

# Use of TRIZ in the Design Curriculum

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## Abstract\*

This paper describes the use of the Theory of Inventive Problem Solving (TRIZ) as a tool for enhancing the creativity of Mechanical Engineering students at Wayne State University. In addition to being a special elective course on TRIZ, this methodology is incorporated into the graduating "capstone" design course.

Key words: creativity, design, problem solving.

## Introduction

"Creative Thinking" is one of the most important issues requiring attention in engineering education. Today, however, the emphasis of many engineering curricula is moving steadily toward increasing the role of computers. While computers and such computer-based techniques as CAD, CAD/CAM, and FEA are powerful tools that significantly improve the productivity of practicing engineers, they do not offer engineers much help in developing novel concepts for solving design and manufacturing problems. It is well known that our competition overseas, both across the Atlantic and Pacific, frequently have much less access to computers, but develop better designed and more competitive products in shorter time frames.

It is absolutely essential that we empower students with a set of guidelines for creative thinking, and provide them with some experience in formulating and conceptually solving design and manufacturing problems. Success in this effort will certainly lead to the added benefit of enhancing the effectiveness of computer-aided applications.

These goals are achievable through the application of TRIZ, or the Theory of Inventive Problem Solving (TRIZ is its Russian abbreviation). Developed in the former Soviet Union by Genrikh Altshuller, TRIZ is an algorithmic methodology which helps break psychological inertia in problem solving. It also provides engineers with powerful algorithmic approaches to formulate, analyze, and solve complex engineering problems, as well as to use objective Laws of Evolution of Technological Systems for directed development of next generation products and processes.

The development of TRIZ began in the 1940s, and today it has matured into a comprehensive technology development and problem-solving methodology. One book, authored by Altshuller, was translated (very poorly) into English in 1984<sup>1</sup>. In 1991 the first author observed a demonstration of a TRIZ-related software, and subsequently organized a seminar at Wayne State University – conducted by two Russian TRIZ

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specialists – for Detroit-based manufacturing companies. This seminar was the beginning of WSU's involvement in TRIZ education and training. A brief description of TRIZ was then published in 1994<sup>2</sup>.

TRIZ, however, is much more than a problem-solving methodology. After several offerings of the course on TRIZ at Wayne State, it became clear that the most important impact it had was in changing the students' mindsets in their approach to problem resolution. The students themselves acknowledged this fact, realizing that TRIZ was not simply a collection of powerful solution techniques, but rather a way of breaking one's psychological inertia. This particular aspect of TRIZ remains largely underappreciated in light of the methodology's general growing popularity and the availability of several TRIZ-related software packages

What does this 'changing mindset' mean? The majority of our students, and most participants of short training courses, are usually employed at large companies (in our case, mostly in Detroit at car manufacturing and automotive suppliers). The climate in these companies is such that natural creativity is not encouraged, but rather suppressed. There are several factors responsible for this. One is overabundance of computers and the unwritten belief that they can solve problems; another is a rigid hierarchy which limits the initiative of young degreed and non-degreed engineers. Fear of failure is also a factor.

While the announced corporate policies are, "don't be afraid of failure, learn by it," actual attitudes reveal quite a different reality. As a result, many students and engineers attending short courses are closed-minded. At the beginning of a course, even simple (but strange looking) problems do not generate much response. Students are afraid to ask questions, much less offer solutions. Doing so might lead to "losing face." TRIZ training provides the much-needed confidence in tackling and solving any tough, unusual, or complex problems. With psychological inertia overcome, students' minds open up and their fears are alleviated. Even weak students experience noticeable changes.

In accordance with these findings, we developed a TRIZ-training approach emphasizing the ideology behind TRIZ rather than software application training. Problems are solved in the course of training, not with the aid of a computer, but rather by using ARIZ (Algorithm for Inventive Problem Solving), Standard Solution Approaches, The Laws of Evolution of Technological Systems, and other basic techniques of TRIZ. In this light, TRIZ is comparable to such powerful engineering methodologies as CAD and FEA. While using the best software systems in working with these methodologies, the practitioner must possess knowledge of design principles and principles of the theories of elasticity and strength of materials. Otherwise, the results will likely be disastrous.

There are two avenues for TRIZ training. One is training in the university environment. Another is training for industry personnel. This paper addresses the former approach. TRIZ-training activities at WSU consist of two parts: a special course on TRIZ and use of TRIZ techniques in the requisite "capstone" design course.

## **Elective TRIZ Course**

We developed (with help from Igor Vertkin) and offered for the first time in 1993 a four-credit course on "Creative Problem Solving in Design and Manufacturing." This elective course is open to senior undergraduate students as well as to graduate students. The course introduces the basics of major TRIZ techniques, taught in an interactive, "hands on" way. Students tackle exercises in class and in the form of homework assignments. They are also tasked with more difficult challenges, such as their employment related problems. All exercises are real-life challenges, previously solved using TRIZ techniques, and have all been practically implemented. For those students whose assignments resulted in the resolution of employment related challenges, the problems were solved in very cost-effective ways, and often the students themselves had changed so much that they became prolific inventors.

The first offering of the course attracted eight students, most of whom really enjoyed it because it was so different from other courses in the curriculum. Typical engineering classes are highly analytical, or require learning of highly structured material with very little deviation from their rigid constraints. The TRIZ course, on the contrary, encourages original thinking, offers challenging problems, and provides students with a powerful methodology, allowing them to quickly solve complex problems. Some students declared that this was "the best class in the curriculum." As a result, enrollment in the course grew steadily and reached fifty-seven by its fifth offering in the Summer of 1995. Interestingly, the majority of our students are part-timers, working for large local manufacturing companies.

## **Use of TRIZ in the "Capstone" Design Course**

After the success of the TRIZ course, some basics of TRIZ were incorporated into the senior undergraduate "capstone" design course. Traditionally, this course required students to design a device for a specified purpose and to participate in its fabrication. The resulting devices were usually heavy and cumbersome, required much effort, overloaded the machine shop, and usually did not significantly enhance the students' design creativity.

Presently, the principal direction of the course is geared toward creative conceptual design. Teams of students are given basic design and manufacturing problems that are approached using the TRIZ methodology to develop conceptual solutions. Since the TRIZ course is an elective, and only about half the students choose to take it, they are given four hours of lectures on TRIZ methodology. Afterward, they are divided into teams, and each team is given a design element or a manufacturing process which has to be conceptually improved. With help from an instructor, TRIZ algorithms are applied to problems in class, and novel conceptual solutions are developed. Following this stage, students perform a patent and literature search, which helps select the best concepts and, in some cases, provides directions for their modification. (Unfortunately, the patent database is underutilized both in industry and, even more so, in the educational process.) After selecting the best concept, students make preliminary and then final design

drawings while paying special attention to issues of manufacturability. The final step involves the fabrication of a conceptual prototype and then testing of the most important parameters of the corresponding devices.

The new "capstone" design course was initially offered twice – in the Fall of 1995 and Winter of 1996. A large turnout was generated, with 34-35 students enrolling in each class. The classes were split based on a uniform distribution of GPA among the enrollees. This approach forced students to develop working relations with other students who might have had totally different backgrounds.

**In the Fall 1995 term the following projects were developed:**

1. Two different conceptual approaches to the design of a briquetting roll press for bulk materials. Conventional presses have rolls with reciprocating half-molds. Such a system, universally used in industry, requires expensive manufacturing and produces briquettes of less than desirable strength. Students were guided through a TRIZ analysis of the problem and designed two, much-improved modifications of a briquetting press. Small hand-driven prototypes were fabricated and tested. Two students continued the project during the next semester through directed study. This work resulted in a system which is now under submission for industrial implementation.

2. Novel design of power transmission gears where the sliding and rolling in the mesh are physically separated. A hand-driven prototype was fabricated and tested.

3. Novel design of power transmission key connection where the key is flexible prior to insertion. A significant (5-6 times) reduction of maximum stresses in the connection was demonstrated. The fabricated prototype allowed comparison of four different key connections.

4. Modification of a gear train, preventing the development of gear rattling. A hand-driven prototype was tested under different regimes.

5. Innovative orientation device for oblong parts (such as logs for paper mills). A prototype for pencils was fabricated and tested.

6. Modification of a powertrain for a previously designed and built hybrid electric car (for a national competition).

**In the Winter 1996 term the following projects were developed:**

1. Accessories drive for internal combustion engines. Three teams designed, fabricated, and tested three different versions of variable transmission ratio flat belt drives. One design is the subject of a patent application by WSU.

2. Clamping device with a wedge mechanism. Use of thin-layered rubber-metal laminates allowed to enhance the efficiency of a wedge mechanism while a high-friction coating enhanced the clamping force even more. A compressed air-powered demonstration rig

was designed and built. It compares conventional, and the newly designed clamping devices.

3. Bench vise to handle parts of arbitrary shape. Two versions, one with spring-loaded pins, and another with vacuum activated bags filled with granular media, were fabricated and tested.

4. Universal joint with "solid state" trunnion bearings that are based on thin-layered rubber-metal laminates, do not require lubrication, are not sensitive to contamination, and have better efficiency than conventional bearings. A manually driven demonstration rig was designed and fabricated.

5. Frame for a human-powered vehicle (recumbent bicycle) for a National Student Competition. TRIZ principles were applied for designing the frame. Although WSU never before participated in such competitions, the team took fourth place, receiving "Special Recognition" by the judges for the report, and placed fourteenth (out of 32 participants) overall in the competition.

These projects not only taught students how to approach problems and develop novel concepts, but they also gave the participants a task and an opportunity to walk through the complete sequence of the design process (concept development, patent search, preliminary and final design, fabrication, testing). Students engaged in previously unfamiliar subject matter, such as briquetting, use of thin-layered rubber-metal laminates, and gear rattling. They were instructed to use the least amount of resources, especially in fabricating complex parts. These challenges led to quickly-formed and strong working relations among team members. Student evaluation of their team colleagues contributed to 15% of the overall grade.

## Conclusions

- Training in TRIZ and the introduction of TRIZ principles into the capstone design course results in highly beneficial changes to the participants' mindsets.
- It is important to make the TRIZ methodology available for masses of students (and engineers), enabling them to become more open, more creative, and more mentally flexible.

## References

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