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► To cite this version:

Tony Tanoyo, Jennifer Harlim, Iouri Belski. Facilitation of a Creative Culture Through the Implementation and Initial Evaluation of a TRIZ Course Within an Organisation. TRIZ Future conference, Sep 2021, Bolzano, Italy. pp.379-390, 10.1007/978-3-030-86614-3_30 . hal-04067796

HAL Id: hal-04067796

<https://inria.hal.science/hal-04067796>

Submitted on 13 Apr 2023

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Facilitation of a creative culture through the implementation and initial evaluation of a TRIZ course within an organisation

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Abstract.

This paper introduces the application of TRIZ training via an online system using a real non-technical problem within the engineering department of an organisation in Melbourne, Australia. The research questions explored are: 1) Can an online TRIZ training using real problem be effectively implemented in an organisation that already has existing and established problem-solving processes in place and balancing the time limitation of engineers and background of engineers?; 2) What were the outcomes of the training introduced?; 3) What are the lessons learned from the implementation of the training program? Action Research method with the collection of both quantitative and qualitative data were used. Outcomes of the exercises were analyzed. Finding in this research shows that online style of training can be effective with the introduction of TRIZ tools such as Method of the Ideal Result (MIR) and Functional Modelling (FM). However, when it comes to the introduction of 40 Inventive Principles, the use of online style training may not be as effective. There are several limitations of this research. This study was conducted within a single engineering firm with small number of participants. The study is focused on one single department within one organisation. While not generalizable, it can be valuable as it may offer insights on how to effectively introduce TRIZ training within an organisation using an online style and using a real problem.

Keywords: TRIZ training, engineering professional development, problem-solving, action research, online training, Method of the Ideal Result, Functional Modelling, 40 Inventive Principles

1 Introduction

Training within the organisation is a common feature and the value of training is undeniable. Among some of the benefits that training brings about are improved performance, satisfaction and morale of employees and increasing productivity [1]. The value of training for innovation within the organisation is also well documented [2, 3].

While the benefits are manifold, training can also be an expensive and time-consuming exercise. Therefore, there is a need to implement training properly. Researchers like Kennett found that different implementation of training can also increase or decrease the likelihood of employee turn-over [4]. It was identified that this can be negated when the “organisation's commitment to learning was team-directed and collaborative” [4] (p. 123).

The organisation involved in the study is a large size, global medical devices company based in Melbourne, Australia. The organisation develops and manufactures medical equipment, including pathology and cancer diagnostics machines. The company has a very strong focus on problem solving. Late last year, the organisation formally included TRIZ within its recommended problem-solving tools repertoire. Therefore, the scope and the opportunity to implement a TRIZ training came up within this organisation.

An initial attempt to introduce TRIZ tools in a workshop style of training did not work very well. Initially the process was undertaken together as a team (ie. The engineers sitting in one room, introduced to the tools, and then tried to use the tools). The training session took 4 full days for the engineers. The process took too long, and the session was found to be confusing for the engineers. The informal feedback gained during the session supported that TRIZ can be a challenge to implement a successful training program. Research like that of Ilevbare et. al. identified barriers in the uptake of TRIZ [5]. Respondents in their research indicate that the complexity of TRIZ and the time required to understand the application can be barriers to the uptake [5]. Kennett's research on the type of effective training for staff-retention also found that it is important to contextualise the training for the diverse workforce [4]. Yet, Ilevbare et. al. found that respondents in their research found TRIZ to be “too rigid and difficult to adapt for application in a variety of situations” [5] (p. 36). Moreover, it was observed by the first author (who is leading the TRIZ training in the organization) that some engineers were more passive and were not able to contribute during the session.

Learning from this experience, the first author then decided to experiment with an online style of training via an internal online survey platform, whereby tools of TRIZ were applied by the engineers on a real problem that required solving within the organisation. The online platform was considered due to the following suggested benefits which include the flexibility of access and time and cost effectiveness [6, 7]. The online learning style of training could be useful to overcome the challenge of the time required for TRIZ learning. The engineers involved in the training were free to participate in their own time. This process required the engineers involved in the training to work on a collective problem mostly individually. This strategy allowed the engineers to take part in the training without much disruption to their own work tasks. There are points when the engineers came together after the introduction/implementation of the tools – but this was still done remotely. The online infrastructure is already within the organisation, therefore no additional cost was needed for the implementation. More details of

how the online training was implemented is presented in the Methodology section of this paper.

The aim of this research is to present an implementation of a TRIZ training program within the engineering department of an organisation in Melbourne, Australia. The research questions explored in this paper are:

1. Can an online TRIZ training using real problem be effectively implemented in an organisation that already has existing and established problem-solving processes in place and balancing the time limitation of engineers and background of engineers?
2. What were the outcomes of the training introduced?
3. What were the lessons learned from the implementation of the training program?

The organisation does not have structured brainstorming approach as part of their problem-solving process. Therefore, to explore the effectiveness of TRIZ training within this study, it was decided that tools such as Method of the Ideal Result (MIR), Functional Modelling (FM) and 40 Inventive Principles were included as these assist in the process of structured brainstorming.

2 TRIZ Tools Explored – Method of Ideal Result, Functional Modelling & 40 Inventive Principles

Three TRIZ tools were explored in the implementation of the training. These tools are MIR [8-10], FM [11] and 40 Inventive Principles, based on the list developed by Mann and Domb [12].

MIR was developed by Belski from the notion of the Ideal Ultimate Result (IUR) and it has been identified to be helpful in the problem identification stage [13]. MIR directs attention to the most important part of the problem and the consideration of current existing resources that may be used to resolve the problem. In this study, MIR was used as a tool to frame up the problem and to engage the participants in establishing a desired list of benefits and harmful effects from an ideal system. While MIR can be used to generate potential solutions [13], this was not done in the study, as the main author would like to introduce other TRIZ tools to the engineers in the exercise. FM [11] is used to improve understanding of the interconnection and relationship between the components of the system to be improved. It is also used to identify the end-product and relationship to the super-system. TRIZ 40 Inventive Principles for business application [12] are used to help generate ideas to improve the current system towards the ideal system.

3 Using a real problem in the training

Often, TRIZ is applied at technical level within trainings. This was a challenge at the organisation as the engineering team is made up of engineers from different fields.

Engineering participants of this study belong to the team responsible for the company's product sustainment. There are total of 11 engineers (including the author) in the hardware sustaining team. The engineers come from a variety of engineering disciplines. So, a non-technical problem was chosen to accommodate the varied experiences of the engineers in the team. A non-technical problem is also aligned with the idea of team based models training as suggested by Kennett [4]. The problem used is also a real problem within the organisation, giving the opportunity for a shared vision for the engineers involved in the study. The problem also shows the application of TRIZ in a business flow context, relevant to all the engineers in the team. The system to be improved selected for this study is the *Problem Solution/ Tasks Completion Process*.

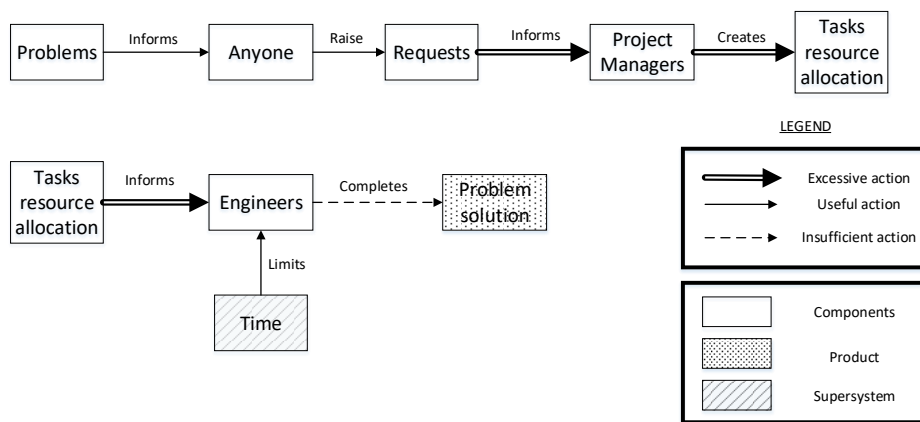


Fig. 1. The Problem Solution/ Tasks Completion Process

The operation of the *Problem Solution/ Tasks Completion Process* can be explained in the following way. Anyone that encountered a problem (disadvantage) raises a request, which informs a project manager. The project manager allocates the task to solve the problem to an available engineer (resource). The engineer is then informed (or not informed in some cases) that a task has been allocated to her. The engineer is expected to complete the task within the given time allocation. And obviously that when there are too many requests given to the engineers, the task is unlikely to be completed on time.

4 Methodology

This overall study uses Action Research [14-17] as the aim of the investigation is to improve the implementation of the TRIZ training program in the organisation. Action Research is chosen as the planning, implementation and data collection stages in this methodology occur at the same time. It allows the main author, who is also part of the engineering team to adjust the training and data collection as the project progresses. It is important to note that the main author did not participate in the exercise as he undertook the role of a trainer and facilitator. As aligned with the Action Research Method,

reflections of the trainer of the course (the main author) will also be included as part of data analysis.

The study involves 2 key stages: 1) Problem identification and 2) Ideas generation as shown on the flowchart in **Fig. 2** below.

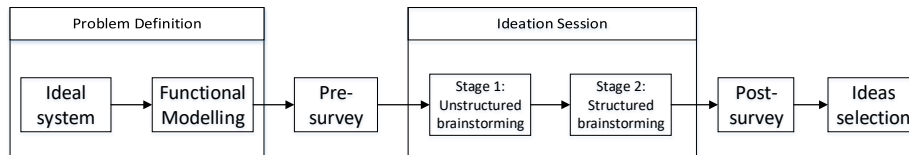


Fig. 2. Research flowchart

During the initial Problem Definition stage, the engineers were first introduced to MIR online via an online survey. They completed this online survey individually. An online kick-off meeting with the group was then conducted to discuss the list of desirable benefits generated from the previous MIR online survey. This is then followed with a group exercise to complete the functional modelling of the current state of the system to the desired future state of the system. At the end of this exercise, some ideas were generated on how to improve the current system and a problem statement is collectively agreed. This exercise is important as part of the problem definition process.

Once problem was clearly defined, a pre – survey questionnaire was conducted. This was followed by the unstructured brainstorming session where the professional engineers generated their ideas freely without any prompts. This exercise was important to avoid situation of a person holding on to the same idea and refusing to think differently. Once the unstructured brainstorming session was completed, it was followed by the structured brainstorming session where the selected TRIZ 40 Innovative principles were introduced to the participants. **Fig. 3** shows a screenshot of how these principles were presented to the participants. Unlike the first stage, the participants this time were given prompts based on TRIZ 40 Innovative principles.

Principle #10: Preliminary action

Problem statement: Not all issues are resolved in a timely manner

Note: This principle can be used to generate ideas to resolve physical contradiction in space. 😊

A. Perform, before it is needed, the required change of an object (either fully or partially).

Pointers:
* Project pre-planning

KANBAN

Fig. 3. Example screen of structured brainstorming activity with TRIZ 40 principles prompt

Only 25 principles that could resolve contradictions by separation in time and space were selected. These principles are listed in **Table 1**. This ideation process was also completed using online survey form over the period of 8 days (3 to 4 principles given per day) with the list of prompts given following the list of guidance published by Mann and Domb [12]. At the completion of the structured brainstorming using the 40 Innovative Principles, the engineers were asked to complete a post-survey evaluation.

Table 1. Summary of selected TRIZ 40 Innovative Principles

Principle#	Description	Principle#	Description
1	Segmentation	18	Mechanical vibration
2	Detachment	19	Periodic action
3	Local quality (conditions)	20	Continuous useful action
4	Asymmetry	21	Haste
7	Nesting	24	Middleman
9	Preliminary counter-action	26	Copying
10	Preliminary execution	27	Inexpensive short-lived objects
11	“Expecting the worst”	29	Pneumatics or hydraulics
13	“Executing the Contrary”	30	Flexible shells thin film
14	Round shapes	34	Discarding and recovering
15	Adjustability	37	Thermal expansion
16	Deficient or excessive solution	40	Composite materials
17	Transition to another dimension		

A comparison of the ideas generated during the unstructured brainstorming and during the structured brainstorming was carried out to evaluate whether the use of the 40 Inventive Principles results in more ideation. The comparison of the pre and post surveys were planned to be used to evaluate the change in the engineers’ perception of their problem solving. The surveys included quantitative and qualitative responses. However, given the small number of engineers involved in the research, a greater emphasis is placed on the analysis of the qualitative responses. Qualitative data are richer in-depth and are suited for smaller sample sizes [18-20].

Out of the 10 engineers (first author is excluded) in a hardware sustaining team, only 7 engineers participated in the kick-off meeting. 9 completed the individual online pre – survey and 7 completed the first stage of unstructured brainstorming.

The initial second stage of Ideation Session stage of data collection was initially expected to be completed by early May 2021. However, as the engineers were given the freedom to complete the exercises at their own time, it was a challenge getting everyone to complete Stage 2 (Structured Brainstorming) in a timely manner. Furthermore,

initially it was planned that all the engineers participating in the online training must complete all the exercises. However, again due to time constraint factors, it was decided that the participants can skip some of the exercises. Once the post-survey was completed, it was considered that the participant had completed the exercise. The second stage data collection is still ongoing with 2 participants completed the training and 5 partially completed the ideation process.

Due to this reason, for the purpose of initial analysis, a case study approach [21] analysis was undertaken for data collected in Stage 2 (Structured Brainstorming). This allowed for the deeper analysis of a smaller data sample as statistical method would not be suitable.

5 Results & Discussion

5.1 The implementation of a non-traditional training for the introduction of TRIZ tools

In this study, a non-traditional way of TRIZ training was implemented in a large size organisation with a small team of engineers. The training was conducted using an online survey-style platform, focusing on a real business-flow problem rather than a technical problem. It was not enforced by the management that the engineers should do the exercise. Using a collective problem-solving approach to the introduction of the TRIZ tools, it was found that most of the engineers in the team chose to participate in the first stage of the training in which problem identification was carried out. It was found that most of engineers were engaged with 7 out of 10 participating in the first stage of the exercise. These findings resonates with the ideas suggested by Kennett that a team effort type of training can be helpful [4].

In problem identification stage, TRIZ tools MIR and FM were introduced. In this first stage of the exercise, the engineers who participated identified that current system does not have any provisions for unplanned/ fly-in tasks. They believed that too many priorities that are not aligned between the various project managers, causing stress. Four engineers also believed that there is no mutual agreement on the time allocation process between the engineers and their project managers. **Fig. 4** and **Fig. 5** show an example of the problem identification model they had come up with the use of both TRIZ tools. The empty box with double line border indicates the missing component/ functions. Detail of this box is shown on the next diagram.

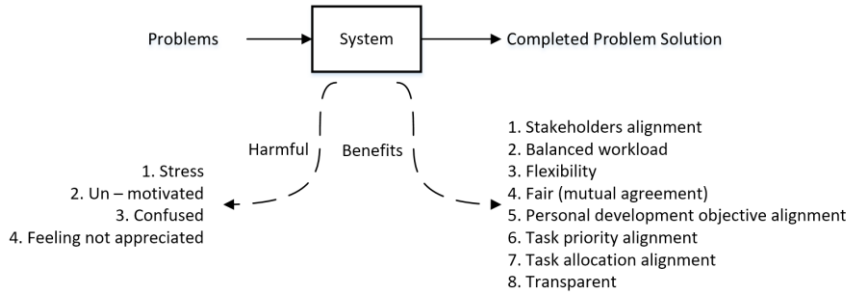


Fig. 4. Overview of the input and output of the system to be improved

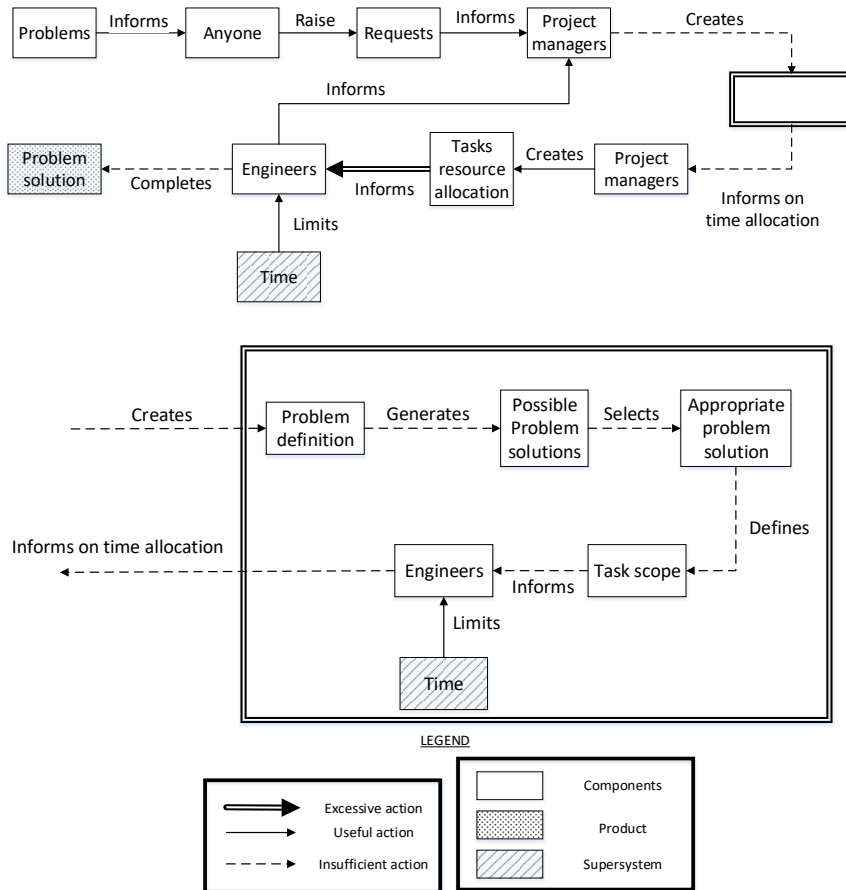


Fig. 5. Functional Model Analysis of the Future Ideal System

Having completed this functional diagram, the team of engineers participating in the ideation session agreed to have the generic problem statement to the current situation as “Not all issues are completed in a timely manner”. The team successfully

came up with a collective problem statement. The outcome from the first stage of the study suggest that implementing training online in this way can gain collective buy-in from engineers. It also shows that MIR and FM can be implemented successfully in this manner.

5.2 Preliminary results from Ideation Session stage: Case comparison of survey responses of participants who undertook the whole process successfully

Only analysis of qualitative data was selected due to small number of data collected during the pre and post surveys. Out of 9 engineers who responded to the pre-survey, 7 engineers believed that TRIZ would have a positive impact on their problem-solving approach. This may suggest that the initial online training was perceived successfully by the engineers involved.

During the process of unstructured brainstorming, 7 engineers completed the process. However, it was noted that participation waned with only 3 out of 7 engineers then moved onto the TRIZ structured brainstorming process where the 40 Inventive Principles were introduced. Out of these 3, one engineer stopped after day 5 (Engineer 1) and eventually filled in the post-survey. Only one engineer (Engineer 2) completed all the exercises involved in the Ideation Session stage. The responses of these 2 engineers are compared in a case study format. Engineer 1 has 3.5 years of industry experience. Engineer 2 has 16 years of industry experience. Below it shows the comparison between the number of ideas that they have generated and more details regarding their pre- and post- survey responses.

Comparison on the number of unique ideas generated between unstructured and structured brainstorming is shown below in **Table 2**. From this result, it is obvious that the number of unique ideas generated from structured brainstorming approach is at least six times more than the ones generated from unstructured approach. This indicates that the use of TRIZ tool, which in this case is the 40 Inventive Principles, can result in more ideas generated to resolve a problem. Engineer 2, who has more industry experience compared to Engineer 1 seems to generate slightly more ideas. However, given the 1 on 1 comparison now, it is not possible to conclude if this is the result of more industry experience.

Table 2. Comparison of solutions generation between unstructured and structured brainstorming between Engineer 1 and Engineer 2

Name	Unstructured	Structured
Engineer 1	4	33
Engineer 2	6	40

The responses of these 2 engineers in pre and post survey are shown in **Table 3** below.

Table 3. Comparison of pre- and post- surveys between Engineer 1 and Engineer 2

No.	Questions	Engineer 1		Engineer 2	
		Pre – survey	Post – survey	Pre – survey	Post – survey
1	Do you expect that the way you approach problems may change as a result of this exercise? How do you think it might change or not change?	The opportunity to create change with problem solving would increase motivation. I would very much appreciate a more open-minded approach.	I think that there was too much not understood about the TRIZ method for this to change the way I approach problems. I am happy to continue working towards understanding TRIZ better in the future.	My approach may become a bit more structured. I don't expect a huge change, since I have been applying PSP etc. for a number of years.	I believe I will use more of the innovation principles to generate solutions, with a wider range of solutions.
2	Have you attempted all the suggestive principles from TRIZ 40 Innovative Principles? If not, why not.		No. Some of the principals were difficult to understand in the scope of our operations. This lead to extra effort and time required than originally planned.		Yes
3	What you think was done well in the exercise?		The intent was good.		Examples/ prompts were very useful to link the concept to a variety of different problems. Especially useful since the innovation principles are quite mechanical oriented, while our specific problem is a process.
4	What do you think can be improved in the exercise?		The ideation principals needed to be explained much better.		I completed everything, but more time would make it easier. 8 days in a row is a bit difficult, especially with other work priorities as well. chance to complete it.

From the responses, Engineer 2 who has more industry experience and completed the whole process is more positive towards the exercise. The response from Engineer 1 confirmed that the implementation of TRIZ can be challenging. Ilevbare et. al. identified that the use of language in TRIZ can be difficult to understand by participants and can be time consuming [5].

In reflection, for future improvement on the ideation process, a workshop style training may be needed to introduce concepts of the 40 Inventive Principles. This is supported by feedback that the engineers involved would like to have guidance tailored and more detailed explanation of the 40 Inventive Principles. Other feedback from other engineers include more time allocation and 2 – 3 days break between each introduction of the 40 Inventive Principles session. Overall, majority of the participated engineers agreed that the TRIZ tools used on the exercise can be applied to help breaking down a problem and they are all agreed that they would be interested to learn more about TRIZ tools because of the exercise.

6 Implications, Research Limitation and Future Research Direction

Though the study is ongoing, the initial results show that the use of online training with real problem application can be useful for organisation to introduce TRIZ tools. The study showed that engineers can be very engaged even with the use of non-technical problem as part of the training exercise. The introduction of the right TRIZ tools at various stages of problem solving can be very helpful to illustrate to staff members the way how TRIZ can be utilized. The study also reveals challenges that can be faced when different TRIZ tools are deployed. This suggests that there is an opportunity to explore what TRIZ tools are suitable to be introduced to engineers via an online learning, and which ones are better introduced in a workshop style of training.

The main limitation in this study is the small numbers of engineers involved. Given the small numbers of sample, it is not possible to extrapolate the data and carry out statistical analyses. However, the methodology of data analyses is carefully chosen to reflect this. The inclusion of more qualitative questions in the survey and the use of case study analysis is more suitable for small data exploration in-depth. This also provides future research opportunity to collect larger samples. Given the success of engaging the engineers in a business problem that impacts them, it is a possibility to perhaps consider the involvement of multiple teams, resolving one problem that impacts them, and introducing concepts of TRIZ to them.

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