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TRIZ: An Alternate Way to Solve Problem for Student

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Abstract
Inventive problem solving is an alternative way of solving problem for student. 60 years ago, in 1956, Altshuller published a new, constructive and methodical approach ideas on problem solving to offer to the world. Even though TRIZ originally meant for fields of industry domains, it has solved problems in other field using some common principles. Thus, this methodology has spread to over 35 countries across the world. It is now being taught in several universities and it has been applied by a number of global organizations who have found it particularly useful to solve their problem. In 2017, KSSM curriculum has been revised to cope up this 21st century demand. This paper is a potentially useful for TRIZ beginner, as an alternative to solve problem comparable to common problem solving method. This paper also discussed the limitation of other common problem method which leads the advantages of using TRIZ.

Keywords: *TRIZ, Problem Solving, Skills, KSSM, Inventive Problem.*

Introduction
The Malaysian Ministry of Education (MoE) awaits 2017 with much eagerness as it is the year that sees implementation of new Standard Curriculum for Secondary Schools (KSSM) for Form One students and a revised primary School Standard Curriculum (KSSR) for Year One pupils. The revision of this new curriculum is to strengthen and improves to ensure that the curriculum is relevant to the present needs and the 21st century's challenge. This is also in line with the Government Transformation Plan. This new curriculum focuses on the pedagogy which emphasize learning in depth through approach to teaching and learning based on higher thinking skills. Problem solving skills is one of the skills that MoE highlighted on. This is again stressed in KSSM framework under humanity stated that the intention of having the revision is to have student with high problem solving skills.

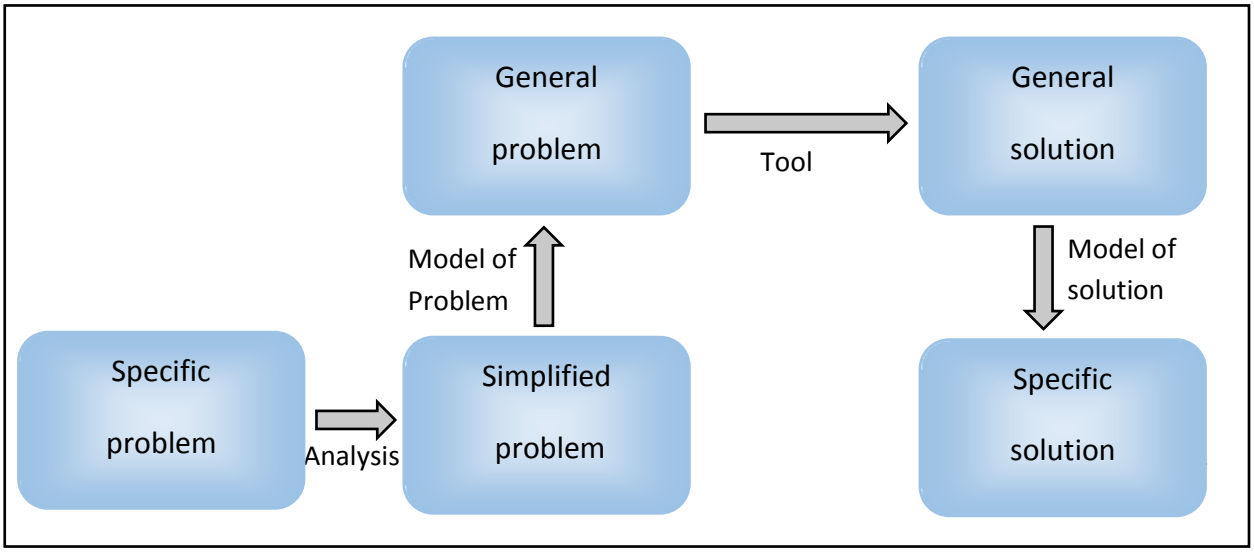
Problem solving is one of the methods used by educators to generate ideas in order to develop solutions that are more effective and practical. In this method, the process of problem solving is implemented according to systematic and organized steps. Hence, students will be guided to solve the problem. During this process, the student will learn to analyze, evaluate and make conclusions. And at the same time, the students can apply their critical thinking skills. They will be easy to memorize and always ready to face any lesson (Ismail & Atan, 2011).

Inventive Problem Solving

Problem solving is a method in which individuals required to move from the start to the goal in the problem space (Newell & Simon, 1972 in Ismail, 2011). Hence, the problem is a process that involves the movement of a situation by the executor and one of the most effective ways to solve the problem is to reduce the difference between the initial situations compared to the next coming situation with desired goal. By means of eliminating the difference in order to get similar pre and post situations. This is similar to the inventive problem solving method where its identify and eliminate the contradiction between the initial situation with the goal state situation (Montecchi & Russo, 2015).

As any other problem solving method which has their own step-by-step method, a step-by-step method for problem solving is invented by Altshuller in 1956 (Davide & Duci, 2015). These methods named TRIZ, is the Russian acronym of Teoriya Rescheniya Izobretatelskich Zadach which means Theory of Inventive Problem Solving (Kamarudin, Ridgway & Hassan, 2015).

TRIZ recommends changing a specific problem into a simplified, generic problem and find solutions by identifying the main function of the problem and its contradiction as in **Figure 1**. The Contradiction Matrix is one of the easiest TRIZ tools to use when solving problem (Gadd, 2011). After identification of both main function and contradiction of a problem, it is then reformulated into TRIZ 39 Parameters (39-P) and then brought forward to the TRIZ Contradiction Matrix.



The matrix consists of 39 improving and worsening features. The following explanations were taken from the TRIZ Journal by Ellen Domb from translations of Altshuller's work.

1. Weight of moving object	21. Power
2. Weight of stationary object	22. Loss of Energy
3. Length of moving object	23. Loss of substance
4. Length of stationary object	24. Loss of Information
5. Area of moving object	25. Loss of Time
6. Area of stationary object	26. Quantity of substance/the matter
7. Volume of moving object	27. Reliability
8. Volume of stationary object	28. Measurement accuracy
9. Speed	29. Manufacturing precision
10. Force	30. External harm affects the object
11. Stress or pressure	31. Object-generated harmful factors
12. Shape	32. Ease of manufacture
13. Stability of the object's composition	33. Ease of operation
14. Strength	34. Ease of repair
15. Duration of action by a moving object	35. Adaptability or versatility
16. Duration of action by a stationary object	36. Device complexity
17. Temperature	37. Difficulty of detecting and measuring
18. Illumination intensity	38. Extent of automation
19. Use of energy by moving object	39. Productivity
20. Use of energy by stationary object	

Table 1 TRIZ 39-P

TRIZ Contradiction Matrix

Contradiction matrix is presented in a table form as in **Table 2**. The 39-P is positioned on the top row and on the first column of the table. The first step is to decide what is getting better and what is getting worse (or what is preventing things from improving) in the problem. The matrix tells which of the 40 principles have been used most frequently to solve a problem that involves a particular contradiction.

For example, in **Table 2**. The parameters of “adaptability and versatility” which is in improving features and “system complexity” which is in the worsening features. The intersection circle in red shows the principle’s number. This numbers of the principles represent the most popular for solving that class of problems, in descending order. If the cell that matches the problem is blank, then use all 40 to find the principle(s) that best can solve the problem (Ang & Ng, 2011).

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Worsening Feature → / Improving Feature ↓	Speed	Shape	Loss of Time	Reliability	Measurement accuracy	Ease of operation	Adaptability or versatility	System complexity	Measurement Difficulty	Productivity
Speed	+	35, 15, 18, 34		11, 35, 27, 28	28, 32, 1, 24	32, 28, 13, 12	15, 10, 26	10, 28, 4, 34	3, 34, 27, 16	
Shape	35, 15, 34, 18	+	14, 10, 34, 17	10, 40, 16	28, 32, 1	32, 15, 26	1, 15, 29	16, 29, 1, 28	15, 13, 39	17, 26, 34, 10
Loss of Information	26, 32		24, 26, 28, 32	10, 28, 23		27, 22			35, 33	13, 23, 15
Loss of Time		4, 10, 34, 17	+	10, 30, 4	24, 34, 28, 32	4, 28, 10, 34	35, 28	6, 29	18, 28, 32, 10	
Measurement accuracy	28, 13, 32, 24	6, 28, 32	24, 34, 28, 32	5, 11, 1, 23	+	1, 13, 17, 34	13, 35, 2	27, 35, 10, 34	26, 24, 32, 28	10, 34, 28, 32
Ease of operation	18, 13, 34	15, 34, 29, 28	4, 28, 10, 34	17, 27, 8, 40	25, 13, 2, 34	+	15, 34, 1, 16	32, 26, 12, 17		15, 1, 28
Ease of repair	34, 9	1, 13, 2, 4	32, 1, 10, 25	11, 10, 1, 16	10, 2, 13	1, 12, 26, 15	7, 1, 4, 16	35, 1, 13, 11		1, 32, 10
Adaptability or versatility	35, 10, 14	15, 37, 1, 8	35, 28	35, 13, 8, 24	35, 5, 1, 10	15, 34, 1, 16	+	15, 29, 37, 28	1	35, 28, 6, 37
System complexity	34, 10, 28	29, 13, 28, 15	6, 29	13, 35, 1	2, 26, 10, 34	27, 9, 26, 24	29, 15, 28, 37	+	15, 10, 37, 28	12, 17, 28
Productivity		14, 10, 34, 40		1, 35, 10, 38	1, 10, 34, 28	1, 28, 7, 10	1, 35, 28, 37	12, 17, 28, 24	35, 18, 27, 2	+

Table 2 Contradiction Matrix Ang & Ng (2011)

TRIZ 40 Principles

It is a basic general guideline that helps to solve the contradiction problem.

1. Segmentation	21. Skipping
2. Taking out	22. Blessing in disguise
3. Local quality	23. Feedback
4. Asymmetry	24. Intermediary
5. Merging	25. Self-service
6. Universality	26. Copying
7. Russian dolls	27. Cheap short-lived objects
8. Anti-weight	28. Mechanics substitution
9. Preliminary anti-action	29. Pneumatics and hydraulics
10. Preliminary action	30. Flexible shells and thin films
11. Beforehand cushioning	31. Porous materials
12. Equipotentiality	32. Colour changes
13. "The other way round"	33. Homogeneity
14. Spheroidality - Curvature	34. Discarding and recovering
15. Dynamics	35. Parameter changes
16. Partial or excessive actions	36. Phase transitions
17. Another dimension	37. Thermal expansion
18. Mechanical vibration	38. Strong oxidants
19. Periodic action	39. Inert atmosphere
20. Continuity of useful action Module	40. Composite materials

Table 3 TRIZ 40 Principle

Steps of Inventive Problem Solving

Solving problems with help of the matrix is easy (Frenklach, 2007).

1. Determine the two parameters of the system. One is improve parameter and the other one is worsen parameter. The improve parameter is the parameter that improving that system while the worsen parameter is the parameter that getting worse after the improvement done.
2. Match each of the two parameters to one (or more) of the appropriate 39 parameters (row: improved features, column: worsens features).
3. Find the intersection at the selected row and column. These numbers indicate the solution.
4. Find the principles' descriptions.
5. Convert the general solution by the specific principle into a specific solution for the problem.

Advantages of Using Inventive Problem Solving Skill

The application of TRIZ 40 Principles found in communication, military, literature, communication, sport, medicine, politics, mass media, diplomacy, justice and other spheres of mankind activity (Retseptor, 2003). The rising interest in TRIZ is generating a market demand for professionals skilled in TRIZ techniques (Wits, Vaneker & Souchkov, 2010). Malaysia was not spared from producing workers who have employability skills that can meet the needs of the labor market and to boost the country's economy (Husain *et al*., 2013). Thus, MoE has implemented the Education Development Master Plan (PIPP) which aims to strengthen education in all levels, including primary school level in order to produce human capital that is competitive in the market world-class career.

Learning TRIZ was found to have a stronger influence on self- efficacy judged on past performance (Harlim & Belski, 2015). Learning specific tools of problem solving together with effective implementation can assist with the development of self-efficacy. Self-efficacy is important as it impacts the willingness to face future problems which has a role in the improvement of problem solving ability. By using TRIZ techniques, Sire *et al*., (2015), found out that the confident level of such trained students to solve any problem they will face and especially in tackling unfamiliar problems were increased.

Limitation of other usual problem solving methods becomes an advantage of why TRIZ is the alternate way to solve problem. The limitations are psychological inertia, lack of knowledge, wrong objective or goal, the solver avoiding conflict or contradiction or the solver might do not know the actual root cause of the problem (Terninko *et al.,*1998). One who uses TRIZ method will try to match real system parameters to the matrix's parameters which enables them to get deeper into the problem and understand it better. A better problem understanding will be the right step in the right direction. Thus, these steps by steps process will cover all limitation stated above.

Conclusion

For the last 6 years, approximately 50 universities worldwide offer some form of TRIZ education at various levels (Wits *et al*., 2010). The conclusion was that the use of a systematic way to analyze the problem and thus solving the problem was helpful for students to direct their attention and discovery (Sire *et al*., 2015).

TRIZ has given a structured methodology for creative problem solving in technologies and other fields as well. However, the methodology of TRIZ itself needs to be adapted and reorganized for easier learning and application in order to make a full use of it (Nakagawa, 2011).

TRIZ provides predictability, repeatability and reliability because of it's structure and algorithmic approach (Terninko *et al.,*1998). Hence, it eliminates all the limitation that other problem solving methods offer. However, on account of the benefits, there is a need for teachers to know about TRIZ method for them to be able to teach to their student (Sire *et al*., 2015).

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