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"Development of thinking skills" course: teaching TRIZ in academic setting.

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Abstract

The question of "How to teach TRIZ" has been the subject of much discussion and debate. Bruner [1] argued that children should be encouraged to “treat a task as a problem for which one invents an answer, rather than finding one out there in a book or on the blackboard”. This statement was taken from Dehaan's [2] article, published in 2009, on “Teaching Creativity and Inventive Problem Solving in Science” (p. 174), in which Altshuller's "Theory of inventive problem solving" has not been mentioned. This demonstrates only one aspect of why teaching TRIZ in educational systems is a challenging mission.
This paper describes the process and method used for developing the Development thinking skills and problem solving course in academic settings. The proposed program is a combination of a generic design and problem solving process thinking methods. The course was developed using 4 main thinking methodologies: Mayer's general problem description, Polya's algorithm for problem solving, Altshuller's Theory of inventive problem solving and System thinking. The new "Development thinking skills" course program is expected to overcome teaching and studying difficulties in acquiring advances problem solving skills in higher education setting.
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Keywords: Teaching TRIZ, Academy, Development of thinking skills, Educational innovations.

1. Introduction

The role of higher education has been topping policy debates across the globe due to the increased recognition of higher-level skills and competencies as essential to national development – especially in the context of globalization and the shift towards knowledge economies. From high-quality teachers to reach education for all goals, to

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engineers and scientists to lead innovation, countries at every level of development have important national policy priorities related to higher education. As such, at no time in human history has the welfare of nations been so closely linked to the quality and outreach of their higher education systems and institutions [3]. Teaching TRIZ and incorporating thinking tools in educationalacademic settings is a challenging mission mainly due to the lack of detailed course planning that should be integrated in conventional higher education curriculum. This paper presents TRIZ methodology used for structuring the development of thinking and problem solving skills course in academic settings designed to address some of UNESCO'S [3] and CDIO syllabus statement of goals for undergraduate students [4] improving inventive thinking skills in higher education systems.

2. Development of thinking skills course objectives and structure

2.1. Course objectives

- To appreciate how problem solving can be improved by utilizing thinking algorithms, as a main tool for generating innovations in many aspects of our lives.
- To understand the methods used for solving conflicts and improve our decision-making process in our
- everyday activities.
- To effectively evaluate and carry out problem-solving by understanding conflicting demands, use suitable thinking tools and choose the ideal solution.

2.2. Course description

"Development of thinking skills" focuses on the thinking algorithms and their use in different fields of interest as: engineering, science, marketing, management, natural systems, storytelling, films, war strategies, games and toys, humor, and crime mysteries.

The module will be taught in English at 9 academic institutions both in Israel and Europe as a part of the EFA-TEMPUS project: http://issuu.com/tempus-efa/docs/tempus-efa_1st_newsletter2

Expected benefits and outcomes: students will be invited to write a personal thinking and research project using real world systems, applying thinking algorithms and suggesting inventive problem solutions.

2.3. Course structure description

The course was constructed by using 4 major thinking methodologies: The *1st thinking methodology*: Mayer's general problem description [5].

In Mayer's book "Thinking, problem solving, cognition" problems generally consist of 3 parts:

- The Given - The problem begins in a certain state with certain conditions, objects, pieces of information presented at the onset of work on the problem.
- The Goals - The desired or terminal state of the problem is the goal state, and thinking is required to
- transform the problem from the given to the goal state.
- The Obstacles - The thinker has certain ways to change the given state or the goal of the problem. He does not know the correct answer. The correct sequence of behaviors or actions that will solve the problem is not obvious.

The *2nd thinking methodology*: Polya's algorithm for problem solving ["How to solve it", 6]:

- 1st Step: understand the problem.
- 2nd Step: devising a plan - find the connection between the data and the unknown.
- 3rd Step: carrying out the plan.
- 4th step: looking back - examine the solution obtained.

The *3rd thinking methodology*: Altshuller's Theory of inventive problem solving, using TRIZ [7, for example] thinking algorithms, for developing student's inventive thinking skills.

The *4th thinking methodology*: Systems: structure, function, thinking and analysis [8] [9] [10]. System thinking teaching objectives:

- Understand the functioning of systems as a whole, thinking in terms of whole systems,

- visualizing the "big picture".
- Simplify and understand better complex problems across different disciplines.
- Identify high leverage points and strategies for improving systems effectively.
- Develop students view and methods for understanding systems from different disciplines such as: engineering, science and natural systems, marketing, management etc.

2.4. Course content and flow description

Course structure was obtained by combining all the above 4 thinking methodologies, categorized into 5 basic steps according to the subsequent action flow described in table 1.

Table 1. Development of thinking skills course structure with thinking algorithm examples.

Development of thinking skills course main outline	Thinking algorithms used	Structure methodology (*1**,*2**,*3**,4*)
(1) How to identify key problems	System thinking Functional analysis Root cause analysis Trimming	1
(2) How to formulate and analyze problems	Non-defined vs. well defined problems Problem definition using system parameters TRIZ tools for problem modeling i.e. contradictions, Su-Field.	1-4
(3) Apply thinking tools for problem solving	TRIZ tools for problem solving: Contradiction matrix, Separation Algorithms.	3
(4) Use models of solutions to solve problems	40 Inventive principles, Standard solutions.	3
(5) How to select your best solution	The Ideal Solution" definitions, Laws of system development and evolution (TRIZ), Biomimetic modeling.	3

1* Mayer's general problem description; 2* Polya's algorithm for problem solving; 3* Altshuller's Theory of inventive problem solving, TRIZ; 4* Systems: system thinking & analysis.

2.5. Course teaching methods

2.5.1. Problem definition

The baseline methodology was constructed using what Mayer [5] has explained as: "it is useful to define the basic terms of problem and thinking": the Given, the Goals & the Obstacles. The latter is a well known concept that has been thought and demonstrated for many years in educational systems used for problem solving. In order to create a link between inventive thinking and everyday language problems, in this course program, TRIZ problem definitions were embedded into problem definitions as described in table 2.

Table 2. Conventional problem components vs. TRIZ problem components.

Conventional problem components in everyday language [5]	TRIZ problem components language
The Given	A description of the initial state of the problem.
The Goals	IFR The Ideal final result.
The Obstacles	Contradictions
A solution - a solution is a sequence of allowable actions that produces a competently specified goal expression [11]	Models of solutions

Embedding TRIZ thinking tools in conventional problem components (in everyday language), was used to construct a unique combination of problem solving language which links between the everyday problem solving components language and TRIZ thinking methodology.

The course program uses this analogy between everyday language and TRIZ terminology for problem solving process and has incorporated inventive thinking skills within the conventional education super system: integrating TRIZ problem definitions with conventional problem solving process categories. The benefit of showing the analogy between the TRIZ problem formulation as a contradictions and the obstacle is expected to 1. Overcome difficult teaching problems 2. Improve performance and increase the efficiency of educational systems.

2.5.2. Thinking with models

What is a thinking model? The word “modeling” comes from the Latin word modellus. It describes a typical human way of coping with the reality. Abstract representations of real-world objects have been in use since the Stone Age. A model can be defined as a simplified version of something that is real. Human have developed various kinds of models: structures, systems, process, simulations etc. Thinking with models should be incorporated to inventive thinking course syllabus, to practice the use of multiple modeling methods. Markman [12] has presented useful examples for practicing thinking with models plus knowledge representations: Cartesian coordinate system, hierarchy diagrams, Venn diagrams, flow charts etc.

2.5.3. Abstraction and generalization thinking tools

Generalization is defined as both an object and a means of thinking and communicating [13]. Or, generalization is constructed through abstraction of the essential invariants. The abstracted qualities are relations among objects, rather than objects themselves [14]. Inventive thinking requires using abstractions and generalization thinking tools when applying TRIZ models of problems and solutions. Those essential thinking tool, should be explained with exercises before using TRIZ thinking algorithms.

3. Summary

When constructing a new curriculum that includes developing thinking skills for undergraduate students, systematic thinking should be adopted for combining the existing teaching format with the new modifications within educational systems. Initiating educational innovations and reforms would probably be difficult to obtain and monitor in the short term. Changes made to curriculum and educational programs should be studied and evaluated for testing their applications and contribution to the development of thinking skills in our next generations.

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