Teaching and Learning TRIZ as an Innovative Educational Technology: A Systematic Literature Review

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Abstract
Since its inception, the Theory of Inventive Problem-Solving (TRIZ) has been used to enhance technological creativity. However, various difficulties arise during the process of learning and teaching. This paper aims to provide a comprehensive overview of the ongoing research and challenges in the application of TRIZ in teaching, learning, and the utilization of educational tools. The primary research questions addressed include: What are the existing problems and difficulties in teaching and learning TRIZ? What are the most commonly used and popular TRIZ tools for teaching and implementation? What educational methods and tools are available to support the teaching, learning, and implementation of TRIZ? The databases IEEE, Elsevier, Springer, and Google Scholar were searched from January 2010 to December 2022. The findings are discussed based on 15 primary studies, focusing on the challenges encountered in learning and teaching TRIZ, difficulties in implementing TRIZ, and the available educational methods and tools for TRIZ.

Keywords
Learning, Teaching, Education, Technological Innovation

1. Introduction

Innovation and the relentless pursuit of knowledge that propels it are of paramount importance, given the close interrelation between a country's economic development and its capacity to innovate. TRIZ (an acronym for 'Theory to Solve Inventive Problems' in Russian) has been increasingly incorporated into the academic curriculum of several universities [1, 2]. TRIZ is a unique methodology that provides a systematic approach for understanding and defining problems. Unlike other related methodologies, it offers a suite of tools specifically designed to generate problem-solving ideas [3]. In fact, recent research suggests that TRIZ training is enhancing problem-solving attitudes among undergraduate students [4].

Historically, the teaching of TRIZ has predominantly been facilitated by experts in classroom-based workshops, characterized by their extensive duration of 160 hours. However, a mere 8 hours of this allocated time is devoted to practical exercises. This approach has led to a substantial gap in skill development, limiting the ability of trainees to effectively apply the methodology in real-world situations [5].

The theoretical framework of TRIZ is noted to be quite comprehensive, thus necessitating significant time investment for mastering its tools [5, 6, 7]. The combination of this broad scope and its instructional design has posed challenges in knowledge acquisition and application [7].

The success of any educational methodology lies significantly in its capacity to foster student motivation. Yet, this becomes a formidable challenge when the effectiveness of the teaching methodology cannot be promptly validated. This situation can detrimentally affect student motivation, which may consequently impede their learning progress [6, 8].

Another critique of the existing teaching strategy is its heavily theoretical focus, often sidelining the practical aspect [6,9]. This disproportionate emphasis on theory over practice has

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been highlighted as a major issue, compromising the overall effectiveness and applicability of the learning process.

The primary objective of this research is to carry out a systematic review of the literature pertaining to the challenges, tools, and methodologies employed in TRIZ teaching and learning for professionals and/or students. This study aims to garner a comprehensive understanding of the current landscape and identify any potential gaps or areas that warrant further investigation in TRIZ education. Through a meticulous analysis of existing literature, this review aspires to provide valuable insights, thereby contributing to the improvement of teaching and learning practices within TRIZ.

This article is organized as follows: Section 2 introduces the Systematic Literature Review (SLR) as a research methodology. Section 3 presents and analyzes the results of the SLR, while Section 4 discusses the conclusions.

2. Methodology

For the research, a Systematic Literature Review (SLR) has been conducted. This method enables the identification, evaluation, and interpretation of existing research on a specific topic [10]. The process consists of three phases: planning, execution, and reporting of results.

2.1. Plan

The first phase of the systematic literature review (SLR) is planning. This phase consists of several activities that range from identifying the need to conduct the review to defining the data sources for information retrieval. The following activities are described in detail.

2.1.1. Research need

Since the inception of TRIZ in the USSR, its education has primarily been delivered by independent providers and experts well-versed in the methodology. This was particularly the case during the 1970-1990 period. Later, its teachings spread to the United States and Western Europe in the 1990-2000 era [5]. Predominantly, these workshops have utilized lecture-based pedagogy, aiding participants in comprehending the evolution and significance of the TRIZ methodology. However, a noticeable gap persists in the development of practical skills. Despite the initial enthusiasm students display during the training, they frequently grapple with considerable challenges when attempting to apply TRIZ independently [5]. This issue can be attributed to students' self-efficacy, or their belief in their own abilities to accomplish tasks or goals [4].

2.1.1. Research questions

Three research questions were defined:

1. What problems and/or difficulties exist in the teaching and learning of TRIZ?
2. What TRIZ tools are the most used and/or popular for their teaching and application?
3. And what educational methods and/or tools exist to help in the teaching, learning, and application of TRIZ?

2.1.2. Search string and data sources

To conduct the SLR, we extracted the essential keywords from the research questions. By utilizing the logical connectors AND and OR, we formulated the search string to be used in the data sources. The resulting search string is as follows: TRIZ AND (Teaching OR Learning OR Training OR Challenge OR Education OR Tools OR Method).

2.1. Execution

The second phase of the SLR is the execution of the review, during which the inclusion and exclusion criteria are defined to select the primary studies and subsequently extract the data.

For the execution of the SLR and the subsequent extraction of the results, the following data sources have been selected: IEEE, Springer, Elsevier, and Google Scholar. The main properties for selection criteria were the relevance to the research questions, inclusion/exclusion criteria, the scope and coverage of TRIZ in education, and information accessibility.

2.1.1. Inclusion and exclusion criteria

As the first step in conducting the review, inclusion and exclusion criteria should be established.

Inclusion criteria:

1. The articles must have been published between 2010 and 2022.
2. The articles must be written in English.
3. The articles must contain the word "TRIZ" in the title, AND in the title, abstract, or keywords, they should include the terms: teaching, learning, training, challenges, and/or method.

Exclusion criteria:

1. The articles considered for this paper should meet certain criteria. First, they should primarily focus on the pedagogical aspects of TRIZ teaching. Second, they should provide ample information about the challenges associated with learning this method. Additionally, these articles should engage with discussions on the most frequently used tools within the TRIZ methodology. Conversely, articles should be excluded if they reference didactic methods or instruments that do not facilitate or enhance TRIZ teaching and learning.

3. Results

The results of the SLR that has been carried out are detailed below. Data from the primary studies has been extracted, analyzed, and synthesized.

3.1. Primary studies

A total number of 15 primary studies have been found. The process of identifying primary studies through databases and registers is outlined in Fig. 1, encompassing three key phases: identification, screening, and inclusion.

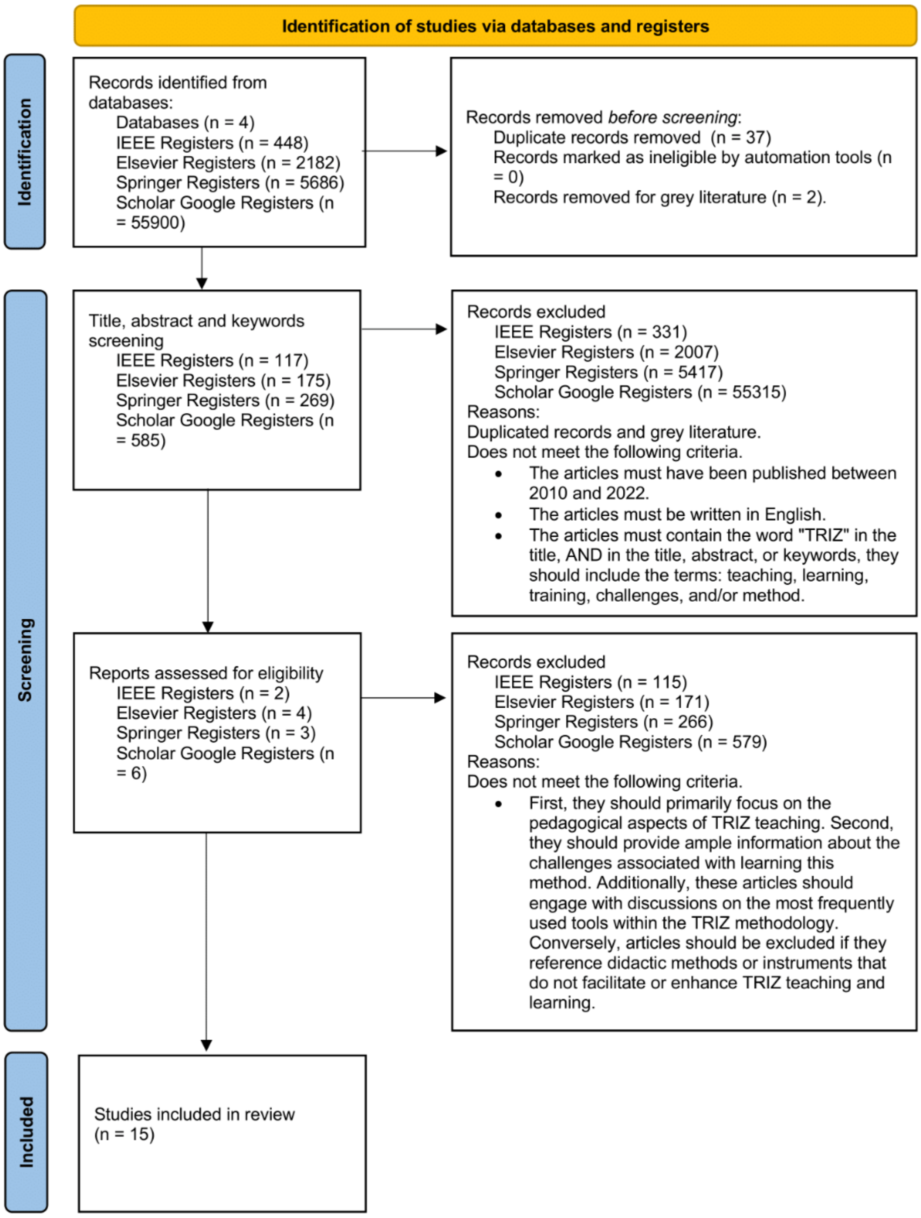

Figure 1: Selection process of the primary studies.

The summary of the primary studies can be seen in Tables 1, 2, 3 and 4.

Table 1
Description of the primary studies (part 1)

Problem/difficulty/challenge	Brief description of proposal	Ref.
The challenge lies in the time-intensive nature of effectively teaching the Theory of Inventive Problem Solving (TRIZ) within engineering education due to its complexity, demanding more class periods compared to less effective methods, hindering its widespread adoption.	A solution through innovative TRIZ-pedagogics, integrating TRIZ with other disciplines to streamline learning. The author's method focuses on applying TRIZ principles to "re-invent" systems from diverse disciplines, aiming to overcome contradictions and enhance understanding.	[1]

Table 2
Description of the primary studies (part 2)

Problem/difficulty	Brief description of proposal	Ref.
Enhancing student competency in problem-solving within the STEM curriculum in Malaysia poses a challenge, prompting the need for effective implementation strategies, including the integration of TRIZ and other creativity theories.	This study advocates for the strategic integration of TRIZ alongside other creativity models within the curriculum to fortify complex problem-solving skills among students in Malaysian schools. Analyzing feedback and addressing highlighted issues will refine the teaching and learning process, ensuring continuous improvement and efficacy.	[2]
Despite TRIZ's international acclaim in problem-solving, there's a need to simplify its application and demonstrate its integration with existing methods like Six Sigma, CM, SCM, QFD, and Taguchi, while also highlighting its practical adoption across companies of varying scales.	Authors aims to streamline TRIZ application by introducing a simplified problem-solving model, showcasing successful integration with existing methodologies, and offering practical case studies to illustrate its efficacy. Through exercises and real-world examples, it aims to empower readers to harness TRIZ for innovative problem-solving and system evolution.	[3]
Understanding the impact of TRIZ education on students' self-efficacy and problem-solving attitudes is crucial, yet evaluating this beyond measurable outputs like exams and projects remains a challenge, affecting sustained problem-solving enthusiasm and resilience despite initial setbacks.	This study aims to assess the influence of TRIZ-based courses on students' self-efficacy and problem-solving attitudes, examining shifts in pedagogical approaches (traditional vs. project-based learning) and course delivery (in-person vs. remote), offering insights to optimize TRIZ education methods for enhanced problem-solving skills and perseverance.	[4]
Despite TRIZ being acknowledged as a robust problem-solving tool, its acceptance and adoption among learners in Malaysia, particularly within industries and institutions, remain limited, posing a challenge to its effective utilization and further study uptake.	This paper aims to scrutinize the challenges associated with the limited acceptance of TRIZ among learners in Malaysian industries by analyzing the experiences of TRIZ Level 3 experts. It seeks to uncover reasons for the low uptake and offer recommendations to facilitate wider acceptance and utilization of TRIZ for innovative problem-solving.	[6]
Despite its global adoption and promotion, practical challenges hinder the effective application of TRIZ, overlooked in existing literature.	This paper diverges from traditional TRIZ literature, focusing on practical challenges faced in understanding and implementing TRIZ, utilizing a survey to gather firsthand experiences and recommending key tools within the TRIZ toolkit for beginners based on observed usage.	[7]
The implementation of an intensive 84 or 140-hour TRIZ master course, varying significantly from traditional university courses in subject, timing, and intensity, poses potential challenges and opportunities that need assessment for effective integration within the curriculum.	This paper outlines an analysis of the TRIZ master course, focusing on its structure, outcomes, and student feedback. It aims to evaluate its effectiveness, challenges, and impact on fostering innovative thinking and problem-solving skills among students within the University of Twente.	[8]

Table 3
Description of the primary studies (part 3)

Problem/difficulty	Brief description of proposal	Ref.
The investigation assesses the impact of TRIZ training within a global FMCG organization, exploring factors influencing innovative behavior, cognitive and affective elements, yet encountering variances in expected outcomes and environmental support predictions in idea generation and implementation phases, prompting the need to refine the understanding of TRIZ's comprehensive impact and effectiveness within organizational contexts.	This study aims to deepen the understanding of TRIZ training's influence on innovation by scrutinizing the interplay between cognitive and affective factors, job-relevant capabilities, and environmental support, providing an enhanced evaluation framework to measure the multifaceted impact of TRIZ training within organizational settings.	[9]
The complexity of applying the 40 Altshuller Inventive Principles in TRIZ, which demands high abstract thinking, hindering newcomers' effective idea generation in engineering problem-solving.	Method to simplify the abstract nature of inventive sub-principles within TRIZ, aiming to enhance idea generation. It investigates the impact of modified sub-principles on idea quantity and distribution across engineering domains among undergraduate and graduate students.	[11]
The study focuses on leveraging TRIZ innovation theory to enhance the training approach for "new engineering," aiming to cultivate innovative thinking, problem-solving skills, and engineering creativity among students. However, it lacks specific quantifiable metrics or empirical evidence to validate the effectiveness of this integrated approach in improving students' innovative abilities comprehensively.	This research aims to empirically assess the efficacy of the "Double Creativity" course in new engineering, utilizing quantitative and qualitative measures to evaluate the impact of integrating TRIZ innovation concepts into the teaching methodology. By employing pre-and-post assessments, case studies, and student feedback, it seeks to validate the tangible improvements in students' innovative consciousness, problem-solving capabilities, and overall engineering proficiency resulting from this integrated approach.	[12]
The research aims to enhance innovation effectiveness in the conceptual development phase of industrial new product development processes, leveraging problem-solving techniques like Design Thinking (DT) and TRIZ, yet lacks comprehensive empirical evidence to validate the efficacy of their integrated framework in improving NPD outcomes across industries.	This study proposes an integrated framework merging Design Thinking and TRIZ methodologies within the conceptual development stage of industrial new product development, intending to empirically validate its effectiveness through rigorous testing and validation within the automotive industry, aiming to provide tangible evidence of its applicability and benefits in an incremental industry context.	[13]

Table 4
Description of the primary studies (part 4)

Problem/difficulty	Brief description of proposal	Ref.
The article addresses the challenge of dissatisfaction among senior executives regarding innovation in their organizations despite acknowledging its high importance, emphasizing the need for more effective and structured approaches to consistently generate novel ideas during problem-solving processes.	This article advocates adopting structured problem-solving techniques (such as Subtraction, Task unification, Multiplication, Division, Attribute dependency) within organizations, encouraging a shift from traditional brainstorming to "inside the box" thinking, aiming to systematically train individuals to generate innovative ideas by utilizing constraints and structured methods to solve problems creatively.	[14]
The challenge lies in not just imparting theoretical knowledge but also instilling practical skills in individuals within a limited timeframe when learning TRIZ, demanding interactive methods for swift knowledge transfer and effective application	This article suggests leveraging gamification as a recognized approach to teaching and learning TRIZ, compiling and analyzing various games and case studies that offer playful yet instructive experiences, aiming to provide an overview of the settings and types of games that facilitate effective TRIZ tool learning and application.	[15]
The challenge lies in designing a game, TRIZzle, to teach the Theory of Inventive Problem Solving (TRIZ) effectively to beginners without an engineering background, ensuring explicit learning within a fun gaming environment.	This case study details the development of TRIZzle, focusing on addressing the challenge of explicit learning within an engaging gaming context, aiming to provide insights and lessons learned for content experts planning to gamify learning materials for teaching or training across diverse fields.	[16]
The challenge is the absence of a contradiction matrix of the 40 Inventive Principles (IPs) in the service context, leading to increased time and effort in identifying the appropriate principles to address service-related problems within TRIZ.	This study proposes a categorization method by grouping the 40 IPs under five Service Redesign Approaches (SRAs), demonstrating through a sample case study the feasibility of aligning principles with SRAs to streamline their application in solving service-related issues within TRIZ.	[17]

3.2. Analysis and Synthesis of Results

Those who have taught or learned TRIZ have encountered various difficulties. These challenges encompass the acquisition of knowledge, its application in problem-solving, its breadth, the time required for understanding, the personal and organizational resistance they face, the motivation required to learn it, and the teaching strategies that have been followed.

3.2.1. Benefits, Difficulties and Challenges of Learning and Teaching TRIZ

Lovotov and Sekaran [11] aimed to reduce the abstraction level of inventive TRIZ sub-principles in order to generate more ideas. To achieve this, an experiment was conducted with three groups of undergraduate and graduate students studying mechanical and process engineering. The two undergraduate groups consisted of 40 and 34 students, while the graduate group had 23 students. The distribution of ideas was focused on the fields of MATCHEM-IBD (Mechanical, Acoustic, Thermal, Chemical, Electrical, Magnetic, Intermolecular, Biological, and

Data processing). The students were given 10 minutes to record as many individual ideas as possible using the recommendations of the five inventive sub-principles for three given problems, which were printed on the idea-generation forms. On average, students proposed 1.53 times more ideas when using the less abstract sub-principles (5.63 ideas per person) compared to the more classic sub-principles (3.67 ideas per person).

In a study, the effects of TRIZ-oriented courses on students' self-efficacy and problem-solving attitudes towards design activities were investigated, particularly in relation to changes in pedagogical approaches—namely, traditional learning (TL) and project-based learning (PBL)—as well as course modality, including in-person and remote instruction [4] The study discovered that PBL was more effective than TL in enhancing students' self-efficacy. However, TL proved more efficient in improving students' problem-solving attitudes by the conclusion of the course.

In Malaysia, TRIZ has been introduced to enhance the complex problem-solving skills of students in the Curriculum and Assessment Standard Document for Design and Technology subjects [2]. This approach also integrates STEM courses with TRIZ for creative design. TRIZ was initially implemented in 2018, and it became the first official textbook used in all schools across Malaysia. A survey was conducted in Malaysia with 1032 respondents involved in the teaching and learning process of TRIZ, out of which 72 respondents were students who shared their learning experiences. The feedback received highlights the importance of higher levels of creativity and innovation for both teachers and students, particularly in the Design and Technology subject. The results also identified three main factors that contribute to the success of TRIZ's adoption: (1) the process of explaining the application of TRIZ in the design and technology subject, (2) the practical implementation of TRIZ knowledge in the classroom, and (3) the availability of additional knowledge and resources to support TRIZ in the subject.

Individuals trained in TRIZ often assert that its complexity and rigidity make understanding, acquiring, and applying the knowledge it provides a significant challenge [7]. This complexity emanates from its array of tools, contributing to a convoluted structure. The resulting extensive theoretical foundation frequently leads to a sense of tediousness during the learning process, with assimilation of the information being no easy task [6].

As TRIZ is an expansive and intricate methodology, studies in this field demand more time compared to other related methodologies [1]. Therefore, a substantial investment of hours is needed to comprehend and practice TRIZ at a deeper level, which ultimately allows for the production of meaningful results [7].

The presence of a standard is integral for guiding the application of TRIZ. Observations have been made regarding the lack of a step-by-step structure that dictates the usage of the tools incorporated in TRIZ [6, 7]. Thus, it is recommended to discover approaches to teaching the methodology that simplify the identification of suitable tools for problem-solving, and offer a clear application framework [7]. Instead of aiming to teach the entire breadth of TRIZ, it might be beneficial to concentrate on teaching only the essential aspects, consequently developing a simplified version that encourages swift results [7].

In many organizations, productivity takes precedence over innovation [8]. Given the extensive learning period TRIZ requires, it can be challenging for individuals to readily embrace or internalize the methodology [7]. Additionally, individuals might overlook the potential necessity of a problem-solving methodology [7].

Resistance to TRIZ can also emerge from students during the teaching process. The difficulties inherent to learning the methodology can lead to motivational issues. Moreover, individuals already conversant with other related methods may not acknowledge the necessity to learn TRIZ, thereby showing indifference towards it [6].

Three factors are critical when implementing TRIZ in an organization: personal motivation, understanding of the methodology and its application, and an organization's willingness to adopt it [8]. Once the benefits of using the methodology are evident and spark an interest in learning it, individuals usually show willingness to devote the required time to master at least the main tools [8]. The motivation to continue learning TRIZ often arises after its problem-solving effectiveness has been witnessed [6]. Consequently, integrating practical learning to ensure comprehensive understanding is seen as crucial, as it helps sustain appropriate motivation.

At the commencement of training, theory is usually the focus [9]. Often, the learners are overwhelmed by the sheer volume of information and are made responsible for learning about the subject with only guidance from the instructor. This approach, however, has resulted in a somewhat negative perception of the methodology. Therefore, it's suggested to emphasize practical exercises right from the onset of the training. By doing so, individuals can directly experience the benefits of TRIZ, bolstering their confidence in its effectiveness [6].

Interestingly, some individuals have described their training in the methodology as straightforward. This group found the training to be simplified, pragmatic, and engaging [9].

3.2.2. Methods and Tools of TRIZ

The published TRIZ-derived methods are designed to enhance the study of the methodology. They provide simplified guidelines that make its understanding and application easier, while also addressing the time required for its study, particularly when integrated into university academic programs.

Additionally, an array of serious games and didactic instruments has been developed to assist in the understanding and practical application of TRIZ, furnishing interactive environments for teaching the methodology.

Ge and Shi [12], a training method for enhancing innovation ability in the context of "new engineering" is discussed. This method incorporates the principles of TRIZ engineering innovation and encompasses various aspects such as teaching content, engineering practice, and ability training. Its primary goal is to foster students' innovative thinking and enhance their problem-solving skills through the application of innovative approaches. The teaching approach emphasizes experiential learning and role exchange, promoting the development of both innovation and teamwork abilities. Rather than being solely driven by the teacher, classroom activities involve active student participation. Students are divided into groups, where they engage in collaborative discussions and task completion. This approach encourages students to engage in research, analysis, discussion, decision-making, and evaluation, thereby fostering a systematic problem-solving mindset. To evaluate the effectiveness of the method, the authors applied it to a general design and innovative design course involving 100 participants. They assessed participants' inventive abilities using a 0-10 scale before, during, and after the course. The results showed improvements in various aspects, including design and analysis ($M = 4.37$), design reasoning ($M = 4.69$), overall solution ($M = 3.89$), optimization and evaluation ($M = 4.15$), innovative thinking ($M = 3.71$), and competition results ($M = 2.21$). However, the authors did not provide any information regarding the challenges or difficulties encountered during the implementation of their method.

A framework integrates integrating TRIZ and Design Thinking (DT) into the conceptual development phase of an industrial New Product Development (NPD) process [13], they used DT for problem treatment and problem definition, and TRIZ for solution verification, all in a the discipline of continuous improvement. The framework was evaluated in an automotive case study focused on developing a new, lighter weight vehicle body door seal concept. After testing, the use of TRIZ to guide idea generation and screening proved to be more efficient. Ideas were compared based on technical assessments of important variables, rather than engaging in unproductive discussions between the design and engineering teams. Design thinking (DT) played a significant role in engaging end-users during problem definition and prototype evaluation, which can be challenging in an engineering-led project. Additionally, DT introduced the innovative concept of "rapid prototyping" in the automotive context, proving to be highly efficient when dealing with concept phase ideas.

Simplified TRIZ, a condensed version of the methodology, was developed and proposed by Kalevi Rantanen and Ellen Domb [3]. This method begins with the definition of a system, consisting of a tool and an object where the tool performs an action on the object. It further emphasizes that the root cause of the problem to be addressed is a contradiction within the system. Hence, the goal is to resolve this contradiction—once it has been clarified and properly defined—through an analysis of the available resources, which includes environmental factors and system waste. Additionally, a clear definition of the ideal final result is essential. This involves depicting the best possible solution that effectively eliminates the contradiction. The 40 principles of inventiveness and patterns of evolution are incorporated into this method, serving as supplementary tools to aid in achieving the desired end result.

TRIZ-Pedagogics was developed to address the time needed to learn the methodology when it's integrated into university curriculum subjects. The method, known as Creative Theories, involves problem-solving tasks that humanity has already resolved but are unknown to the students. TRIZ application is necessary to find a solution using the knowledge acquired during the course of study [1]. However, the implementation of the Creative Theories method is only appropriate during a designated stage of instruction, specifically for solving tasks.

Systematic Inventive Thinking (SIT) [14], a TRIZ-inspired method, revolves around two fundamental principles. The first principle, called a "closed world", suggests that people are more creative when focusing on the internal facets of a situation or problem and when their options are limited rather than broad. This involves utilizing only the available resources to generate as many solutions as possible. The second principle, "function follows form", promotes thinking about problem-solving differently. Instead of beginning with a well-defined problem as is typical in innovation, SIT recommends starting with an abstract, conceptual solution and then linking it back to the problem it solves. SIT also introduces the concept of contradictions, which occur when two opposing factors must be reconciled. Addressing one factor often exacerbates the other, leading to an unacceptable trade-off. Hence, resolving the contradiction becomes key to effectively solving the problem.

GamiTRIZation, a serious game based on TRIZ heuristics, provides innovators with meta-rules—rules for breaking the rules [15]. Yet, a contradiction exists with current games used in teaching and learning TRIZ. Typically, games consist of established rules that must be followed, which is counter to fostering innovation. GamiTRIZation, however, is an unconventional game that can be applied to almost any existing game. The objective is to disrupt the host game's rules during each turn using the 40 principles of inventiveness, thereby encouraging players to innovate new rules.

TRIZzle [16], is a mobile game prototype designed to introduce the 40 principles of inventiveness from TRIZ to individuals without engineering knowledge. The game spotlights ten select TRIZ principles: segmentation, extraction, local quality, mixing, multifunctionality, nesting, weight compensation, preliminary neutralization, copying, and change of optical properties. Each principle is showcased in a unique game level with distinct features. The development of TRIZ Puzzle involved a collaboration between a game development team and a TRIZ content expert. The two entities together created a puzzle game that struck a balance between educational content and enjoyable gameplay. This was achieved with guidance from an instructor.

The TRIZ Service Categorization [17] comprises cards representing the 40 principles of inventiveness, categorized into five service approaches: self-service, direct service, preservice, bundled service, and physical service. The categorization is established based on the similarity between the approaches and the principles.

4. Conclusions and discussion

The information obtained by conducting the SLR has provided an overview of the current state of challenges in TRIZ teaching and learning.

It can be concluded that the methodology is complex and difficult to assimilate, as the theory is extensive and initially lacks practical application, leading to a sense of boredom among beginners. Furthermore, certain TRIZ tools are preferred over others. Therefore, emphasis should be placed on teaching specific aspects of the methodology to simplify the learning process.

An effort must be made in training to ensure that the theory and practice of the methodology occur simultaneously, thereby promoting the acquisition of quick results in its application. This

approach would facilitate the adoption of TRIZ by organizations or individuals. Enhancing the learning strategy and fostering student motivation are crucial aspects of teaching TRIZ.
The educational methods and tools presented in Table 5 have been implemented with the objective of enhancing the teaching and learning of the TRIZ methodology. To establish the criteria for comparison, we have considered the results obtained from the research question "What problems and/or difficulties are encountered in the teaching and learning of TRIZ?" These comparison criteria are described below.

Table 5
Strengths and improvement opportunities for educational methods and tools derived from TRIZ. 'x' = Strength and improvement opportunities, and '-' = improvement opportunity.

Category	Approach	Criteria				
		Theorical	Practical	Simplified	Application guide	Internal Production
Methods	TRIZ-Pedagogics	x	x	-	-	-
	Simplified TRIZ	x	-	x	x	-
	SIT	x	-	x	x	-
	New engineering	x	x	-	-	x
	TRIZ and Design Thinking	x	x	x	-	x
Tools	GamiTRIZation	-	x	x	-	-
	TRIZzle	-	x	x	-	-
	TRIZ Service Categorization	-	x	x	-	-

Theoretical: Didactic methods or instruments derived from TRIZ that, due to their design or nature, have a greater weight in the theoretical part of the methodology, maintain the traditional teaching strategy.
Practical: Didactic methods or instruments derived from TRIZ that, by their design or nature, have a greater weight in the practical part of the methodology, change the traditional learning strategy.
Simplified: Didactic methods or instruments derived from TRIZ that, by their design or nature, contain a smaller set of methodology tools than the traditional form, thereby simplifying their teaching.
Application guide: Didactic methods or instruments derived from TRIZ that, by their design or nature, can guide the problem-solving process and are not limited to just teaching some tools.
Internal production: Didactic methods or instruments derived from TRIZ that, by their design or nature, are intended to produce results during the teaching and learning process. They can motivate students in the teaching process and, therefore, also reduce personal or organizational resistance to implementation.
To optimize the teaching and learning of TRIZ through various methods and tools, it is crucial to adhere not only to the criteria identified in literature, which include theoretical, practical, and simplified approaches, but also to tackle the most notable shortcomings. These deficiencies include the lack of application guides that incorporate motivational aspects such as games or gamification strategies, as well as fostering internal production through methods like experiential learning, prototyping coupled with design thinking, or other such initiatives.

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