TRIZ and LSS Integrated Models Assessment: A Holistic Model Development for Organizations' Excellence

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Abstract

Today, the business world is in extreme competition. Every organization is striving hard to find an ideal strategy to stand out from the rest of its competitors. However, achieving Excellence is far from easy, and faced with problems. Organizations usually use improvement approaches with experts in Total Quality Management (TQM), Lean Management (LM), and Lean Six Sigma (LSS) to overcome punctual problems. Unfortunately, companies still need a holistic and innovative framework involving the organization staff for solving problems. Therefore, this paper proposes a futuristic framework for organizations' improvement integrating TRIZ and LSS from the strategy to operational execution. The proposed model was based on a literature review on excellence, LSS, and TRIZ. Furthermore, the Authors' experience as academics, researchers, and industrialists facilitate the framework experimentation in a real context. The results show that the framework allows companies to develop a continuous improvement culture, focus on priorities and develop an innovative approach to solving problems. This system will enable future research and management systems to take the framework as a basis for continuous improvement and to open the opportunity to discover TRIZ differently.

Keywords
Lean Six Sigma, TRIZ, Framework assessment, Problem Solving, Excellence, Strategy, Operations.

1. Introduction
Excellence represents one of the most valuable objectives that companies seek. It is essential to be innovative, continuous improvement, and satisfy customers' requirements (Antony, 2017). Unfortunately, few companies improve themselves continuously, solve problems efficiently and prosper year after year (Edgeman, 2018). Moreover, many companies considered leaders in their field end up failing (Carvalho & al, 2019). Companies are still looking for the ideal framework to achieve excellence. Over the past few decades, many management systems and approaches such as TQM, LM, Kaizen, Six Sigma (SS), LSS, and TRIZ have emerged for improving Business (Prashar, 2018;). LSS Was defined as the global and popular methodology to improve customer satisfaction, reduce cost and increase process speed. LSS provides value focus and allows process robustness (Antony, 2017; Sunder, 2018; Parashar, 2018). LSS

was deployed in many industries, such as Motorola and General Electric (Antony, 2017). The method helps companies to make great financial successes and increase customer satisfaction. Unfortunately, LSS did not prevent Motorola from losing its international market share. Motorola accumulated $14 billion of savings based on Six Sigma (Soti, 2012) but could not predict the market evolution. Organizations need a strategic vision and innovative tools to face rising consumption and intensifying competition (Antony, 2017). Soti (2012) confirms that the Theory of Inventive Problem Solving (TRIZ) can provide remedies for those weaknesses. TRIZ has a positive reputation for being a very powerful problem-solving method (Czinki, 2016). TRIZ tools and philosophy help solvers transcend the mind's psychological inertia and reach an efficient solution (Soti, 2012). However, TRIZ is still not a popular methodology as Lean Six Sigma in most industries (Soti, 2012; Goldis, 2013). Sojka (2020) adds that TRIZ tools are abstract and time-consuming to learn. The issue of interest is how to present a holistic framework integrating LSS and TRIZ for solving companies' problems and ensuring continuous progress?

Several authors published papers about the use of TRIZ tools in combination with LSS. They prove the integration effectiveness (Mann, 2001; Soti, 2012; Muruganantham, 2014; Toivonen, 2015). Many articles present the possibility of non-technical problems (Mann, 2001; and Mueller, 2005). Several papers pinpoint the similarities and the correlation between TRIZ and LSS (Aggarwal & al, 2005; Anosike, 2013; Toivonen, 2015). Some authors combine TRIZ with MUDA, DMAIC (Define, Measure, Analyze, Improve, Control) (Soti, 2012), or SMAIC (Select, Measure, Analyze, Improve, Control) (Muruganantham, 2014). Most papers use TRIZ at the Define and the Improve phases. They use the Ideality, Contradiction Matrix, and 40 Inventive principles to solve problems. Ben Moussa (2019) presents a study of an innovative method of integrating ARIZ to lean management. Toivonen (2015) describes the integration of Toyota kata with TRIZ for sustaining innovation. Brad (2015) integrates TRIZ with Six Sigma in the form of an algorithm called Sigma-TRIZ. They all conclude that the Lean application would be more creative when TRIZ methods support lean tools. However, Could those frameworks respond to excellence basics for a holistic and sustained improvement?

This article points out complementarities between TRIZ and LSS and suggests new tools integrating TRIZ and LEAN tools to simplify TRIZ integration in industries. Then, we present the main basic criteria to get excellence. Accordingly, we compare literature structures to those criteria. As a result, we propose in section 4 "the excellence heart1.0" as a holistic and innovative framework to support companies for sustained progress. This will enable stakeholders to communicate and focus their energy on the company's progress. The framework result is discussed in section 5, while we describe our experience to construct and implement the framework in industries. In conclusion, we describe the main findings, limitations, and future research opportunities.

2. Literature Review

2.1 The need for TRIZ and LSS's integration

TRIZ is a Russian abbreviation of "Teorija Rezhenija Izobretatelskih Zadach", which means the "theory of inventive problem solving"; GenrichAltshuller develops it in 1946 (Lin & al, 2016; Lanke & al, 2013). Altshuller studied more than 400,000 patents to generate the Contradiction Matrix with 40 inventive principles (Savransky, 2000). TRIZ is a systematic knowledge-based methodology of inventive problem-solving. It develops solvers' creativity for different problems (Ben Moussa & al, 2019; A. Lanke & al 2013). TRIZ generates better ideas in a short time and helps to solve problems efficiently and deeply (Rantanen, 2008; Pacheco & al, 2016). Mann (2001) presented TRIZ as a pyramid. In the lower level, Mann classed TRIZ tools. In the middle, he presented ARIZ as TRIZ methodology. Finally, at the head, Mann shows TRIZ philosophy and confirms that TRIZ philosophy can contribute to excellence.
The application of TRIZ was limited to technical problems. Since 2000, Mann proposed TRIZ to solve business problems. Later, many authors try to understand the correlation between TRIZ and other problem-solving tools and extract TRIZ benefits (Kermani, 2003; kovenko, 2004). Unfortunately, TRIZ is too much complicated for practical use (Sojka 2020). It takes a lot of time to assimilate. Sojka (2020) stresses the necessity to use TRIZ in a simplified way. We need to propose adapted tools to use in industry, management, and business.

Lean and LSS are much more popular (Goldis, 2013). Many organizations around the world use Lean or LSS to become more successful (Antony, 2017). However, we need experts to know when and how to use LSS tools. TRIZ provides generic solutions that allow users to predict specific solutions and enhance creativity.

Table1. Some LEAN and TRIZ Tools assessments.

Lean tool	When to use	Relative tool in TRIZ	Observations
San Gen Shugi or the "three real philosophies"	required to get the right problem data	Space and Time philosophy Nine window	Triz can give more information about the problem thanks to the evolution system
Who, What, Where, When, Why, and How?	Used to define problems	TRIZ philosophy: Resources; Functionality; Ideality; Space and time; contradictions.	TRIZ can provide better problem definition thanks to the problem's dematerialization.
SMED	Used to improve the change over time and to increase productivity.	TRIZ principles: -Segmentation -Taking out -Preliminary actions	TRIZ matrix suggests generic solutions, which are SMED basics.
Visual management	Used where information is communicated by using visual signals.	TRIZ principes : Changement de couleur Mecanical vibration	
Kaizen	Rapid improvement with a focus on particular activity o process and involving everyone.	Action flash	Action Flash is necessary for dangerous changes. And for rapid improvements.
Standard	Define rules and make practice unique for everyone	Universality - copy	The generic solution makes us think out of the box. We can imagine standard with videos, lighting...
Performance measurement	Take account of performance results. Extract periodically the non-value	Periodic action	
Eliminating MUDA	Non-value that affect the performance	- Periodic action: use pauses to stop machines for maintenance -Periodic action: provide row material with a frequency to reduce stock - Continuity of useful action: Eliminate waiting time and transportation by association tow distant operations. -Intermediary: use a material handler to bring raw material.	Solutions for MUDA are unknown in LSS. Only experts can propose solutions. TRIZ with the contradiction matrix and the 40 principles can facilitate generating solutions.

Table 1 presents some examples of LSS and its similarity with TRIZ tools. First TRIZ philosophy allows the user to understand problems and detect root causes. Then with the contradiction matrix and 40 principles, solutions become evident. In addition, solvers do not need to be experts to find the ideal solution. TRIZ database opens the solver mined to ideality.

To conclude, it is evident that LSS creates a big change in the company's world (Antony 2017). Moreover, LEAN philosophy, Lean tools, and Six Sigma statistics allow organizations to change for the better. However, a holistic framework integrating LSS to TRIZ is needed for the actual economical context

2.2 Basics for the holistic excellence framework from literature

In the beginning, Excellence was perceived as getting the desired situation (Carvalho & al, 2019). In fact, at the age of Taylor and Ford, Excellence seemed like an assembly line to simplify operator's work and produce large car numbers. However, Taiichi Ohno and Shigeo Shingo, after the Second World War, initiated the TOYOTA Production System (TPS) with a focus to eliminate non-value. That enables Toyota to make more savings and to be present in the world market. For the first time, the way for Excellence becomes more structured in a systematic approach, and the objectives are defined. In fact, in 1990, J. Womack presented the word "lean manufacturing" as a description of the Total Production system (TPS) (Navas, 2015). He describes Lean manufacturing as a systematic approach to identifying and eliminating wastes continuously to have higher quality, at the right time, and at the lowest cost (Navas, 2015). In 1987, Motorola created six sigma to improve business. Many organizations use this approach to enhance product quality and reduce variation (Antony 2017). However, Lean and six sigma integration have become more convenient for organizations. LSS has business impacts such as reducing costs, increasing customer satisfaction and enhancing service and product quality (Antony, 2017; Alblooshi, 2020). Cherrafi (2016) describes LSS as a methodology that increases the value as desired by the customer and achieves the highest rate of improvement. According to Navas (2015), LSS attacks any problem by reducing variation and getting through improvement.

The use of LSS just as a set of tools or as a methodology to solve problems may harm the organization's performance. Organizations need a Holistic Improvement process starting from the strategy, involving everyone in the organization, and enhancing creativity. According to some Excellence and LSS literature reviews (Carvalho & al, 2019; Antony, 2017; Yadav & al, 2018; Raval, 2018; Shamsi, 2018), many barriers hurdle the use of LSS to attain excellence. Many organizations put much effort into executing an improvement project to achieve excellence, but they do not take enough time to choose the right one (Yadav & al, 2018). Moreover, the lack of people involved in the improvement process engages staff resistance and psychological inertia to solve even simple problems (Carvalho & al, 2019). Furthermore, once the project ends, they ignore sustaining the improvement and sharing results and best practices with everyone in the organization (Carvalho & al, 2019). However, it must not be the end of the progress; we need to improve continuously the organization according to the global strategy to succeed. Moreover, Antony (2017) considers creativity and innovation as a competitive advantage for companies.
Using those literature reviews, we extract five basics to empower organizations.

- Setting a vision or a strategy
- Detecting problems or opportunities continuously at the right time with factual information.
- Motivating and engaging people/developing autonomy.
- Developing creativity /thinking out of the box.
- Sustaining results.

3. Methods

This research aims to propose a holistic approach to solving problems. The literature proved the efficiency of LSS and TRIZ integration. However, we need to improve both LSS and TRIZ Limits and ensure Excellence basics. Therefore, to propose a framework integrating LSS and TRIZ, we started by searching LSS and TRIZ frameworks in many database publishers that included Elsevier (sciencedirect.com), Taylor & Francis (T&F) (tandfonline.com), Emerald (emeraldinsight.com), TRIZ journal (https://triz-journal.com/) and Google Scholar (https://scholar.google.com/).

The search terms are "LSS AND TRIZ," "Lean AND TRIZ," "Six Sigma AND TRIand "TRIZ AND management", "TRIZ AND quality," and "TRIZ AND business." We identified only 59 articles from 2000 to 2020.
Most of the articles presented from 2000 to 2009 discuss TRIZ and TRIZ tools definitions (Mann, 2001), the use of TRIZ in non-technique problems (Mann,2000) and business (Mann, 2001), the correlation between TRIZ and LSS tools (Averbukh, 2006). Some authors' design frameworks integrate TRIZ and LSS (Šibalija, 2009). From 2000 to 2009, most of the research was composed of conference papers or articles published in "The TRIZ journal".

We filter the list based on four criteria:

- Papers from 2010 to 2020
- TRIZ must be integrated into Lean, LSS, Six Sigma, or Lean tools.
- The article must be a framework or a case study.
- Exclude design issues

According to these criteria, 18 papers are identified on the topic. As presented in Figure 1, to enrich the research, we study LSS's literature reviews and articles to extract LSS's barriers and the way to excellence. We study TRIZ and Lean Six Sigma articles published from 2000 to 2009 and "TRIZ and problem solving" papers. We define TRIZ, TRIZ tools, methods, and philosophy. Then we extract TRIZ barriers.

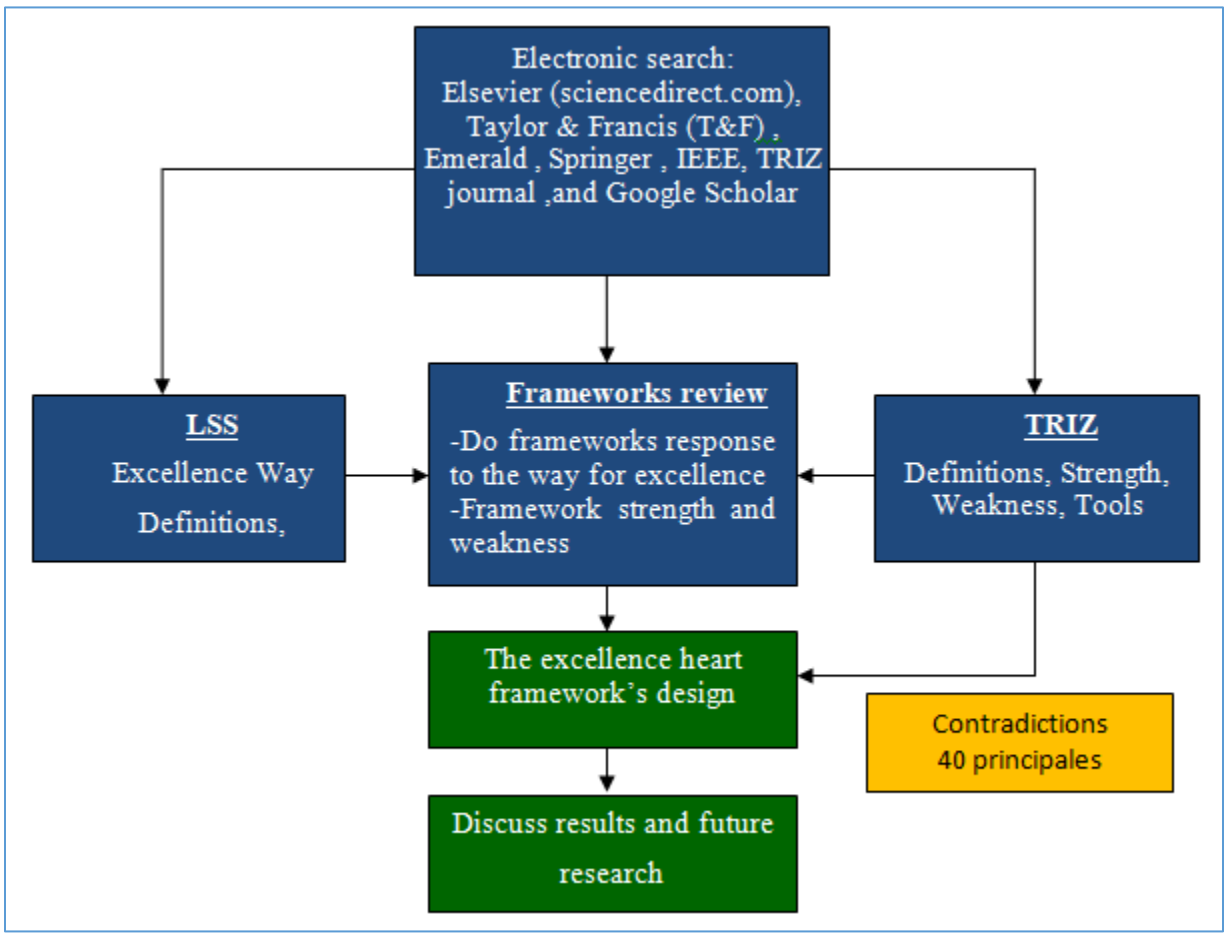

Figure 1. Research methodology diagram

The framework design is based on the LSS and TRIZ frameworks limitations according to excellence basics. In the discussion and result, we describe our experience in implementing the model.

4. Data Collection: Frameworks integrating TRIZ and LSS assessment

Frameworks integrating Lean, Six Sigma, or LSS to TRIZ proved their efficiency for improving creativity and generating innovative solutions. Most frameworks associate DMAIC with TRIZ in the improvement step (Wang, 2010; Lin & al, 2016). Moreover, Bard (2015) presented the SIGMA-TRIZ algorithm as a set of interrelated and convergent process improvement projects linked to the objective. The algorithm is used in the improvement step to generate potential solutions. Besides, Ben Moussa (2019) presented a systematic framework using "Lean warehousing – DMAIC" to generate solutions. Ben Moussa uses TRIZ only if the first generated solution does not satisfy the defined objective. Some authors integrate TRIZ with other Lean tools. For example, Kumaresan (2011) integrates

TRIZ to propose permanent solutions in the SMED approach. Furthermore, Tiuc (2016) implements permanent corrective actions using TRIZ in 8D's improvement step. However, Soti (2012), Maia (2014), and Toivoneen (2015) employ TRIZ differently. They associate TRIZ tools with all improvement steps.

As described in Table 2, Most of the Authors propose frameworks to conduct temporary projects. However, Soti and Toivoneen propose holistic methodologies that start from creating a strategy and getting operational objectives, training employees to be leaders for the improvement, and finishing with the improvement itself.

Table 2 presents frameworks assessment according to excellence criteria extracted in the previous section.

Table 2. Frameworks assessment according to the excellence criteria

Excellence criteria							
Title	**Authors**	**journal**	**Setting a vision or a strategy**	**Detecting problems continuously at the right time.**	**Motivating and engaging people/developing autonomy.**	**Developing creativity /thinking out of the box.**	**Sustaining results.**
Sigma-TRIZ: Algorithm for Systematic Integration of Innovation within Six Sigma Process Improvement Methodologies	Brad 2010	Quality Management and Six Sigma	Yes	No	No	Yes	No
Applying Lean Six Sigma and TRIZ Methodology in Banking Services	Wang 2010	Total Quality Management & Business Excellence	No	No	No	Yes	No
Integration of SMED and TRIZ in Improving Productivity in Semiconductor Industry.	Kumaresan 2011	Jurnal Mekanikal	No	No	No	Yes	No
Six Sigma with Innovation Tool Kit of TRIZ.	Soti 2012	International Journal of Business Innovation and Research	Yes	No	Yes	Yes	Yes
Integrating Lean, Theory of Constraints, and TRIZ for Process Innovation.	Anosike 2013	Innovation and Enterprise	No	No	No	Yes	No
Performance Improvement and Cost Minimisation for Manufacturing Components in a Fabrication Plant by applying Lean with TRIZ Principles.	Muruganantham 2013	International Journal of Productivity and Quality Management	No	No	No	Yes	No
Integrated Application of TRIZ with Lean in the Manufacturing Process in a Machine Shop for the Productivity Improvement.	Muruganantham 2014	International Journal of Productivity and Quality Management	No	No	No	Yes	No
How could the TRIZ tool help continuous improvement efforts of the companies?	Costa Maia 2014	Procedia Engineering	Yes	No	Yes	Yes	Yes
Leading Innovation to Improve Complex Process Performances by Systematic Problem Analysis with TRIZ	Brad 2015	Procedia Engineering	Yes	No	No	Yes	No

Continuous Innovation – Combining Toyota Kata and TRIZ for Sustained Innovation.	Toivonen 2015	Procedia Engineering	Yes	Yes	Yes	Yes	Yes
Process improvement by application of Lean Six Sigma and TRIZ methodology Case Study in Coffee Company	Jiang 2015	International Journal of Application or Innovation in Engineering &Management (IJAIEM)	No	No	No	Yes	No
Value Stream Analysis for Complex Processes and Systems.	Toivonen 2016	Procedia CIRP	yes	No	Yes	Yes	No
A Study of Process Optimization for Roasting Taiwanese Coffees by Applying Six Sigma.	Lin 2016	International Conference on Fuzzy Theory and Its Applications (iFuzzy)	No	No	No	Yes	No
Systematic EcoInnovation in Lean PSS Environment: An Integrated Model.	Pacheco 2016	Procedia CIRP	No	No	No	Yes	No
TRIZ Model Used for Complaint Management in the Automotive Product Development Process	Tiuc 2016	Procedia - Social and Behavioral Sciences	No	No	No	Yes	No
Study of an innovative method based on complementarity between ARIZ, T lean management, and discrete event simulation for solving warehousing problems	Ben Moussa 2019	Computers & Industrial Engineering	No	No	No	Yes	No

We observe that:

- TRIZ is still not explored enough in all improvement steps. It is used only in the Innovation step to generate innovative solutions.
- Most frameworks concentrate their efforts on solving problems detected by brainstorming. Unfortunately, they may not concentrate their effort on the organization's priorities.
- Frameworks concentrate on complex problems. That involves only experts. Unfortunately, most of the detected problems in organizations are simple or complicated and do not need much investment of time and energy to be solved.
- We observe that DMAIC and the studied frameworks, do not give importance to problem detection. They start directly from the definition of the problem.
- Sustaining organizations' results involve a continuous improvement in both operations and strategy. However, the studied frameworks do not consider this part.

We conclude that organizations need a holistic framework to ensure continuous improvement. Getting excellence starts from a robust strategy and goes through successful execution using all resources and competencies. TRIZ with the capacity to enhance creativity will have a powerful impact on strategy execution efficiency.

5. Results and Discussion

5.1 The "Excellence heart 1.0" model:

Companies need a systematic and holistic model on the road to excellence. We propose the "Excellence heart 1.0" framework, in Figure 2, as a continuous improvement model engaging everyone to achieve the company's mission and to satisfy customers.

The model presented in Figure 2 has two levels. First, the strategic level presents an annual review of the company's vision. The strategy converses to operational objectives. Then, the operational level uses the defined objectives to detect and solve problems. New tools are proposed to enhance the operational level.

5.1.1 Strategic level

Every organization has a vision of the actual business level. However, companies' leaders have to develop their vision and ambitions for the company's future. Porter's five forces and SWOT are the most comment used tools to develop strategies. The ideal result, the evolution system, and the nine windows can provide efficient solutions to generate ideal strategies. They allow understanding real drivers for better competition. They help companies to learn about the organization's performance and portfolio, their extern environment (macro, and micro environments), and their intern systems (stuff, structure, leadership, management system…). Compiling those parameters, the organization defines the ideal result as a long-term vision and operational objectives before competitors. Furthermore, organizations need to prioritize effort and align shareholders' vision and objectives with employees. Planning for executing the strategy is important. The Hoshin kanri is an interesting Toyota tool to set the company's annual objectives. It allows to share

the vision, and discuss and build the annual objectives. It is an opportunity to propose strategic projects for the following years. As a result, resources, training, and financial budget are discussed and planned.

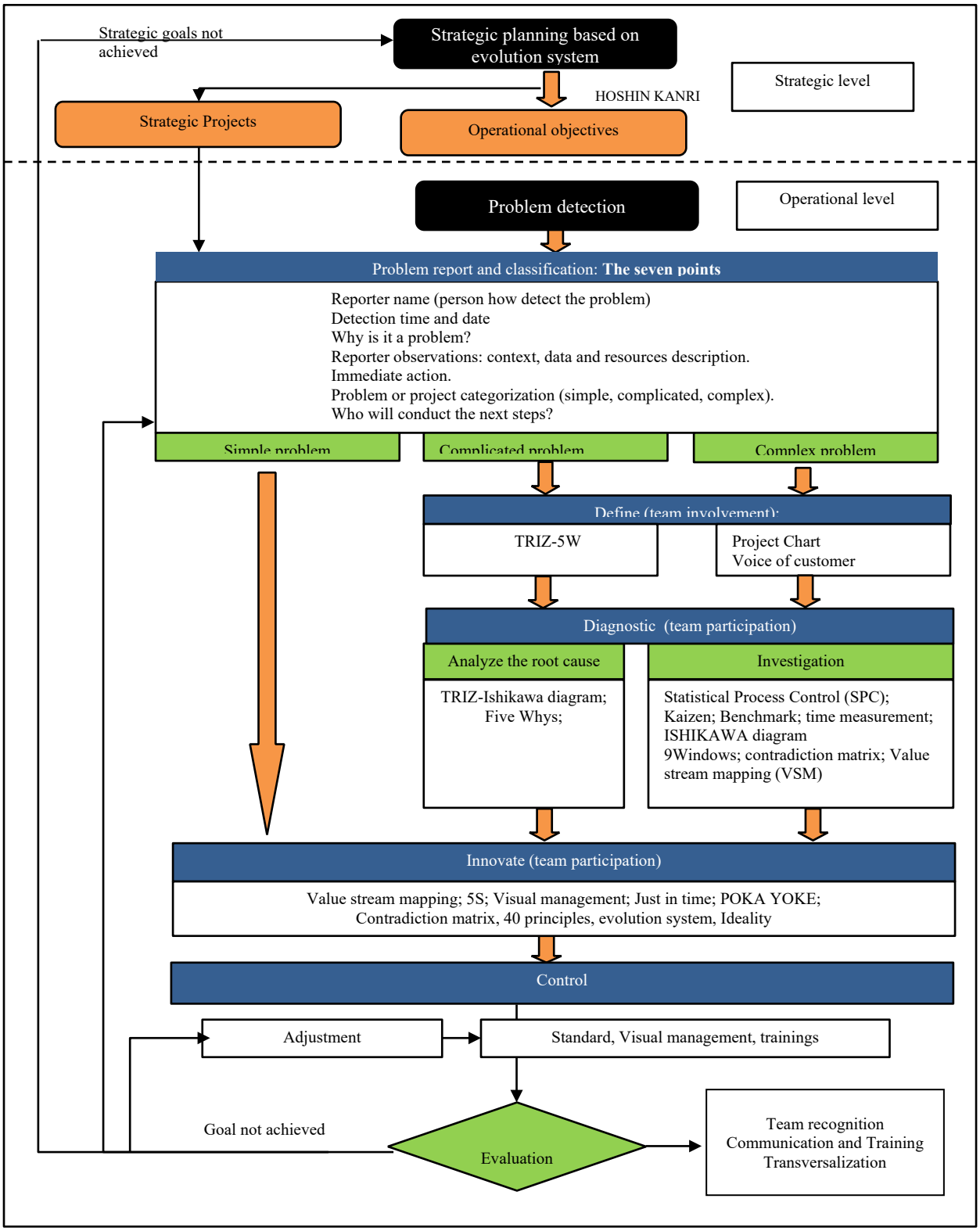

Figure 2. "Excellence heart framwork1.0" a holistic model for organizations' excellence

Key indicators, routine objectives, audits, brainstorming, and customer requirements describe the actual situation. Problem identification becomes more effortless. Problems appear when there is a gap between the actual situation and objectives. It makes everyone focus on the value as defined in the strategy.

5.1.2 Operational level:

a. Problem detection:

The operational level starts when there is a gap between the actual situation and objectives. The ability to detect problems in a short time and ensure information accuracy makes a real difference in the problem-solving result. TRIZ proposes four generic solutions for quickly detecting problems with correct information (28 mechanics substitution; 32- color change; 1 - segmentation; 24 - intermediary). Moreover, TRIZ proposes to improve data accuracy without losing time; the following generic solutions (24-intermediary; 26-copying; 28-mechanic substance; 32-color change). So using TRIZ, we propose examples of possible solutions in Table 3.

Table 3. Examples of solutions to detect problems and ensure data accuracy

Principals	Generic solution	Specific solution
#28 Mechanics substance	Change from static to movable fields, from unstructured fields to those having a structure	Stop machines. Moving flags
	Use electric, magnetic and electromagnetic fields to interact with the object.	POKA YOKE white electric light
	Replace a mechanical means with a sensory (optical, acoustic, taste, or smell) means	ANDON, Digital systems to detect and summarize problems (MES)
#32 colors change	Change the color of an object or its external environment:	Use light or flag in different colors: ANDON; Visual management (red/green)
#1 segmentation:	Divide an object into independent parts:	Make every resource responsible for detecting problems.
#24 intermediary:	Use an intermediary carrier article or intermediary process:	Describe problems in intermediary support (paper, board, or digital support) to get the factual information
#26 copying:	Replace an object or process with optical copies	Get a copy from the digital or automatic detector to analyze problems.

We propose the "seven points report" to describe the problem context, first observations, and first actions to stop the problem. In addition, if the problem detector has no competencies to resolve the problem, he designates the problem solver.

- Reporter name (person who detects the problem)
- Detection time and date
- Why is it a problem?
- Reporter observation: context, data, and resources description
- Immediate action
- Categorization (simple, complicated, complex)
- Who will conduct the next steps?

The success of a solution depends on problem-solvers (Mueller, 2005; Czinkia, 2016).). Anyone can solve simple problems. However, competencies are needed to analyze and choose the optimal solution for complicated problems. Moreover, experts can lead investigations to solve complex problems (Czinkia, 2016). Based on those criteria, we build our framework to engage everyone to solve problems depending on their competencies and, the problem complexity.

b. Project and Problem-solving approach:

The LSS's approach for solving problems is DMAIC (Cherrafi & al, 2016). It is a basic structure to attain improvement (Cherrafi & al, 2016; Hakimi, 2018). It is used with statistical support and non-statistical as lean manufacturing tools. Hakimi (2018) presented the DMAIC steps as follows:

- Defining: To clarify the problem and the results.
- Measuring: To present the current situation and to put measurable parameters.
- Analyzing: To settle on the problem generating causes.
- Improve: To design and implement adjustments to get a better result.
- Control: To set management solutions for sustainable improvements.

The DMAIC, PDCA, 8D, and A3 reports have the same philosophy. First, they present the problem context, then understand potential causes, propose solutions, and set best practices to ensure a sustainable solution. Within this philosophy, authors suggest four steps to solve Problems: (DDIC) Define, Diagnose, Innovate, and Control. We propose to bring together measure and analyze steps to be more efficient and tangible. We need to continuously verify the measurement effectiveness and analyze data to ensure that information, observations, and scientific hypotheses are representative. In the measurement step, we need to identify the process parameters, set a data collection plan, and conduct cause-effect analyses. Then in the analyze step, we gather data and analyze which parameter significantly affects the process (Jiang, 2015). In this way, we can lose time when the measured parameters are wrong. Figure 3 shows the benefits of the mono diagnostic step.

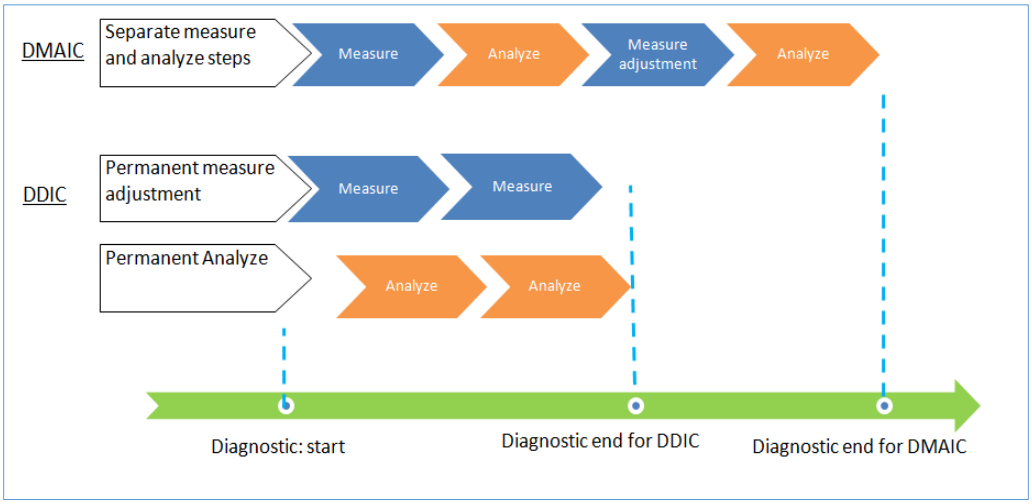

Figure 3. DMAIC and DDIC assessment (source: authors)

The DDIC is the approach we use in the framework for complex and complicated problems. The defined step is crucial to obtaining the correct data for efficient problem-solving. Solvers must be reactive in defining the project team and conducting this first step to preserve the real occurrence context for complicated and complex problems. TRIZ philosophy is the ideal tool to describe problems. In this optic, the Space and Time pillar allows setting the system context and defining the system evolution in time and space. Moreover, functionality describes the basic needs and shows why this situation is a problem. Furthermore, ideality allows making clear objectives according to the global strategy. It explains the gap between the actual situation and the desired situation. Integrating those TRIZ pillars and the five W's « Who, What, Where, When, and Why? " helps collect more details about the problem. We suggest the TRIZ-5W's in table 4 as a new tool to overcome team psychological inertia and be more consistent during the problem definition.

Table 4. The TRIZ-5W to define problems

Resource:	Who detects the problem? Who has the problem? Who is affected by the problem? What is affected by the problems?
Time:	When does the problem occur? When is the problem detected? When must the problem be solved?
Space:	Where does the problem occur? Where is the problem detected?
Functionality:	What is the primary function of the system? Why is it a problem? What are the obstacles to achieving the actual function?
Ideality:	What is the ideal final result? What does the customer want? Why does the problem occur?

Source: Authors

The diagnostic step depends on the problem's complexity. For complicated problems, the Ishikawa diagram can be utilized to detect the root cause. The diagram makes evident the problem causes and highlights potential future problems and risks that we need to consider. Unfortunately, the Ishikawa diagram is still not exhaustive. Some users need to add other factors like management and information (Suárez-Barraza & Rodríguez-González, 2018). Moreover, when we try to set possible causes with the project team, the fear of benign personally attacked or accused by the problem presents a natural barrier. The human resources factor is usually misunderstood. The TRIZ Ishikawa diagram (Elyoussoufi & al 2022) can respond to this issue and increase solvers' creativity in Figure 4.

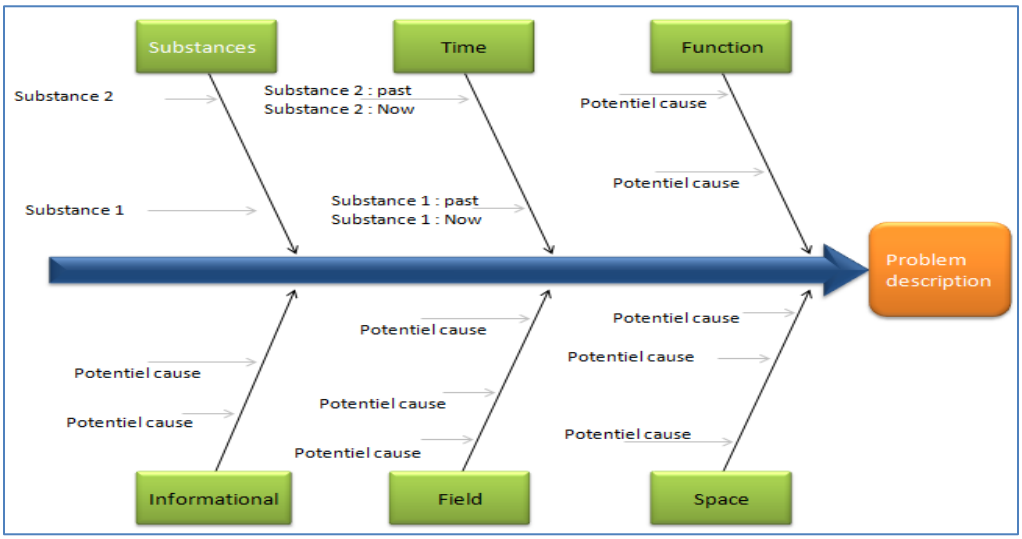

Figure 4. TRIZ-ISHIKAWA Diagram (source: Elyoussoufi & al, 2022)

Moreover, VSM, time measurement, and other lean tools have a tangible impact on understanding the problem context and detecting improvement opportunities. TRIZ can also solve complex problems. Indeed each system follows an evolution law, which makes it possible to go towards the desired solution. Moreover, contradictions are a cause of any problem. Solving contradictions can bring us to the desired solution through an abstraction made by the contradiction matrix (Czinkia, 2016).

The innovation step also depends on the problem classification. Personal knowledge, the company's database, or 40 principles can be applied at the detection step to solving simple problems. However, we can use many available tools for complicated and complex problems, like Kanban, Heijunka, Poka-Yoke, and SMED. So many Tools are based on Toyota and other companies' knowledge and experience. Unfortunately, using the right tool at the right time requires experience. TRIZ with the contradiction matrix can guide the solver to a list of abstract solutions. The project team can propose several potential solutions using brainstorming.

At this stage, solutions are identified and achieved. Visual management, Poka-Yoke, and standards must be implemented or revised to sustain the proposed solution. The solution is communicated and tested. The result is evaluated according to the objective. However, sometimes we need to make adjustments. When the goal is achieved, the Problem solver or project leader communicates, informs, or trains the concerned stakeholders. The detection system allows a continuous and sustained improvement over time

5.2 Discussion

Through the literature review, we extract five essential basics of excellence. We review frameworks integrating LSS and TRIZ according to those five basics. We conclude that most of the studied frameworks use TRIZ in the innovation step. Furthermore, frameworks do not present a continuous improvement philosophy. Projects are chosen using brainstorming rather than strategy or KPI. We suggest starting the "excellence heart framework" from the organization's strategy. Objectives and strategic projects are declined to the operational level to be executed. We recommend implicating the company's stakeholders in the improvement through HOSHIN KANRI. Furthermore, everyone is responsible for detecting and initiating the seven-point report when there is a gap between objectives and the actual results. To improve the detection step efficiency, we use the TRIZ matrix. We suggest some examples such as visual management and digital solutions to increase agility and preserve data accuracy. Besides, in the literature, TRIZ is less used than LSS. Users feel some complexity in learning TRIZ tools. We integrate TRIZ with LSS to simplify TRIZ use in the industry and to eliminate some LSS tools' limitations.

During ten years of experience, authors worked in many multinational companies. They gradually build this framework. First, we implement operational objectives for each production line. At this moment, the idea was to set an improvement culture at all companies' levels. We train a team to be project leaders and LSS experts. In addition, we set the DDIC approach as a standard to conduct improvement projects using only LSS. We could improve the global efficiency from 50% to 80%, and reduce the lead time from 15 days to 5 days. The result was incredible especially because of the process stakeholder's implication. The result was maintained during the daily operational review. The project's success has a significant impact on the improvement culture. Service managers start new projects improvements. Unfortunately, at this moment, we had time resource conflicts. Many projects are opening and many projects do not respond to the global strategy. The Hoshin kanri was the ideal solution to focus our energy on the global strategy. Finally, to improve team creativity, we integrate TRIZ in the DDIC approach to overcome psychological inertia. We increased productivity from 86% to 116%. Furthermore, we could respond to the new customer take time without machine investment.

The Excellence heart framework presents basics that are important to get excellence. The framework moves over the problem limits and gives a systematic and innovative approach to solvers. The global culture has a significant impact on making possible the framework implementation.

6. Conclusion

In conclusion, the excellence heart framework could be used to solve any business problem. The strategic and operational levels enable communication between stakeholders and focus the staff energy on objectives. TRIZ and LSS integration makes problem-solving easier. Therefore, the framework engages everyone in continuous, innovative, and sustained improvement. The proposed Tools make possible the TRIZ integration into industries. The framework integration in the company's production system or ISO will positively affect companies' performance.

Further research must take into consideration human complexity. The company's culture, management, staff motivation, and human personalities need to be studied and integrated into the framework. The framework was tested in complex and complicated problems, but we need to test if the framework will positively influence chaotic issues in the COVID19 context or in the ware context.

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