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Structure of a lesson on the development of the students' creative personality in the CFCT-TRIZ pedagogical system

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Abstract. The article describes the theory and practice of introducing the system of creative education CFCT-TRIZ into the Voronezh State Technical University.The system was developed by Professor, Doctor of pedagogical sciences Zinovkina M.M. We give an example of teaching the substantive part of the course for the students of the construction specialty. The article will be of interest to the specialists working in the field of creative pedagogy.

Key words: CFCT-TRIZ, creative pedagogy, creativity, contradiction, invention.

1. Introduction

Modern educational standards make high demands on graduates of higher educational institutions. They should have a whole range of competencies that help them improve and develop their intellectual potential throughout their lives, find non-standard solutions to emerging problems, adapt to new situations, analyze their capabilities and gain new experience, work in a scientific team, generate new ideas, and so on. The analysis of the stated requirements and the pedagogical situation in the education showed that the best result can be given by a multilevel continuous creative education. The system of the continuous formation of creative thinking (CFCT-TRIZ), developed under the supervision of Professor M. Zinovkina, is aimed at achieving this goal [1, 2]. This innovative pedagogical system covers all stages of the formation and development of a person from childhood to old age. As professors of higher education, we are more interested in the strategy of the continuous formation of creative engineering thinking (CFCET) in higher education. CFCET proposes to conduct an integrated cycle of courses on the methodology of technical engineering creativity in the university. The basis of such courses is TRIZ (in English the name is typically rendered as "the theory of inventive problem solving", or TIPS), created by the Soviet scientist and inventor G.S. Altshuller [3, 4, 5, 6, 7] and developed by his students [8, 9, 10, 11].The theory of Altshuller has received worldwide recognition and is widely used as a tool for solving creative problems[12, 13, 14,1 5, 16, 17, 18].

2. The structure of a creative lesson on the system of CFCT-TRIZ

The implementation of innovative pedagogical technologies in the multi-level system of CFCT-TRIZ means changing the structure of lessons and their original content.

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Let us consider how this system is implemented in a particular lesson at the Construction Faculty of VSTU [19, 20, 21]. As a basis for the development of the methods of creative lessons with first-year students, we took the structure of a double creative lesson proposed by M.M. Zinovkina [2].

Block 1 (*motivation*) represents a specially selected system of original objects that can cause surprise to a student. This block ensures the student's motivation for the lessons and develops their curiosity. In this block, as a rule, the students were invited to guess from the photo or video of unusual objects what they were meant for.

Blocks 2 and **6** (*content part*) include the program material of the educational course and provide the formation of systemic thinking and the development of creative abilities.

Block 3 (*psychological unloading*) represents a system of tasks for psychological relief. For this purpose, the students were shown some exerciseson the harmonization of cerebral hemispheres development.

Block 4 (*brain-teaser*) represents a system of increasingly complicated brain-teasers, embodied in real objects, in the design of which an original, witty idea is realized. For this, the Tangram game was used, which allows one to assemble complex plot constructions from simple geometric figures, moving from relatively simple to more and more complex.

Block 5 (*intellectual warm-up*) represents a system of increasingly complex tasks aimed at developing the motivation, logical thinking and creative abilities of students. In this block, the students were offered to solve logical problems, allowing them to develop their ability to reflect.

Block 7 (*summary*) provides feedback from the students about the lesson and provides a qualitative and emotional assessment of the lesson by the students. Then some parts of the lesson were corrected, based on the results of the feedback.

3. Example of teaching the content part of the course for students of VSTU

Let us consider the methodology of teaching how to work with methods of resolving contradictions using intellectual tools for the development of creative thinking by examining the creative task.

The creative task: it is necessary to build a bridge with the span of more than 1 km across the strait so that ocean liners can pass under it.

3.1. Let us analyze the creative task

In order to build a stationary bridge over a water obstacle, the design of a beam bridge is usually used as a classical solution. The main bearing elements of a beam bridge are beams or girders. They work in bending and transmit the load to the piers installed on the base of the bridge. The beams and girders of a bridge are assembled into larger parts called spans. Each span is supported by piers. Spans can be split and continuous, and also cantilever. Each split span rests on two piers at the edges, and continuous spans can be supported by three or more piers. If the span of a bridge is small, then you can use the construction of a movable bridge. However, there is no such design of a movable or beam bridge, so that ocean liners can pass under it. What should one do?

To solve the creative problem, we will apply methods of activating creative thinking [3, 4]. The thing that lies at the base of every creative inventive task is a contradiction. The intensification and deepening of the contradiction is the main way to solve the problem: from the contradiction lying on the surface (administrative contradiction) to the deep contradiction present inside the system (technical contradiction) and,in the end, the ultimate development of the contradiction (physical contradiction), when some part of the technical system is immediately in two mutually exclusive states.

Let us define an administrative contradiction. An **administrative contradiction** is a contradiction between a need and a possibility of its satisfaction. It is often set by some administration or a customer and is formulated in the form: "It is necessary to do this and that, and how – it is not known."

Let us formulate the administrative contradiction in this problem: it is necessary to build a bridge with the span more than 1 km over the strait so that ocean liners can pass under it, but no one knows how to do this.

Let us now try to deepen the administrative contradiction in order to find its causes and move on to the technical contradiction and the model of the problem.

A technical contradiction is a contradiction between certain parts, qualities or parameters of a system. A technical contradiction arises with the improvement of some parts of the system due to unacceptable deterioration of the others. It represents the cause of the administrative contradiction and deepens it.

As a rule, improving some characteristics of an object, we sharply worsen the others. Usually, we have to find a compromise, that is, to sacrifice something.

A technical contradiction arises as a result of a disproportion in the development of different parts or parameters of a system. With significant quantitative changes in one part of the system and a sharp "lagging behind" of its other parts, situations arise when quantitative changes of one of the system's sides conflict with the others. The solution of such a contradiction often requires a qualitative change in the technical system itself. This is the law of the transition of quantitative changes to qualitative changes. Generating a creative problem model, we can facilitate the formulation of a technical contradiction.

A **creative problem model** is a mental, conventional scheme of the problem, reflecting the structure of the conflict in a system. One of the elements of a **conflicting pair** is the main object of consideration, and it is called a **product** or an object, and the second element is a **tool**. A **product** is an element of the technical system thatneeds to be processed (manufactured, moved, change, improve) according to the problem requirements. A **tool** is an element that directly interacts with the product.

In this problem, the conflicting pair is the span length of the bridge and the bridge pier. **The product** here is the span length of the bridge, and **the tool** is the bridge pier. The longer the span of the bridge, the more piers are required, which makes it complicated for ocean liners to passunder the bridge.

Let us aggravate the conflict and formulate the creative problem model as the technical contradiction: if the length of the bridge span will be enough to let ocean liners pass under the bridge, the problem is solved, but the bearing capacity of the span without bridge piersis not provided, which does not allow one to create such a span**.**

3.2. Analysis of the creative problem model

Let us define an **operational zone**, that is, a space within which the conflict specified in the problem model arises. In our case, the operational zoneis the span of the bridge with piers.

Let us now define **substance-field resources** of the system, the environment, and the product in question. To do this, we will perform a su-field analysis of the problem.

As is known [3, 4, 5], to improve the efficiency of technical systems, their structure should be specific. A model of such a structure is called a **su-field model**.

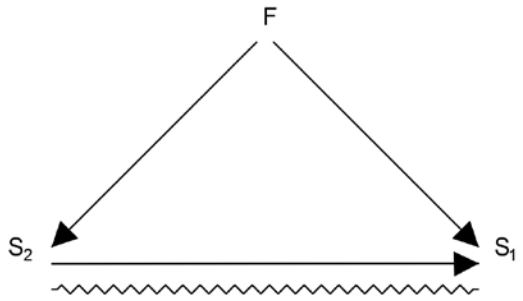

Figure 1. Schematic representation of the su-field model.

A **su-field model** is a minimally controlled technical system consisting of two interacting objects and the energy of their interaction. The interacting objects are conditionally called **substances** and are denoted $\mathbf{S_l}$ and $\mathbf{S_2}$, and the interaction energy is called a **field** is denoted **F**.

The term "**Su-field**" is derived from the words "Substance" and "Field".Typically, $\mathbf{S_1}$ is a product, $\mathbf{S_2}$ is a tool that "processes" the product $\mathbf{S_1}$, and **F** is a field. Let us construct the su-field model: we have $\mathbf{S_1}$ – the length of the span (product), $\mathbf{S_2}$ – the bridge pier (the tool "processing" the product $\mathbf{S_1}$), and **F** is the gravitational field. The su-field model is represented by the following scheme (Fig. 1).

Here the wavy line denotes a harmful interaction, which, according to the conditions of the creative task, must be eliminated.

3.3. Definition of an ideal final result and the physical contradiction

An ideal technical system is a system that does not exist, but its functions are fulfilled, i.e. the goals are achieved without the means. **An ideal final result** is an ideal to which one should strive for to solve a problem. The proximity of the solution to the ideal one determines the level and quality of the solution.

Let us formulate the ideal final result for our case: the span of the bridge by its own allows itself to be longer than 1 km without loss of bearing capacity and without the installation of intermediate bridge piers.

The analysis of the formulation of the ideal final result allows us to proceed to the formulation of a physical contradiction.

A physical contradiction is the presentation of diametrically opposite demands to the properties in a certain part of the technical system, that is, some part of it has to be in two mutually exclusive states.

The stage of revealing a physical contradiction represents an exact post-setting of the problem.

Let us formulate the physical contradiction for our creative problem: the span of the bridge has to be longer than 1 km without loss of bearing capacity and without the installation of intermediate bridge piers, and should not be longer than 1 km without loss of bearing capacity and without the installation of intermediate bridge piers.

The solution of the creative problem consists in resolving the physical contradiction.

Let us use the typical methods of eliminating physical contradictions created by Altshuller G.S. and collected in the information fund [3, 4, 5]. The information fund includes standards for solving inventive problems, technological effects, techniques for eliminating contradictions, ways of applying nature resources and technologies.

Firstly, we use the rule for the destruction of a su-field model, which says that we should destroy unnecessary or harmful su-field model by introducing extraneous substance $\mathbf{S_3}$ (Fig. 2).

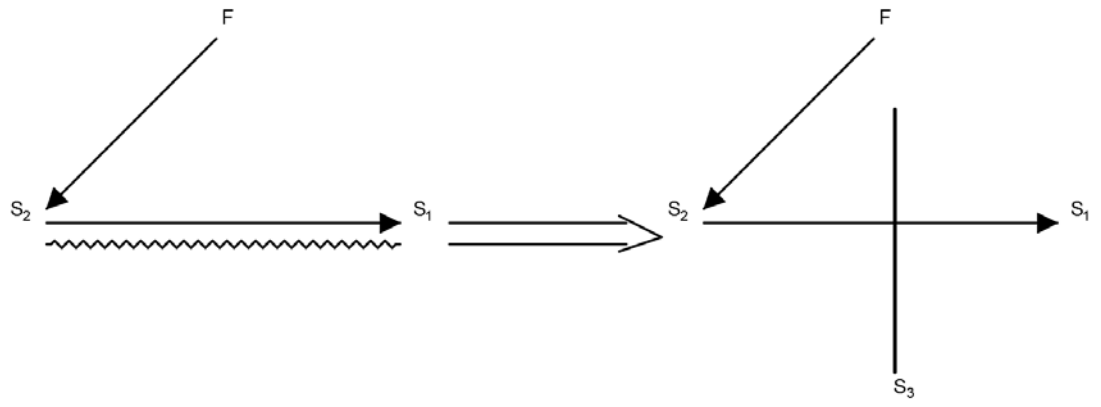

Figure 2. Elimination of harmful connections between the substances in the su-field model

Secondly, we use a certain **X**-element, which takes on the functions of the element $\mathbf{S_3}$.

Thirdly, we use the Altshuller table and analyze what needs to be changed by the requirements of the problem and what impermissibly worsens. The analysis of the table makes it possible to use the following set of typical methods for resolving technical contradictions [3, 4, 5]: the division principle, the taking out principle, the anti-weight (balance preserving) principle, the inversion (upside down) principle, the dynamics principle, the “blessing in disguise” (convert harm into benefit) principle, the intermediate means or “fitting” principle, theself-servicing principle.

The logic of solving creative problems according to TRIZ sharply narrows the field of searches and purposefully leads to the solution of the problem. Basing on the analysis of the methods above, we cometothe solution in the form of a hanging or suspension (cable truss) bridge design.

Hanging bridges, or suspension bridges, are installed where it is impossible or impractical to install bridges with intermediate piers. Bearing elements of such bridges are pylons and connecting cables. Pylons are installed on opposite banks or slopes, and between them, the main cables are stretched, which extend to the ground and are fixed there. Vertical cables, chains or beams supporting the canvas of the bridge are attached to them.

Cable truss bridges are a kind of suspension bridges. The difference is that the cables connect the canvas of the bridge directly to the pylons or to one, central pylon, and not to the horizontal cables. This construction makes the bridge more rigid and stable in comparison with the classic suspension bridges.

The construction of one of the world's largest cable truss bridges was completed in the Far East of Russia in the spring of 2012. The new bridge goesover the Bosporus East Passage and connects the mainland with the Russky Island. This is the first bridge of such dimensions and design in the territory of Russia. It can rightly be called a unique achievement of Russian engineers. It has the longest cable-stay span in the world (1104 m), the longest suspension cables (580 m), its pylons reach the height of 320 m. The total length of the structure is 3100 m, and the height of the main canvas is 70 m above the water, which allows even the most cumbersome ocean liners to pass under it (Fig. 3).



Figure 3. General view of the bridge to the island Russky
Source: website https://bigpicture.ru

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