ISSN 0798 1015

REVISTA ESPACIOS

HOME Revista ESPACIOS ÍNDICES A LOS AUTORES

EDUCACIÓN • EDUCAÇÃO • EDUCATION Vol. 38 (Nº 40) Año 2017. Pág. 28

Creation of the environment for the development of inventive abilities in subjects of education

Creación del entorno para el desarrollo de capacidades inventivas en temas de educación

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Received: 29/07/2017 • Approved: 05/08/2017

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ABSTRACT:

The article proves the expediency of using the tools of the Theory of Inventive Problem Solving (in Russian - TRIZ) to address the challenges of inventive abilities development in the subjects of education. As the solution, the authors provide specific educational environment named "TRIZ-inventor" implemented in the additional education program for primary school pupils. The developed program provides for the formation of creative educational resources-based environment in the course of mastering the methods of inventive problem solving. Elements of the educational environment named "City of inventors" allow teachers, students, parents, and psychologists master the tools for transforming objects and situations using the research and methodology complexes such as "Training room", "Entertainment park", "Museum of inventions", "Laboratory of inventors", and "Center for the inventions evaluation". The use of the program results in generating a learning environment that ensures the development of skills for creation and evaluation of authorial products of creative activity of those involved in education, increasing the level of their efficiency.
Keywords: TRIZ-based education, educational

RESUMEN:

El artículo demuestra la conveniencia de utilizar las herramientas de la teoría de la resolución de problemas inventivos (en ruso-TRIZ) para abordar los desafíos del desarrollo de las capacidades inventivas en los temas de la educación. Como la solución, los autores proporcionan el ambiente educativo específico nombrado "TRIZ-inventor" puesto en ejecución en el programa adicional de la educación para los alumnos de escuela primaria. El programa desarrollado prevé la formación de un entorno educativo basado en recursos creativos en el curso de la dominación de los métodos de resolución de problemas inventivos. Los elementos del entorno educativo denominado "ciudad de inventores" permiten a los docentes, estudiantes, los padres y los psicólogos dominan las herramientas para transformar objetos y situaciones utilizando los complejos de investigación y metodología tales como "sala de entrenamiento", "Parque de entretenimiento", "Museo de invenciones", "laboratorio de inventores", y "centro para la evaluación de invenciones". El uso del programa resulta en la generación de un entorno de aprendizaje que asegure el desarrollo de habilidades para la creación y evaluación de productos de autor de

environment; inventive abilities.

la actividad creativa de los involucrados en la educación, aumentando el nivel de su eficiencia.
Palabras clave: educación basada en TRIZ, entorno educativo; habilidades inventivas.

1. Introduction

Need of modern society in individuals, who are able to address problems from different fields of knowledge, leads to the active development of creative education system. Formation of personality, able to produce new information and quickly adjust their worldview in accordance with the newly acquired knowledge becomes a relevant objective. In this regard, the subjects of pedagogical research touch not only the responsible executives, inventors and innovators, able to set and choose ambitious goals in professional activities, but also schoolchildren, who are able to solve problems at the authorial level in terms of novelty and originality.

Modern education, which is based on the theory of inventive problem solving (hereinafter TRIZ-based education), justifies the need for teaching problem-solving skills. The basics of creativity in TRIZ-based education are seen as objective scientific knowledge that allows solving open problems using universal methods. Thus, TRIZ-based education is a training system of younger generation, who is able not only to maintain but also boost living standards of society.

In contrast to other creative education systems, it is focused on building specific decision effective in a given situation without busting a large number of options. At the same time TRIZ-based education synthesizes the most relevant theories of creativity from different fields of knowledge such as psychology, pedagogy, methodology of creativity, and innovation.

Contemporary concepts of TRIZ-based education solve the problem concerning development of theoretical representations about personality development in the course of creative activity, based on the TRIZ, and transfer technology of TRIZ basics as a science. The main sources of the TRIZ-based education syllabus for schoolchildren are as follows: 1) TRIZ-based problem solving tools; 2) the theory of creative personality development (Russian acronym - TRTL), 3) TRIZ-based course of Creative Imagination Development (RTV), 4) classical TRIZ-based General Theory of Powerful Thinking (OTSM).

The contents of the TRIZ-based course consolidates productive, innovative, and inventive types of creative activities, includes tasks aimed at implementing knowledge creation, transformation, and use of man-made objects in a new quality, as well as development of personal qualities to solve typical and atypical problems.

Currently, three approaches are conventionally distinguished in the concept of TRIZ-based education: traditional (classical) approach, contemporary (popular) approach, and future-oriented (advanced) approach, which are differentiated according to purpose, content, implementation technologies' strategies (Terekhova, and Nesterenko, 2015; Nesterenko (Selutskaya) 2013).

The developed course is the initial preparation phase of problems solver based on future-oriented (advanced) approach of TRIZ-based education. The main objectives of the course include:

- development of ability to analyze and solve problems on the authorial level;
- development of creative thinking skills based on dialectical and systemic ideas, the basic mental operations (analysis, synthesis, generalization, abstraction, and specification);
- development of innovative research and inventive activity practices when dealing with the problem;
- organization of productive activities based on algorithmic transformations;
- task-oriented reflection of transformations based on criteria (novelty, originality, efficiency (usefulness), and ideality).

The theoretical background of the curriculum is based on TRIZ and OTSM research (Altshuller, 1979; Altshuller and Vertkin 1994; Terekhova, 2013; Khomenko 2012) as well as research into TRIZ-based education, performed by the curriculum authors and their colleagues (Terekhova,

and Nesterenko, 2015; Nesterenko (Selutskaya), 2013; Sidorchuk, 1998).

2. Methods

Practice-oriented nature of the program assumes a special structure and a way of organizing classes. Conventionally, the classes can be divided into two large groups: the problem-oriented and project-oriented classes. The classes of the first type provide the development of inventive tools through specially organized play activities. These tools are then used when creating inventive solutions. In the classes of the second type tools are rediscovered by children in the course of the study, and then are used to create inventive ideas.

The section "Problems". In this section pupils master the basic tools of the course, which include descriptive cards, morphological table, work cards, system lift, time tape, system's passport, a tool for evaluating ideas – "Inventometer" (invention meter), as well as games aimed at analyzing and comparing objects on the grounds of indications, their grouping, classification, and ranking.

Explored tools are used to generate original ideas and products by the following ways: changing meaning of feature; conducting morphological analysis and synthesis; idealizing the system (versatility, transfer of function to other systems, transfer of function to the subsystem); and adjusting the object to different supersystems (dynamization). Furthermore, pupils master ways of studying and describing artificial systems based on the "system's passport" tool.

Section "Projects". In this section the pupils together with the teacher create specific methods and techniques based on earlier studied tools that allow them to execute the project and obtain creative products. In the first case pupils carry out system analysis of the obsolete object, and on its basis suggest ideas of various applications of this object. In the second case the pupils examine ways to change the meaning of the feature and use acquired knowledge to create towers out of anything at hand. In the third case the pupils identify ways of combining the opposite meanings of the feature, which are then used to create an object that combines the maximum number of opposites.

To create an environment for the development of inventive ability we conducted formalization of the training cycle structure on studying features of objects of the world. The training cycle designed to study the features of objects consists of 3 sections, focused respectively on the study of features' meaning and methods of their transformations, the design of creative product and the solution of challenging (inventive) problem. Depending on the previous training of children and the learning environment, some of the sections are combined, and sometimes two features are studied in the framework of a single section. In addition, the productive activity can be partially performed in the framework of other extra-curricular activities or independently. More detailed content of each unit is given below.

The 1st section of the cycle involves entering the "Town of inventors" through the "Training room"; carrying out exercises to develop the sensory canals; training of perception – representation – imagination; working at the "Laboratory"; acquainting in detail with feature-indicating cards and "features' collecting box" consisting of objects brought from home or available in the games room (collecting objects having different meanings of a given feature). "Entertainment park" involves conducting games with objects that allow implementing and practicing the basic operations for a given feature; working at the "Laboratory", carrying out experiments aimed at changing the feature instance, starting preparing the exhibition of feature for the "Museum of inventions"; creating the "Features' collecting box", i.e. conditional feature carrier (blobs of paint, simple geometric shapes for the feature of "shape", the types of surfaces for the feature of "texture", etc.); exit from "Town of inventors".

The 2nd section of the cycle involves entering the "Town of inventors" through the "Museum of inventions"; actualizing the experience gained in the previous lesson; conducting games with the features' collecting box; working at the "Laboratory"; combining different or opposite object features in different ways (reference for variability); compiling riddles; carrying out productive

activity, i.e. solving creative task with a restriction based on a given feature; evaluating creative product; placing creative products in the "Museum of inventions" at the “Exhibition of the feature”; exit from the “Town of inventors”.

The 3rd section of the cycle involves entering the “Town of inventors” through the “Entertainment park” and “Illusion room”; carrying out exercise to develop associative and creative thinking ("What it looks like?", associations’ chain); “Museum of inventions”, actualizing the experience gained in the previous classes; discussing creative products; “Laboratory of inventors”; solving the problem in "Rescuers’ club" technology (based on features learned earlier); fixing solutions in creative works or through adaptation for the stage; placing creative products at the exhibition of features of the “Museum of inventions”; exit from the “Town of inventors”.

Conclusive block of training. Preparation and holding the event named "Tour around the Town of inventors".

Training is implemented in the following forms:

1. Games and game tasks allow forming skills necessary for the inventive problem solving as well as developing appropriate abilities. They allow the teacher to manage the educational process flexibly, choosing games to practice necessary skills and varying the required time.

2. Mini-conversation, through which the teacher acquaints children to the concept or tool, sums up the tally of a game and draws conclusions. This usually takes no more than 2-3 minutes.

3. Mini-surveys conducted by children during their team work allow children to "discover" independently or with the help of the teacher the concepts and tools that are further used for obtaining inventive ideas.

4. Problems aimed at designing creative products by children allow obtaining the original idea using the studied tools. Problems are solved in the group. In some cases, the pupils are encouraged to find their own solution to similar problem in independent homework. The solution to the problem ends with evaluation of idea according to the criteria of utility, efficiency, novelty, and originality (this is done using the tool named "Inventometer").

Methodological support to the program, which includes description of tools, games and tasks, challenges and technologies associated with the organization of their solution, provides the opportunity to construct training using the above described elements.

The formation of attitudes on certain activities and the provision of holistic emotional perception of training are implemented through the specially created educational environment "Town of inventors". This environment is dynamic in nature since it can be supplemented with new elements.

The program environment includes the following components:

- **Training room.** Here the games are conducted to develop arbitrariness, team building, training of attention, memory, imagination, as well as action-oriented games to master the tools that are studied in the framework of the program. All games and exercises are held in the movement, children move freely around the room.
- **Entertainment park**. Similarly as the Training room, Entertainment park allows organizing a variety of games, including action-oriented ones. However, the environment of the Park allows focusing on the fantastic transformations, such as moving along the time tape, changing the size and other characteristics of the object to the values that do not exist in reality.
- **Museum**. This is the place where originally images of various objects are posted. Further, collections are supplemented by models and items made by children in the classroom and at home. In the "Museum" children conduct surveys of groups of similar objects and the systems’ development. Creating various thematic exhibitions in the framework of the "Museum", children have the opportunity to group, classify, and rank the objects from the feature collecting box in different ways that allows forming and developing mental operations needed to transform and create objects.
- **Laboratory**. Working at the Laboratory occupies a central place in the content of the proposed

course. Here children solve problems, create drawings and models of new objects, as well as study the characteristics of objects and the ways of their transformation. Assessing the quality of proposed solutions and choosing the best one can be done using Inventometer - a special tool for evaluating inventions, which is available at the Laboratory.

- **Inventions store**. Pupils can offer the products of their inventive work for sale in the Inventions store. However, a fussy store manager takes only truly useful and effective inventions. Pupils have to work hard to prove that their invention does not bring harm to anyone and is really necessary for many people.
- **Royal palace.** In the Town of inventors there is a king, who tries to surround himself only with innovative things. His daughter is a beautiful but rather petulant Princess. They are the main customers of young inventors, who often need to solve Royal problems.

3. Results and discussion

The resulting quality of problem solving by schoolchildren in the developed environment was analyzed in terms of three aspects: 1) the creative process; 2) the creative product; and 3) the creative person. Identified cognitive-intellectual and personal-individual (affective and sensory) factors of creativity define the procedural characteristics of the activities, its results, and creativity of the individual. Indicators to assess the ability to solve problems efficiently are the levels of creative thinking development, creative imagination in creative problem solving (problems, problem situations, and non-standard tasks), suggesting systematically and consistently transforming reality, combining incompatible, and relying on subjective experience that serves the basis of the systemic, dialectical thinking; arbitrary, productive imagination; as well as indicators to assess the productive efficiency of the solution. Table 1 presents the results of a statistical study of 179 schoolchildren of 3-4 grades.

Table 1. Correlation relations of problem solving productive efficiency by junior schoolchildren (N=179)

Diagnostics criteria	**Variable**	**Correlation with productive efficiency**	**Significance level**
Creativity	Degree of development	.164(*)	0.028
The trends of behavior in the group	Dependence	-.593(**)	0. 000
	Independence	.566(**)	0. 000
	Sociability	.184(*)	0.014
	Asociality	-.238(**)	0.001
	Readiness for the struggle	.699(**)	0. 000
	Avoidance of the struggle	-.578(**)	0. 000
The dominant style of behavior in conflict situation	Cooperation	.438(**)	0. 000
	Avoidant behavior	-.337(**)	0. 000
The orientation of the personality	Focus on communication with others	-.295(**)	0. 000
	Focus on activities	.358(**)	0. 000

Social communicative competence	Social communicative clumsiness	.589(**)	0. 000
	Intolerance of uncertainty	.692(**)	0. 000
	Aspiration for confinement	.267(**)	0.005
Vision of the future	Personal advancement	.407(**)	0. 000
	Financial success	-.311(**)	0.001

The conducted analysis has shown the availability of the following correlations: partial correlation with the indicators of creativity (readiness); full correlation with all indicators of behavioral tendencies in the real group (dependence/independence, sociability/asociality, readiness /avoidance of the struggle); the relationships with the dominant style of behavior in a conflict situation (cooperation, avoidance), as well as the relations with indicators showing the orientation of the individual (focus on communication with others, focus on activity) are reflected partially; full compliance with all the examined indicators of social communicative competence (social communicative clumsiness, intolerance of uncertainty, aspiration for confinement); partial reflection of relations with the future image (personal advancement, and financial success).

Analysis of positive and negative statistically significant relationships is reflected by several variables with various degree of manifestation. Data obtained in the experiment were refined through multiple regression analysis to determine whether the development of these qualities is just accompanying element of psychology and pedagogical support when working with problem, or a relationship, which determines the productive efficiency dynamics. The results of the multiple regression analysis conducted with regard to the sample of pupils (N=179) have shown that the most reliable predictor for the subjects of education at this age is the behavioral trend in the real group when solving various problems (Table 2). Thus, the increase in the work productive efficiency in pupils of 3-4 grades, when dealing with a problem, is influenced by environmental conditions and group forms of work, interaction in these groups when solving a problem, constructive behavior in the conflict, the attitude to the problem, the significance of its solution, ways of expressing opinions, as well as the value priorities of the "ideal self-conception". We should note the consistency of obtained correlations within the statistical significance of the indicators expressing the behavioral trends, and the role of communications through various psychodiagnostic techniques.

Table 2. The results of the multiple regression analysis of productive efficiency in problem solving by schoolchildren of 3-4 grades, and statistically significant personal features

The results of the regression for dependent variable: Productive efficiency R = .90156564 R2= .81282060 Corrected R2= .79738313						
F = 52.65243 df = 8.97 p = 0.000000 Intercept: 17.554316341						
Standard error of estimate: 1.685893 t(97) = 10.412 p = .0000						
Predictors	**Beta**	**Std. Err.**	**B**	**Std. Err.**	**t(97)**	**p**
Associated term			17.55432	1.685893	10.41248	0.000000

Readiness for the struggle	0.341009	0.061264	0.46314	0.083204	5.56626	0.000000
Intolerance of uncertainty	0.2 63364	0.057866	0.2 1648	0.047564	4.55127	0.000015
Dependence	-0.2 84516	0.055456	-0.39333	0.076665	-5.1 3051	0.000001
Social communicative clumsiness	0.1 96085	0.055231	0.1 4304	0.040291	3.55028	0.000596
Avoidance	-0.1 41725	0.047319	-0.2 0491	0.068414	-2.99511	0.003482
Sociability	-0.080276	0.047005	-0.1 0863	0.063605	-1.70782	0.090868
Originality	0.062954	0.045124	0.03533	0.025324	1.39512	0.1 66164
Personal advancement	0.065892	0.050871	0.08389	0.064769	1.2 9527	0.1 98301

4. Conclusion

In the course of experimental study we have identified different subject characteristics providing increased productive efficiency when dealing with the problem. The maximal growth of productive efficiency in the early school years is provided by the indicators characterizing behavioral trends in the creative environment and dominating style of behavior in conflict situation, as well as perception by younger adolescents of themselves and others as participants in the conflict, as well as indicators showing their personal communicative features.

The program-based training is carried out in Moscow since 2014 at the experimental sites of the Department of Education Development of the Academy of Qualification Improvement and Professional Retraining of Education Workers.

In consequence of the implementation of the development program of inventive abilities through the creation of the learning environment in children we revealed a favorable evolution of the problem solving efficiency.

Acknowledgements

The work was carried out with the financial support of the FGBOU VO Krasnoyarsk State Pedagogical University named after V.P. Astafieva under the contract for the performance of research works from 21.06.2017 #16-749 on the theme "Creation of the environment for the development of inventive abilities in subjects of education".

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Revista ESPACIOS. ISSN 0798 1015
Vol. 38 (Nº 40) Año 2017

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