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Design methods as a taught course at the Tomsk Polytechnic University

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ABSTRACT: The current situation has created an enormous demand for a growing supply of new ideas and solutions. Nowadays, a great deal of information is received from different sources; how can all of this information be managed so that it becomes useful for students? There exist over 200 techniques for engineering problem solving. The wide range of methods is included in a course at the Tomsk Polytechnic University (TPU), Tomsk, Russia, with the core theory called TRIZ (in Russian). Today, it is not actually about getting the information on devices and directions, but rather forecasting skills and understanding the basic laws of development in science and technology. This theory has been used successfully many times around the world. Some competent teachers consider that training with methods of TRIZ expands a person's creative possibilities. This course reveals how specific techniques, developed on the basic principles of TRIZ, can be used in a broad range of applications. The main aim of this course is to elaborate on students' inventiveness and hone their skills in engineering problem solving. Using TRIZ, students are taught how to find and solve problems. Students are not afraid to face new tasks; they can observe phenomena in correlation and thus systems thinking is formed.

> *The skill of the engineer is to know the moment when it is necessary to stop phenomena's learning and to begin their mastering.*
>
> N. Parkinson

INTRODUCTION

This article presents the results of teaching through design methods. Many people consider that the word *design* is usually connected with manufacturing design or architecture.

When designing a machine, it is recommended that some basic rules be kept in mind. There can be no full account made without examination of various economic and ergonomic factors. Economy-oriented designing means careful consideration of all of the factors that determine the efficiency of the machine and the correct evaluation of the relative importance of every factor [1].

Beyond the traditional definition of design, the concept also means:

- Design of large systems (for example, airport, transport, computers, education, etc);
- Design with regard to the participation of society in decision making;
- Design as creativity;
- Design as a teaching course that accommodates art and science;
- Design as life.

In other words, design is an action that must be undertaken in order to achieve some result.

For quite some time now, the concept of education has held the following approach: the teacher must teach and must give some knowledge, while the student must learn, remember and design according to established rules.

However, today, technical progress is changing the face of the Earth at an ever-accelerating pace. Scientists are finding ways to learn more in less time, to remember more and for a longer time, to do things faster and so on.

This situation generates an enormous demand for a growing supply of new ideas and solutions. Nowadays, there is a great deal of information received from various different sources. Yet how can all this information be successfully managed and made useful for students?

An ever-increasing percentage of the world economy depends on the knowledge of workers. As such, these workers need to be highly educated and skilled. This gives rise to the problem of forming such a motivation that will help students to acquire essential skills and knowledge for their future professional careers. This problem demands special attention. It is currently not so much about actually getting particular information concerning devices and directions that is so important, but rather forecasting skills and an understanding of the basic laws of development in science and technology. An engineer needs skills in order to be able to find and define the problem that needs solving [2].

A teacher in a contemporary situation is not only a keeper and a reproducer of information; he/she is also the manager of a student's creative activities. Given this, a teacher has to know and possess certain methods so as to manage such activities.

Determining a problem involves a systems approach in education. Specifically, it is that the student is placed at the centre of education and that this student recognises himself/herself as a complicated system and understands that

the surrounding world is in the world of systems as well. As such, it is necessary to be in harmony with all of these factors in order to avoid accidents. Such an approach is presented in the range of modern educational concepts, one of which is called TRIZ, which is elaborated on below.

AN OVERVIEW OF DIFFERENT DESIGN METHODS

> *The method is more significant than the discovery because the true method of investigation will lead to the new, more valuable discoveries.*
>
> Landau

During the 1970s, new methods of design were created and advanced in different countries. Scientists have been working on different areas of design, such as:

- Operation investigation;
- Ergonomics or human engineering;
- Management;
- Manufacturing design.

There now exist over 200 techniques for engineering problem solving: brainstorming, sinectics, morphological tables, business games and so on.

The wide range of methods is included within the teaching course on design at Tomsk Polytechnic University (TPU), Tomsk, Russia, but the core of the course involves the Theory of Invention Problem Solving (TIPS), otherwise termed TRIZ (in Russian).

It was Henry Altshuller who published his first book about this particular theory, which is based on the experience of people who have already solved real problems.

The so-called Theory of Invention Problem Solving is connected with psychology and philosophy, with physics and chemistry, with art and design. The main idea of this theory is that development of each system is due to the laws of the technical system evolution [3].

The laws of engineering do not depend on our knowledge about their existence. For quite some time now, designers have been following these laws by intuition. Here, management can serve as an example. Up until the middle of the last century, the belief prevailed that management as a subject could not be taught at all. It was impossible to imagine someone who had mastered the necessary skills and qualities of a manager as part of his/her general schooling and university training and hence was ready to cope effectively with any creative task. Yet now there exist various universities of management and marketing. The same situation has developed with the theory of invention problem solving.

THE FORMATION OF PRODUCTIVE KNOWLEDGE

In the manufacturing field, the main aim of a designer is to develop a machine that would be the most economical and that would have the best technical and operational characteristics. The Theory of Invention Problem Solving names these characteristics as criteria of a machine's development. The most important characteristics of machines are their productivity, efficiency, strength, reliability, weight, size and other key factors.

The priority of each of the above-mentioned characteristics depends on the purpose of the given machine, for example:

- For control instruments: accuracy;
- For transport machines: weight, etc.

Many persons in different countries have used this theory successfully since its origination and it does indeed seem quite effective with regard to technical problem solving. Some competent teachers consider that offering training utilising methods of TRIZ also serves to expand the creative attributes of each person. This course reveals how specific techniques, developed upon the basic principles of TRIZ, can be used in a broad range of applications.

The aim of TRIZ is to elaborate on the inventiveness of each student and to master skills in engineering problem solving.

Today, most scientists have come to a general conclusion that all forms of decision-making are in accordance with the design laws, as follows:

- The formation of a technical assignment (the choice of functions and consuming characteristics of the object).
- The choice of a prototype.
- Improvement of the prototype selected.

When forming a technical assignment, it is necessary not only to choose all of the relevant functions and consuming characteristics, but also generate new functions and consuming characteristics that may improve the object without additional costs.

CAD/CAM systems allow for the optimisation of parameters of technical systems, but do not allow for the generation of new technical solutions [4]. As such, the earlier that specialists pay attention to the laws of systems development, the more successful they will be in their professional activity, whether it be design, technology, research, business, politics, culture, sport and so on.

An engineer needs to have skills in finding and defining those problems that need solving. The main aim of pedagogy is to develop the creative abilities and skills of every person. By utilising TRIZ, students are taught how to find and solve problems. Students are not afraid to face new tasks; they can observe phenomena in correlation and, thus, systems thinking is formed. The process of the self-formation of each student is the result [5].

Skills to analyse an object *in time* (the past, present and future) and *in space* (under-system, system and over-system) comprise the basis of creative thinking. The ability to observe a system in the future means not making mistakes in the present. Likewise, the ability to observe a system in the past means not making mistakes in the future.

The elements of the systems approach are included in the syllabus of almost every department at the TPU in such subjects as:

- The Technology of Engineering Problem Solving;
- Methods of Scientific Creativity;
- Systems Analysis.

CONCLUDING REMARKS

More than ten years of delivering a course, which cover the methods of engineering creativity, has indicated the need to have this concept penetrate the syllabus that has been designed for students of this major. Explaining and teaching students examples of technical contradictions is less important than to form and develop skills that use these methods for their project works. When working on a project, it is suggested that a student makes a technical assignment for object creation by himself/herself.

Bachelor degree work includes a functional analysis of the object as a technical system. This is assigned in order to assess the productivity of the chosen object and define the further technical development of the system.

New methods to teach students engineering and design, as well as engineering creativity, will help to improve students' skills and proficiency as future designers, technologists and production managers.

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