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Effect of TRIZ on the creativity of engineering students

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ABSTRACT

Using a nonequivalent pretest–posttest design to evaluate a 6-week educational program, we explored the effect of the Theory of Inventive Problem Solving (Teoriya Resheniya Izobretatelskikh Zadatchin [Russian], TRIZ) on the creativity of 121 university freshmen studying engineering. Creative processes and creative products were the dependent variables in this study. Using scores of previous design works as covariates, this study used multivariate analysis of covariance (MANCOVA) to analyze the effects of TRIZ on students' creative processes and creative products. We found that TRIZ has a strongly positive effect on a student's ability to analyze problems, and to generate, select, and execute a strategy. TRIZ also increased the creativity with which students designed products, including their ability to develop and implement novel ideas. Based on these results, suggestions for teaching practices and future studies are proposed.

1. Introduction

Because the modern world relies heavily on engineering and technology (Engineering is Elementary, 2013), engineering should be a part of all students' education (Cunningham, 2009; Rogers, Wendell, & Foster, 2010). Indeed, the worldwide demand for engineers has been increasing rapidly; however, many engineering students have not yet achieved the ability to solve problems. Therefore, engineering curricula need to foster students' abilities to solve problems and view projects from an interdisciplinary perspective that leads to innovation (Mousoulides & English, 2011; Sunthonkanokpong, 2011; Ahlgren & Verner, 2013).

Engineering design combines creativity with innovative engineering techniques by converting new ideas into tangible forms (The United Kingdom's Economics and Finance Ministry, 2007). The Theory of Inventive Problem Solving (Teoriya Resheniya Izobretatelskikh Zadatchin [Russian], TRIZ), which was developed by Altshuller based on a review of 400,000 patents, is an approach to fostering creativity that has been primarily applied to problems related to technology and engineering (Ma, Jia, Liu, & Cai, 2010; Oman, Tumer, Wood, & Seepersad, 2013). However, it can also be effectively employed in the design of various products and in areas related to engineering design (Russo, Rizzi, & Montelisciani, 2014; Li, Ming, He, Zheng, & Xu, 2015).

Previous studies have shown that TRIZ significantly affects technical problem solving, innovation, technology forecasting and planning, business management, etc. (Ilevbare, Probert, & Phaal, 2013; Russo et al., 2014). TRIZ helps to identify problems, develop systems and find possible solutions. Although TRIZ can effectively solve problems in the aforementioned domains,

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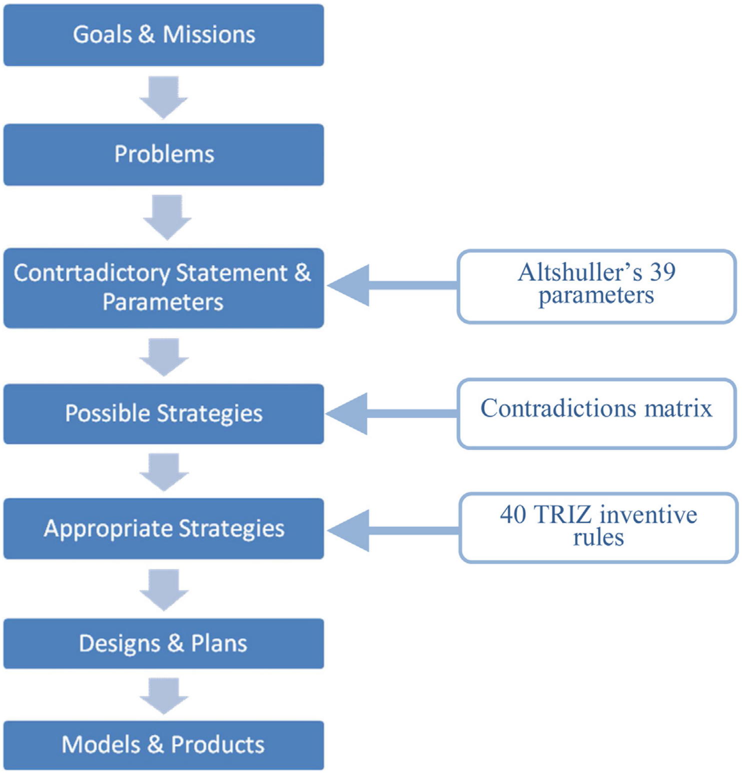

Fig. 1. The TRIZ approach.

it is even more important to determine whether it can improve the creativity of students' engineering designs (Albers, Lohmeyer, & Schmalenbach, 2011).

The present study explores how TRIZ affects engineering students in terms of their creative performance to better understand the creative process, and provides suggestions to improve creative outcomes.

2. Literature review

2.1. TRIZ

TRIZ is a knowledge-based systematic methodology for inventive problem solving (Gadd, 2011), which offers a systematic approach to finding technical solutions and increasing the innovativeness of technical systems (Ilevbare et al., 2013).

TRIZ assumes that problems related to innovative design involve one or more contradictory statements, and that when one parameter improves, another may deteriorate. TRIZ places 39 parameters, identified through patent analysis, into a matrix in which technical contradictions can be detected. It also outlines 40 principles of creative invention to resolve the contradictions, and solutions are achieved by matching the contradiction with its appropriate principle (Li & Huang, 2009; Pin, Haron, Sarmady, Talib, & Khader, 2011; Verhaegen, D'hondt, Vertommen, Dewulf, & Duflou, 2009; Zhang & Shang, 2010; Chulvi, González-Cruz, Mulet, & Aguilar-Zambrano, 2013; Petrović, Miljković, & Babiv, 2013; Ilevbare et al., 2013; Huang & Phu, 2013). The TRIZ approach involves the following steps: specifying potential functions, idealizing, defining problems, analyzing parameters, forming parameters, selecting a design solution, and implementing an innovative design (Moehrle, 2013; Ge & Wang, 2013; Hsu, Tsai, & Chen, 2013) (see Fig. 1).

As a technique that effectively resolves contradictions related to engineering problems and that reaches a balance/consensus among different interests, TRIZ has been rapidly and widely adopted in the academic and industrial domains (Fresner, Jantschgi, Birkel, Bärnthaler, & Krenn, 2010; Li & Huang, 2009; Pin et al., 2011; Zhang & Shang, 2010; Moehrle, 2013).

TRIZ has been widely adopted in many countries by a variety of academic research facilities, as well as by learning and teaching units (Ilevbare et al., 2013). This study found that the papers published by Science Direct (http://www.sciencedirect.com/science/search) from 2013 to 2015 are mostly about TRIZ applications in engineering and management. For example, "The 10th Japan TRIZ Symposium 2014" organized by the Japan TRIZ Society (2014) invited a number of companies (e.g., Idea, Olympus, Sony, Nikon, Pioneer, Sanno, Fujitsu, Hitachi) and university representatives to talk about their experiences with TRIZ. Most of these experiences were related to industry, technology, business and man-