of his activities has changed radically. Currently, an expert activity is differentiated from a realizer activity, since contrary to the last one, an expert is familiar with the activity as a whole, he considers its substance in various situations, he is able to design, change and develop the activity.

The current state of engineering is increasingly estimated as critical, and four areas of such a crisis are recorded: the uptake of engineering by unconventional design, the takeover of engineering by technology, the awareness of the negative consequences of engineering, the crisis in the traditional scientific and engineering picture of the world [1].

In this context, the presence of such factor as the technological culture in the “professional background” is stated as determining, it is characterized with multidimensional nature, creative nature, and includes not only production but also socio-cultural aspects.

2. Materials and methods

We have developed a methodology for training students in solvation of technical problems with standardized methods and the use of a database of physical effects, phenomena and their parameters.

The use of standardized methods for finding solutions for technical problems does not ruin the creative process, but streamlines it, making it possible not to waste time and energy on finding already known solution methods. These methods contain the patterns in the creative process that the engineer must know to obtain the desired result in an optimal way, to overcome technical difficulties.

When formulating the problem, the initial problem-based situation is clarified by defining its goal, restrictions, and criteria of solution choice. All these categories determine the desired state, which must be reached as a result of the search for a solution. The goal describes the desired result relevant to a technical or social need. To define a goal means to answer the question: “What will be the result of the decision?” The goal statement usually concerns two states: the initial and the final desired ones.

Restrictions are the conditions under which the goal achievement can be considered as acceptable. These conditions usually have the form of prohibitions to change or apply something or, conversely, of indications to the necessity of using the particular means of the goal achieving.

The restrictions can be of three levels: a) physical feasibility (the decision must comply with the laws of nature); b) technical feasibility (the decision must correspond to the resources and scientific and technical potential of the society); c) economic validity.

The decision selection criterion reflects one of the most essential features of the desired solution, according to which it can be distinguished from the numerous possible solutions which ensure the goal achievement under the given restrictions. The solution optimization is made according to the criterion.

As a result of the problem formulation, a “solution model” is obtained which makes guidance at subsequent stages. For all these reasons, this stage is utmost important. The solution model in problem formulation is stated at the level of economics and, partly, at the level of technology, and the search for solutions is carried out first at the physical level and only then it progresses to the technical level.

In our study, the students learn to deal with technical problems for the improvement of technical objects. We will interpret a technical object as a holistic unity of interrelated material elements. When solving a technical problem of the curriculum in practical classes in physics, we will limit ourselves to the optimal principled solution, without addressing its structural characteristics.

The focus of thinking is achieved by orienting to the ideal end result — an ideal technical object (method, ideal device, machine). The concept of an ideal object is one of the fundamentals of the entire method of finding technical solutions. An ideal object occurs when the object is absent and the
result is the same as with its presence. To have such a result or get close to it, in the end, it is necessary to eliminate the physical contradiction.

To find and eliminate the physical contradiction, various special algorithms have been developed: a stock of analogue tasks, a stock of special techniques or operators, a stock of physical effects and phenomena to determine the most suitable effects for overcoming the contradictions within the problem, as well as a stock of complex standard techniques (standards) which are particularly strong combinations of methods for contradictions resolution.

In view of the above and on the basis of the work analysis, we offer the following algorithm for solving a technical problem as a means of the students’ technical thinking development.

The algorithm for solving a technical problem

1. Formulation of the problem:
   1.1 Introduction to the technical problem specifications:
      - identification of a technical object;
      - build-up of a technical object scheme (operating principle).
   1.2 Identification of the ultimate goal of the problem solution:
      - identification of the variable characteristic of the object (the characteristic that should be changed);
      - identification of an invariable characteristic of the object (the characteristic that cannot be changed when solving the problem).

2. Specification of terms, build-up of a problem model
   2.1 Identification of the physical principle underlying the technical object operation.
   2.2 Identification of a conflicting pair of object characteristics (variable and invariable).

3. Problem model analysis
   3.1 Formulation of a technical contradiction.
   3.2 Formulation of a physical contradiction.

4. Finding a fundamental solution of a technical problem.
   4.1 Formulation of the perfect end result.
   4.2 Elimination of physical contradiction and finding a fundamental solution in physical form with the help of:
      - stock of typical models of analogue problems;
      - identification of an invariable characteristic of the object (the characteristic that cannot be changed when solving the problem);
      - stock of physical effects and phenomena;
      - stock of standard methods for eliminating physical contradictions.
   4.3 Transition from the physical form of a problem solution to a technical one (removal of a technical contradiction):
      - formulation of the object operating method
      - development of the object basic design for implementing this method

5. Evaluation of the obtained solution of the technical problem:
   - verification of the degree of compliance of the obtained solution to the ideal end result;
   - in the case of an insufficient degree of compliance, it is possible to repeat the search for a solution, starting with any point having modified (updated) search restrictions.

It should be noted that the evaluation of the resulting solution on efficiency is a very important step in solving a technical problem from the point of view of the above search restrictions, as it at maximum contributes to the development of trainees' technical thinking.

The methods of identifying, analyzing and removing contradictions, the structural synthesis apparatus, the search logic basic concepts are fundamental basic elements of technological thinking.
development in general. Therefore, teaching students these basic elements is the basis of the proposed methodology.

3. Results and discussion

The use of the developed methodology allowed us to obtain the results presented in the article.

At the first stage, the initial level of technological culture indicators for students of the control group (K) and experimental group (E) participating in the experiment was determined and analyzed. The results of the comparative analysis are given in table 1.

**Table 1.** Comparative analysis of the results of the study of a technological culture of future engineers at the initial stage.

| Indicators                                      | Levels | Control (%) | Experimental (%) |
|------------------------------------------------|--------|-------------|------------------|
| Readiness to solve career oriented problems    | high   | 7           | 6                |
|                                                | medium | 40          | 39               |
|                                                | low    | 53          | 55               |
|                                                | high   | 9           | 8                |
| The level of moral and ethical values in the field of technological culture | medium | 46,5        | 47               |
|                                                | low    | 44,5        | 45               |
|                                                | high   | 6           | 4                |
| Level of technical thinking                    | medium | 21          | 20               |
|                                                | low    | 73          | 76               |
|                                                | high   | 5           | 5                |
| Level of creativity, ingenuity and innovation  | medium | 21          | 23               |
|                                                | low    | 74          | 71               |
|                                                | full   | 6           | 4                |
| Independence of thinking                       | partial | 83         | 82               |
|                                                | dependency | 11        | 14               |
|                                                | high   | 13          | 12               |
| Cognitive motivation in the field of physics   | medium | 40          | 41               |
|                                                | low    | 47          | 47               |
|                                                | negative | 47        | 47               |

It is impossible to fully align the initial levels of technological culture indicators in the compared groups, therefore, to increase the reliability of the result of the formation of students’ technological culture in the process of studying physics, the E group was chosen as an initially less educated one. To confirm the effectiveness of the pedagogical conditions identified, we divided the experimental group into two parts (E1 and E2). For the work with the first part, we used the entire range of methods, taking into account the allocated pedagogical conditions for the formation of students’ technological culture in the process of studying physics, for the second part, we did not use information technologies as three interrelated components: objects of study, tools for learning disciplines and new information technologies.

After the formative experiment, the diagnostics of the level of development of indicators of students’ technological culture was carried out. Comparative analysis of technological culture indicators taken after the formative experiment is given in table 2.

**Table 2.** Comparative analysis of technological culture indicators after the formative experiment.

| Indicators                                      | Levels | Control (%) | Experimental (%) |
|------------------------------------------------|--------|-------------|------------------|
| Readiness to solve career oriented problems    | high   | 8           | 12,5             |
|                                                | medium | 43          | 58               |
|                                                | low    | 49          | 29,5             |
|                                                |        |             | 11,5             |
|                                                |        |             | 58               |
|                                                |        |             | 30,5             |
As a result of the work carried out, we came to the conclusion that the proposed content of the formation of the technological culture of students as future engineers allows:

- to deepen knowledge in the field of development and implementation of technologies in modern conditions of social development; technological transformations taking place in society;
- to make students realize the place and tasks of their activity in the emerging technological society;
- to focus on some aspects of future professional activities related to the development and operation of technologies;
- to form readiness for independent use of information technologies in educational, and then in professional activity;
- to make the educational and practical activities motivated, both for the entire educational process and in relation to physics.

4. Conclusions

Thus, the results of the formative experiment allowed us, first, confirm the validity of our research, second, clarify the correctness of our hypothesis about the ways and means of forming the students’ technological culture in the process of studying physics, third, substantiate and test the developed educational-methodical and organizational support for the formation of this culture.

As a result of the developed methodology application, the number of students with medium and high levels of development of indicators of technological culture has increased significantly. Moreover, the difference in indicators for two experimental groups highlights the significance of using information technologies in the study of physics as an important pedagogical condition for the formation of students’ technological culture.

Within our developed approach to the arrangement of educational activities, we ensure continuity, succession in the study of disciplines of all cycles, integration of special, professional and technological training, which contributes to the formation of a certain technological world view and mastering technological culture in general.

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