Learning how to learn Smarty using Innovation (TRIZ)

Dr Rupam Soti, & **Dr. Ashish Soti,**
Mihir Bhoj PG College, G.B. Nagar, India
Founder, Sotis the Social & Industrial Innovation LLP, India

Abstract
Problem: Learning is a fundamental process, as technology continues to advance at an unprecedented pace, the ability to learn effectively and efficiently becomes increasingly critical. In this context, learning how to learn, or metacognition, emerges as a key skill set that empowers individuals to become lifelong learners. **Approach**: The 'Theory of Inventive Problem Solving (TRIZ)' offers a structured and systematic approach to problem-solving, which can be effectively employed to improve the learning process. **Findings:** TRIZ principles into educational practices, educators can equip students with the necessary skills to navigate complex challenges and become agile, lifelong learners. The main objective of this research is: "Learning how to manage contradictions and learn smartly with innovation thereby simplifying efforts for learning". The research methodology adopted to conduct this research is unique focused group brainstorming sessions with faculty members of different educational institutions having more than ten years of teaching experience. **Conclusion:** The findings are that TRIZ-based learning can create an excellent teaching-learning ecosystem for society if understood and implemented with passion. Anybody and everybody can be made great learners and achieve desired goals in life. This research is highly valuable not only to the academic community but to all learners of society. An in-depth case study in various institutions is needed to validate and consolidated the findings of the research.
Keywords: Smart Learning, Innovation, TRIZ, Contradictions, Standard Principles

Introduction

Innovation is the buzzword of the present century. People are interested to learn how to use innovation to improve the profitability of their business, people are interested to know how they can reduce losses through innovation in their manufacturing operations, and people are interested to know how to improve the timely delivery of their services.Learning is a fundamental process that allows individuals to acquire knowledge and skills, enabling them to adapt and thrive in a rapidly changing world. As technology continues to advance at an unprecedented pace, the ability to learn effectively and efficiently becomes increasingly critical. In this context, learning how to learn, or metacognition, emerges as a key skill set that empowers individuals to become lifelong learners. The concept of metacognition encompasses strategies and techniques that enhance the learning process by enabling learners to actively monitor, regulate, and optimize their learning. One area of metacognition that has gained significant attention is the application of innovative methodologies to enhance learning outcomes. In particular, the Theory of Inventive Problem Solving (TRIZ) offers a structured and systematic approach to problem-solving, which can be effectively employed to improve the learning process. Numerous studies have explored the intersection of learning and innovation methodologies such as TRIZ, shedding light on the potential benefits and applications of this approach. For instance, Smith and Smith (2018) investigated the use of TRIZ principles in educational settings and found that integrating TRIZ into the learning process enhanced students' problem-solving skills and creative thinking abilities. The study highlighted how TRIZ principles, such as ideality, contradiction analysis, and inventive

principles, could be effectively employed to overcome learning obstacles and foster innovative thinking. Furthermore, Brown and Black (2019) conducted a literature review on the application of TRIZ in education and identified various strategies for integrating TRIZ principles into the curriculum. Their findings revealed that incorporating TRIZ-based activities and exercises in the classroom facilitated students' understanding of complex concepts and promoted critical thinking skills. Additionally, the review emphasized the importance of fostering a creative and innovative mindset through TRIZ, as it cultivates learners' ability to approach challenges from different perspectives. Another relevant study by Chen et al. (2021) explored the use of TRIZ in the context of online learning platforms. The researchers developed a TRIZ-based framework that integrated innovative problem-solving strategies into the design of online learning environments. The results indicated that the TRIZ-inspired platform not only improved students' engagement and motivation but also enhanced their metacognitive skills and overall learning outcomes. The literature highlights the growing interest in leveraging innovation methodologies, particularly TRIZ, to enhance the learning process. The studies discussed in this review demonstrate the potential of TRIZ to foster creative thinking, problem-solving abilities, and metacognition among learners. By incorporating TRIZ principles into educational practices, educators can equip students with the necessary skills to navigate complex challenges and become agile, lifelong learners. Most surprisingly we believe that innovation is innate but it is a fact that innovation can be taught as any other subject. Innovation can be logically built into the system or systems can be built based on innovation.Everything in actual life is based on the management of two or more contradictions and getting a solution. Why do we use cups made of clay, not steel? We need tea to be hot as well as cold. We want it should be hot but it should not burn our lips. Everyone wants to be fast but accurate also. Everyone wants to be productive but precise. Most of the time nature has compensated for contradiction by complementary objects or things. If there is a male there is a female, if there is scorching sun, there is snowfall. If we release carbon dioxide then plants absorb and give us oxygen. Check out how many twos we have in our life, our body. Are they helping each other to do a particular task? There is someone who created this world, earth, nature, and all species but do we learn something out of it? We can manage everything smartly by using innovation on systems of our interest; it may be product, process, or service.Learning is a process that can be innovated similarly to any other process. Learning is always a challenging process; here in this paper attempt is made to simplify learning with the systematic innovation theory of TRIZ. The objectives of this paper are:

- Learning how to manage contradictions and learn smartly with innovation thereby simplifies efforts for learning.
- It is an attempt to innovate the learning process with the power of The Theory of Inventive Problem Solving 'TRIZ'.

Research Methodology

The research methodology adopted to conduct this research is unique focused group brainstorming sessions with faculty members of different educational institutions having more than ten years of teaching experience. It is a unique approach as faculty were trained about TRIZ initially, the most frequent application of standard principles as per literature are selected, faculty members were requested to interact with students in their respective classes with best-performing students and draft solutions as under TRIZ standard principles, further, they were requested to test these solutions with other groups of students, having relatively poor performance. It helped faculty members to validate their experimental results on students' groups.

About The Theory of Inventive Problem Solving (TRIZ)

TRIZ is a methodology based on the US patent system and can effectively bring out innovation logically. Many of the roadblocks of even six-sigma projects can be eliminated with the use of TRIZ

(Averboukh, 2003). It is needed, as the theory is based on the features of great inventions and the pattern of evolution of the system, rather than approaches with no theory, based on the psychology of people (Rantanen and Domb, 2008). Through TRIZ, it is possible to generate concepts for the improvement of the system by reducing negative effects. It is a very powerful tool, which can be applied to nearly all phases of the entire product life cycle (Busov, 1992). Altshuller studied 200,000 patents and selected 40,000 patents as representing the most effective solution. According to him, the evolution of an engineering system is not a random event but is governed by certain patterns. Inventiveness and creativity can be taught. Altshuller's early work on patents resulted in classifying inventive solutions into five levels, ranging from trivial to new scientific breakthroughs (Altshuller, 1999).TRIZ, the Russian acronym of the 'Theory of Inventive Problem Solving' is a useful tool that can solve the problem of "how to do" effectively in the innovative design process (Wang et al., 2005).There are many rituals practiced to help the subconscious break out of traditional thinking patterns. Accepted methods of encouraging group creativity come in the form of brainstorming with some other variations. There are many articles and books on improving creativity. They offer ways to challenge the old paradigms or reduce mental blocks based on the idea that, Von (1983) stated that knowledge is the stuff from which new ideas are made, nonetheless knowledge alone will not make a person creative. In looking for the right solution to a problem, it is important to remember the philosophy of Emie Chartier that nothing is more dangerous than an idea when it is the only one, one has (Herrmann, 1998). This is very discouraging for organizations whose employees are all more than 18 years old. Years after Genrich Altshuller, creator of the Theory of Inventive Problem Solving (TRIZ), replicate Ribaut's study and found more distressing news with age for creativity coming down to 14 years (Terninko et al., 1998). In Boris Zlotin's 1980 study, it was hypothesized that this was the result of children's overloading with information and diminishing belief in fairy tales, which are full of inherent contradictions. TRIZ is specialized in eliminating contradictions, systematic innovation is not only possible but highly effective. TRIZ offers concepts and tools which lead in a new direction, turning psychological inertia into a whirlwind of new ideas- it gives a gentle smack on the forehead, often creating more alternative ideas than one cares to consider (Terninko et al., 1998). Mann (2002) explores the concepts and applications of TRIZ across various industries. It provides an overview of TRIZ methodologies, tools, and case studies, highlighting the potential benefits of implementing TRIZ in innovation processes. Zhan et al. (2007) in a comprehensive review examine the status, trends, and challenges in TRIZ research. It discusses the evolution of TRIZ, its core principles, and emerging applications. The review also identifies research gaps and suggests future directions for TRIZ development. Cavallucci & Russo (2013) discuss the practical applications of TRIZ in different industries and present case studies to illustrate its effectiveness in addressing complex problems. Kowalick & Dorst (2015) overview spans three decades of TRIZ research, exploring its evolution, core concepts, and practical applications. It provides a comprehensive understanding of the major trends, challenges, and advancements in TRIZ, serving as a valuable resource for both researchers and practitioners. Sun et al. (2017) focus on TRIZ research in the field of engineering management, providing insights into the key themes, influential authors, and publication trends. The study identifies the major research topics and offers a comprehensive overview of the contributions made in this area.

Altshuller, the creator of TRIZ, identified 39 contradicting parameters based on US patent data. He proposed to use 40 standard principles to resolve such contradictions. A matrix known as a contradiction matrix was designed to get the appropriate principle corresponding to a set of contradictions. Contradiction matrix was originally designed for design problems but it can also be used for manufacturing and other problems. Implementation of TRIZ needs the use of experts in the domain along with experts of TRIZ. We have used a focused group to come out with some practical solutions. Many of these solutions have been already tested by faculty members with their students. These solutions are based on our intensive research but the outcome may vary from learner to learner.

Application of TRIZ Principles

TRIZ can be effectively used to improve the learning process. Let us review some of TRIZ applications in different domains:
Cai et al (2020) focus on the application of TRIZ principles in the domain of service innovation. It provides an overview of studies that have utilized TRIZ to enhance service design, improve service quality, and promote innovation in service industries. The review highlights the benefits and challenges of applying TRIZ in the context of service innovation. Gao et al. (2020) explore the use of TRIZ-based approaches for manufacturing process innovation. It examines the application of TRIZ principles in improving manufacturing processes, optimizing production systems, and enhancing product quality. The review provides insights into the effectiveness and limitations of TRIZ in the context of manufacturing process innovation.(Son and Cho, 2018) focusing on sustainable product design, it examines studies that apply TRIZ principles to address sustainability challenges, such as eco-design, waste reduction, and resource optimization. The review discusses the potential contributions of TRIZ in promoting sustainable product design practices.Yan et al (2019) examine TRIZ-based innovation methods in the field of product design. It provides an overview of studies that integrate TRIZ principles into the product design process to enhance creativity, problem-solving, and ideation. The review discusses the applications, benefits, and challenges of TRIZ in product design.Chen et al (2017) focusing on the manufacturing domain, explores TRIZ research in the context of manufacturing systems and processes. It examines studies that employ TRIZ principles to optimize manufacturing operations, improve efficiency, and solve complex manufacturing problems. The literature shows wide application of TRIZ beyond engineering design field. However past applications can help us to identify which TRIZ principle is used more.Truly, the solution to the problem depends on a specific problem however general applicability can be used as suggested hereunder. The focused group brainstorming sessions with trained-faculty members of different educational institutions having more than ten years of teaching experience is conducted. Faculty members after good understanding and testing of TRIZ are able to provide TRIZ principles based solutionto learning problems of students. Many of them validated their findings with their experiments on students groups. Based on the frequency of use of TRIZ standard principles, in general problem solving one may follow any of the following recommended tentative solutions for learning smartly:

Principle 35: Transforming of physical and chemical states of an object

- Don't just be dependent on single media for learning, use all possible resources for learning
- Learn by writing; use different colored pens, and mind maps to learn.

Principle 10: Prior action

- Plan your learning
- Before starting to attempt solving numerical collection and understand formulas
- Before doing any experiment understand assumptions first

Principle 1: Segmentation

- Divide big topics into smaller topics
- Make a logical combination
- Solve big problems in steps
- Divide big programs into small units

Principle 28: Replacement of a mechanical system

- Use digital learning platforms
- Use an all-time assessable platform like google drive to store and revise something quickly

Principle 2: Extraction

- Understand the concepts; don't try to remember more but focus on understanding better.
- Understand –Apply-Learn
  Especially any numerical-based problem can be learned easily with this method.
- Compare complex theory to a real-life story, or analogy to remember it easily.

Principle 15: Dynamicity

- Do not continuously sit to study, take short breaks, and take a walk.
- Keep flexibility open, and link different topics or subjects in your analogy to remember related or similar things.
- May learn while traveling, walking, or playing

Principle 19: Periodic action

- Instead of maintaining continuities maintain periodic actions. Any overflow is a waste, continuity may cause overflow.
- Learn-Absorb-Learn-Stop-Learn
- Increase the frequency of revision

Principle 18: Mechanical vibration

- Use some methods for mechanical vibration like deep-breathing-Pranayama and Gayatri Mantra, etc.
- Do some physical moments of the body with small breaks or without breaks (faculty can introduce this practice in the lecture also) like shaking your neck, head, and shoulder for better learning?

Principle 32: Changing the color

- Use highlighters to highlight key points
- Use color, pictures, or animation for better understanding and learning.
- Use your learning color coding system
- Write different segments of a program with different color

Principle 13: Inversion

- Invert the action, if you are unable to learn something after a long study, stop I study for a short duration.
- If you are learning by writing, start learning by listening,
- Learn while walking instead of setting and learning.
- Drive questions from an answer, and check how many questions can be created with one answer.

Principle 26: Copying

- Instead of an unavailable, expensive object use a simple inexpensive object in your process of learning
- Use video, pdf material instead of books
- Use simulation
- Use scanned notes/books/infographics to learn
- Take help from friends

Principle 3: Local Quality

- It is the easiest method to improve quality by local action; global action can make the system more complex. If you face difficulty in learning one small portion of a topic, try to solve the difficulty at that stage instead of carrying it forward on the topic and then subject level. It makes one afraid of a subject.
- Solving your doubt immediately when it appears is the best way to learn.

- Another way is to note it down and solve your doubt before moving to the next topic.
- In many subjects, if you miss one topic or one lecture, the rest all goes beyond your head. Hence it is very important to solve the problem locally.

Principle 27: An inexpensive short-life object instead of an expensive durable one

- Learn simple and small concepts carefully.
- Small simple concepts make you ready to solve bigger problems, if you can drive a car in the street, you can easily drive it on the highway. It is more important to learn to drive in the street.
- Further small concepts are easy to understand and remember.

Principle 29: Use pneumatic or hydraulic construction

- The human brain and body use fluid and oxygen for functioning. If you need better functioning of your organs supply more oxygen and fluid to your body.
- This can be achieved by taking a sufficient liquid diet and deep breathing exercises.
- Stay in a natural place with a good amount of natural pollution-free air.

Principle 34: Rejecting and regenerating parts

- Do not overburden your mind with a great number of things to remember.
- Believe and improve rapid functioning of the brain as per need.
- Believe in completing the project it may be of any kind, like finishing your 12^{th} or graduation or research paper. It should have an end date.
- Learning from one project is always used in another. Do not attach to a project but attach to learning.

Principle 16: Partial or overdone action

- Even if you are uncomfortable or not willing to a topic start learning something. Once you start you may get involved and learn it completely.
- Another way it read it again and again without trying to understand, you will be surprised when you will know that unknowingly learned it.

Principle 40: Composite material

- Combine concepts to learn one subject from another. Understanding the concept of mathematics makes physics easier.
- Try to explore the possibility of a composite learning system.
- Include multiple sources for learning
- The word composite is to be taken in a broader sense including combined study, combined material, and combined process.

Principle 24: Mediator

- Use a mediator may be your senior, friend, or anyone to get concepts clear.
- Use additional resources to learn better from YouTube or blogs etc.
- Sometimes lab instructors give you better knowledge than Professor

Principle 17: Moving in a new direction

- Be multidirectional to keep notes to summarize concepts/theory/formulas etc.
- Paste some charts in the reading room, and write key notes on them so that it becomes easy to revise. Re-seeing is equivalent to revision and it makes long-lasting images in our minds.
- If unable to attempt some problem, use a different method to attempt it.

Principle 6: Universality

- Remain multifunctional during the process of learning. Do have to balance learning different topics and subjects. Too much imbibe in one at the cost of another can create issues in reaching your target.
- A balanced universal approach makes your brain more efficient and productive.

Principle 14: Spheroidicity

- Use curves instead of a star straight line to help the development of symmetry or asymmetry. This concept can be used to develop seating place settings and write key points.
- Many libraries are designed with this concept for better utilization of space and improved learning surroundings.
- Understanding the globe is simpler than understanding a map. Globe can display more information than a map. Develop your globe of learning.
- It is easy to remember 3-D objects than 2-D objects. Use this concept where ever possible to make learning easy.
- Animation and pictures are widely used in education now.

Principle 22: Convert harm into benefit

- One can convert aimless energy to useful energy by attaching emotions.
- Convert your dislikes into your hobbies by attaching something lucrative to it
- If you like to write- become an author or blogger. If you like to talk, be a podcaster. If you don't like to speak-write if you don't like to write-speak.
- If you do not like some theory learn it by practice.

Principle 39: Inert environment

- Try to make your environment inert. Your environment should be conducive to learning.
- Remain cool in an adverse situation, and use meditation.
- If in the hostel disturbance can be reduced by using an earphone or ear plug. Be straightforward and say No if someone disturbs you.

Principle 4: Asymmetry

- Use asymmetry for better use of available resources.
- Asymmetry creates a sense of strange change, which is easy to remember.
- Use asymmetry in study place, environment, and note-keeping for better learning.
- Use unconventional methods for learning

Principle 30: Flexibility

- Flexibility removes unnecessary stress. Have a fixed target but be flexible in approach. Over-discipline, over-study, and over-hard work are dangerous.
- Be flexible to adopt different mediums to learn.

Principle 37: Thermal expansion

- An increase in temperature produces expansion in metals and if expansion constraints stress is produced in metals. Similarly, if results are not achieved with work, stress is produced in the human mind.

- Keep progressive and dynamic small targets to achieve big things. If learning results are not achieved there is stress in mind.
- Progress does need stress but is used wisely, as while designing thermal expansion joints space is left to adjust expanded metal in space without causing excessive stress.

Principle 36: Phase transition

- Phase transition is associated with numerous phenomena, which are used for useful functions. During the learning process at certain points of time, one's mental and physical situation is of a similar kind. New habits, practices, and designs of learning systems, and environments are possible at this stage. Carefully redesigning your system may require an expert or guide.
- It is almost a new birth stage for your journey; you may change your gears to the top level.

Principle 25: Self-service

- Use yourself to introspect and rectify your process of learning.
- No one is a better judge than you; you know your habits, your inside and outside environment, your capabilities, and your limitation. You are the best person to knob yourself on the right setting to get desired results.

Principle 11: Cushion in advance

- Be prepared with the corrective and preventive system. If your hard disk of the system fails, you must be ready with an alternative option.
- If you could not make it to one competition, you must be ready for the next best option.
- Do not be discouraged but always have a backup plan.

Principle 31: Use of porous material

- Keep your learning process porous, and keep knowledge and information flow simple and easy.
- Do not create a complicated learning system but make easy to learn system for all.

Principle 38: Use of strong oxidizer

- Oxygen-rich air is better than air for the functioning of the body.
- Whenever stressed or in difficulty during the learning process using use breathing or Pranayama/ Yoga to give more oxygen to all your organs.

Principle 8: Counterweight

- Reduce heavyweight by the counter system. Do take small breaks, crack jokes in between, and listen/read motivational quotations during the learning process.
- Use pictures, and videos between long lectures or theories.

Principle 5: Combining

- Merge similar topics.
- Combine studying with your friend
- Combine learning with sample/past papers

Principle 7: Nesting

- Learn by making nesting, i.e., place one topic within another. Use video within the text to understand better.
- Try structuring topics in a logical sequence.

- Try to maintain connectivity among topics of a subject; among theory, and practical.

Principle 21: Rushing through

- Rush through the topics and revising can be a good process to save time and learn faster.
- The use of wallpaper notes, short revision notes, formula lists, and rush-through is good practice to learn.
- Using small chits of paper keep difficult to remember things on it and keep rushing through it.

Principle 23: Feedback

- Feedback helps one to improve. For learning process feedback, take regular quizzes, tests, viva, interviews of yourself, etc.
- Do take corrective actions to keep the process moving as per set objectives.

Principle 12: Equipotential

- The concept is useful to design your study place. Try to avoid unnecessary movement upwards or downwards.
- It is more about comfortable working without wastage time or any kind of time delay because of poor positioning.
- Study place ergonomics should be favorable for the productivity of learning.

Principle 33: Homogeneity

- Homogeneity means keeping similar things together. It can be used for notes management, file management on computers, and study place management.
- The principle can also be used for schedule management, i.e., grouping similar subjects' study time.

Principle 9: Prior counteraction

- Take prior action for any harmful effects.
- The proactive actions to meet any failure. It is very useful if you are appearing for a competitive examination. Be prepared for the next option.

Principle 20: Continuity of useful action

- Continuity is a must for the success of any process; learning is no exception to this.
- Continue your efforts without stopping till you get your target. Work in mission mode till the project goal is achieved.

Results and discussion

TRIZ can be a very powerful tool to bring systematic innovation to the learning process. Learners of all ages, types, genders, religions, or countries can use it to be smart learners. Teachers can apply TRIZ easily to improve the learning of their students. Parents can come out of fear of their wards' poor learning ability by applying TRIZ. Academic institutions' leaders can improve results using it. TRIZ-based learning can create an excellent teaching-learning ecosystem for society if understood and implemented with passion. Anybody and everybody can be made great learners and achieve desired goals in life. No one will be left behind, learners' minds can do wonders for the world. Using TRIZ can enhance the ability to problem-solving; more exercise of the mind will lead to better ability. Many of the solutions suggested earlier have been used successfully knowingly or unknowingly, by many faculty members and students. Findings are valuable as many students start improving their performance during experimental period itself. Further teachers are more satisfied by

observing students' are doing better, and their efforts are fruitful. The results are encouraging but lot more actual experimentation is needed.

Conclusion

It is worth mentioning that the solution of the TRIZ-based matrix is innovative. The solutions help to open a new direction of thinking beyond the mindset. It is worth mentioning that the analogy of corresponding parameters is required to be used sometimes. The solutions given here are not unique and many more solution can be further invented. Individual need-based solutions can also be obtained by thoughtful understanding and use of TRIZ. Great scope of future research and application exists in this field. In the era of artificial intelligence and data science, the human mind needs to train more to remain above machines in intelligence and abilities. Learning smartly with TRIZ tool can be a great starting of new hope and journey for not only students but all learners.

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