TRIZ AS A TOOL THAT INCORPORATES ART FOR THE EVOLUTION OF INNOVATIVE PROJECTS

ELENA COJOCARI, STANISLAV CȘEMINSCHI [*]

ABSTRACT: *This study presents an in-depth analysis of how TRIZ (Theory of Inventive Problem Solving) can enhance the evolution of innovative projects. The research focused on identifying the successful traits of TRIZ in the new product development cycle. Extensive data collection enabled a comparative study on TRIZ application over time, highlighting its recent use and effectiveness. The study identified domains where TRIZ has been successful and those where it has faced challenges. A key finding is that TRIZ is not just a problem-solving tool but also a method that integrates artistic elements into engineering innovations. By blending technical precision with creative problem-solving, TRIZ enables the development of products that are functionally efficient and aesthetically pleasing. This unique aspect makes TRIZ valuable for designing solutions that resonate both practically and emotionally. The findings suggest that strategic TRIZ application can steer challenging projects towards success, demonstrating its versatility and effectiveness. By adding an artistic dimension to engineering, TRIZ fosters a holistic approach to innovation, ensuring final products are innovative, appealing, and user-friendly.*

KEY WORDS: *TRIZ, Innovative projects, New product development cycle, Comparative study, Data collection, Readiness, Problem-solving tool, Engineering innovations, User-friendly product.*

JEL CLASSIFICATIONS: *L23, O31, O36, Q55.*

1. INTRODUCTION

We live in an era driven by rapid innovation, where the pace of change is ever-accelerating. At the heart of this transformation are innovative start-up projects, which act as the engines propelling society forward. However, the low success rates of these projects are well-documented and often accepted within the entrepreneurial mantra of

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"fail, fail again, fail better" (Cseminschi, et al., 2024). While there is significant value in learning from failure, the ultimate goal is to prepare for success (Altshuller, 1984).

To enhance the likelihood of success, this paper proposes the application of the TRIZ (Theory of Inventive Problem Solving) methodology to the evolution of innovative higher education projects. Before delving into TRIZ, it is crucial to understand the strengths and weaknesses inherent in university projects. This understanding begins with assessing the technological, marketing, commercial, and management readiness of projects at the University of Petroșani (Cseminschi, et al., 2024).

By identifying these readiness dimensions, we can make informed decisions on where to focus improvement efforts. For instance, a project may have strong technological foundations but lack in marketing readiness. Understanding these nuances allows for targeted interventions using TRIZ principles, which can significantly enhance a project's success prospects.

Applying TRIZ to university projects can foster innovative thinking, turning theoretical ideas into practical, market-ready solutions. To begin with, technological readiness must be assessed. This involves evaluating the project's technological maturity, the feasibility of its implementation, and its potential for scalability. Projects with high technological readiness are those that leverage cutting-edge technologies effectively, demonstrating robustness and adaptability. Conversely, projects that lag in this area may face significant hurdles in development and application (Bagheri, 2022).

Marketing readiness is another critical dimension. It examines the project's potential to meet market needs, the effectiveness of its value proposition, and the strategies in place for market penetration. Projects with strong marketing readiness are those that not only identify but also effectively communicate their unique value propositions to their target audience. Poor marketing readiness can lead to misalignment with market demands, resulting in limited adoption and success (Baber, 2021).

Commercial readiness focuses on the project's business viability, including financial planning, revenue models, and the potential for generating sustainable income. This dimension ensures that the project is not just innovative but also commercially viable. A project may be technologically and marketing-wise sound but could fail without a solid commercial foundation (Baber, 2022).

Lastly, management readiness evaluates the organizational and operational capacity to execute the project. This includes assessing leadership, team capabilities, resource management, and strategic planning. Effective management ensures that the project stays on track, meets its milestones, and adapts to challenges dynamically (Osterwalder & Pigneur, 2010).

By analyzing these readiness dimensions, we can identify specific areas that require enhancement. The TRIZ methodology offers a structured framework to address these areas by applying its 40 inventive principles, which include strategies like segmentation, taking out, local quality, asymmetry, merging, and universality, among others. These principles guide project teams in overcoming obstacles creatively and systematically (Blank, 2013).

For example, if a project struggles with technological readiness due to scalability issues, TRIZ principles such as "Taking Out" (removing an interfering part) or "Segmentation" (dividing the system into independent parts) can offer solutions. These principles encourage breaking down the problem into manageable parts or removing redundant components, thereby enhancing scalability (Kaplan, 1996).

Similarly, for projects with low marketing readiness, the TRIZ principle of "Local Quality" (improving a feature or component to address local needs) can be applied. This involves tailoring the project's features to better meet specific market demands, thereby enhancing its appeal and market penetration (Mazur, 1996).

In the realm of commercial readiness, the TRIZ principle of "Universality" (making a part or system perform multiple functions) can be particularly useful. By developing multi-functional components or systems, a project can reduce costs and increase value, making it more commercially viable (Goehle, 2013).

For management readiness, the TRIZ principle of "Nested Doll" (placing one thing inside another) can be utilized to streamline operations. This involves integrating various management processes and systems, improving efficiency and coherence in project execution (Morschheuser, et al., 2017).

The application of TRIZ in educational projects not only enhances their chances of success but also instills a culture of systematic problem-solving and innovation among students. By engaging with TRIZ, students learn to approach problems methodically, think outside the box, and develop solutions that are both practical and innovative (Dicheva, et al., 2015).

Moreover, integrating TRIZ into the curriculum fosters an entrepreneurial mindset, preparing students to tackle real-world challenges with confidence and creativity. This holistic approach to education not only equips students with technical knowledge but also hones their analytical and strategic thinking skills, essential for their future careers (Su, 2013).

2. TRIZ: AN OVERVIEW

In this section, we will explore the Theory of Inventive Problem Solving (TRIZ), its principles, statistical trends over the past decade, and its primary applications. We will also trace its origins and initial domains of use.

TRIZ, the Theory of Inventive Problem Solving, was developed by Soviet inventor and science fiction writer Genrich Altshuller and his colleagues starting in 1946. TRIZ is a methodology for systematic innovation, offering a structured approach to understanding and solving problems. It was developed by analyzing a vast number of patents to identify patterns of innovative solutions (Cseminschi, et al., 2024).

2.1. TRIZ Principles

The TRIZ methodology comprises 40 inventive principles designed to help solve complex problems creatively. These principles are presented in the following table:

Table 1. TRIZ principles

N^0	Inventive principle	N^0	Inventive principle
1	Segmentation	**21**	Rushing Through
2	Extraction	**22**	Convert Harm Into Benefit
3	Local Quality	**23**	Feedback
4	Asymmetry	**24**	Mediator
5	Consolidation	**25**	Self-service
6	Universality	**26**	Copying
7	Nesting	**27**	Dispose
8	Counterweight	**28**	Replacement of Mechanical System
9	Prior Counteraction	**29**	Pneumatic or Hydraulic Construction
10	Prior Action	**30**	Flexible Membranes or Thin Films
11	Cushion in Advance	**31**	Porous Material
12	Equipotentiality	**32**	Changing the Color
13	Do It in Reverse	**33**	Homogeneity
14	Spheroidality	**34**	Rejecting and Regenerating Parts
15	Dynamicity	**35**	Transformation of Properties
16	Partial or Excessive Action	**36**	Phase Transition
17	Transition Into a New Dimension	**37**	Thermal Expansion
18	Mechanical Vibration	**38**	Accelerated Oxidation
19	Periodic Action	**39**	Inert Environment
20	Continuity of Useful Action	**40**	Composite Materials

2.2. Statistical Trends and Applications

Over the past decade, TRIZ has seen varied applications across numerous fields. According to recent statistics, there has been a notable increase in TRIZ usage in sectors such as engineering, product development, and industrial design (Altshuller, 1984). The method has also been integrated into educational programs, particularly in universities, to foster innovative thinking among students (Bagheri, 2022).

Based on the analysis of scientific papers and articles from the Web of Science (WOS) over the last five years, it has been determined which domains and categories have most frequently researched, exploited, and applied TRIZ (Theory of Inventive Problem Solving) and its principles. The findings indicate that TRIZ is predominantly popular in the fields of Computer Science Information Systems and Computer Science Artificial Intelligence. Following these, the domains of Engineering Multidisciplinary, Green Sustainable Science Technology, and Engineering Industrial also show significant engagement with TRIZ methodologies (Savransky, 2000; Zlotin & Zusman, 1999).

The breakdown of TRIZ applications by category, as evidenced by WOS data, reveals a notable concentration in the following areas:

- ↗ **Computer Science Information Systems**: This category leads in TRIZ research and application, reflecting the growing complexity and innovation needs in information systems development and management (Savransky, 2000).

↗ **Computer Science Artificial Intelligence**: The integration of TRIZ principles in AI research underlines the emphasis on inventive problem-solving to advance AI technologies and methodologies (Zlotin & Zusman, 1999).

↗ **Engineering Multidisciplinary**: TRIZ's versatility is well-suited to the diverse challenges encountered in multidisciplinary engineering projects, promoting innovative solutions across various engineering fields (Berg Marklund, 2013).

↗ **Green Sustainable Science Technology**: The principles of TRIZ are increasingly applied to develop sustainable technologies and environmentally-friendly solutions, demonstrating its relevance to contemporary global challenges (Domb, 1998).

↗ **Engineering Industrial**: Industrial engineering projects benefit from TRIZ's structured approach to problem-solving, enhancing efficiency and innovation in industrial processes (Mann, 2002).

Additionally, TRIZ principles have found applications in other emerging categories, though to a lesser extent. These include fields such as Biomedical Engineering, Materials Science, and even sectors like Business and Management, where innovation and problem-solving are critical to development and competitive advantage (Osterwalder & Pigneur, 2010; Blank, 2013).

The percentages of TRIZ application in these categories, according to the analysis of WOS data, highlight the diverse utility of TRIZ across different scientific and industrial domains. This distribution not only underscores the adaptability of TRIZ principles but also points to its growing influence in driving innovation and solving complex problems across multiple disciplines (Savransky, 2000; Zlotin & Zusman, 1999; Berg Marklund, 2013; Domb, 1998).

These insights into TRIZ's applications across various domains are visualized in Figure 1, presenting a clear representation of the data and trends over the past five years. This comprehensive view illustrates where TRIZ has made the most impact and continues to be a valuable tool for innovation and problem-solving (Savransky, 2000; Zlotin & Zusman, 1999; Berg Marklund, 2013).

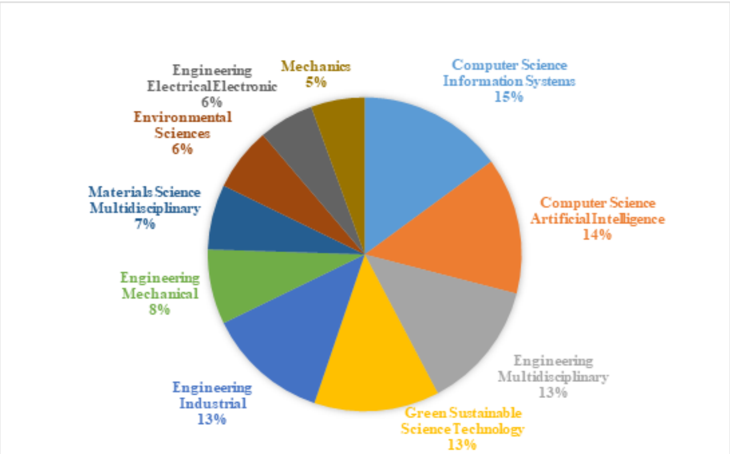

Figure 1. Percentage of studies and articles integrating TRIZ

Statistical trends regarding the application of TRIZ (Theory of Inventive Problem Solving) and its principles vary based on industry, region, and specific application contexts. In the figure 2 are some general trends observed:

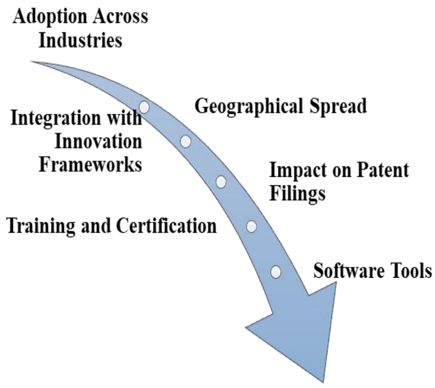

Figure 2. Trends of TRIZ application and evolution

- ☆ **Adoption Across Industries**: TRIZ principles have gained popularity across a wide range of industries including automotive, aerospace, electronics, consumer goods, and healthcare. Each industry applies TRIZ differently based on its specific challenges and innovation needs.
- ☆ **Geographical Spread**: While originally developed in Russia, TRIZ has seen widespread adoption globally. Countries with significant application include the United States, Germany, Japan, China, South Korea, and others where innovation-driven industries thrive.
- ☆ **Integration with Innovation Frameworks**: Many organizations integrate TRIZ principles into their broader innovation frameworks such as Design Thinking, Lean Six Sigma, Agile, and others. This integration aims to enhance problem-solving capabilities and foster a culture of continuous improvement.
- ☆ **Impact on Patent Filings**: There is evidence suggesting that companies using TRIZ principles tend to generate more patents and intellectual property. This indicates its effectiveness in stimulating inventive solutions and protecting innovations.
- ☆ **Training and Certification**: The demand for TRIZ training and certification programs has grown, reflecting a commitment to institutionalize TRIZ knowledge within organizations. Professional certification programs cater to engineers, designers, and innovation leaders seeking to master TRIZ methodologies.
- ☆ **Software Tools**: The development of software tools supporting TRIZ application has facilitated its adoption. These tools assist in problem analysis, idea generation, and systematic application of TRIZ principles.

Overall, these trends underscore TRIZ's growing relevance as a structured approach to innovation and problem-solving, influencing diverse sectors and fostering a systematic approach to inventive thinking.

2.3. Industry Adoption

TRIZ has been widely adopted in various industries, including automotive, aerospace, electronics, and healthcare. For instance, companies like Samsung and Intel have integrated TRIZ into their R&D processes to enhance product innovation and solve complex technical challenges (Baber, 2022). This broad industry adoption underscores TRIZ's versatility and effectiveness in fostering innovation.

The industries in which TRIZ was found most useful are shown in the figure 3.

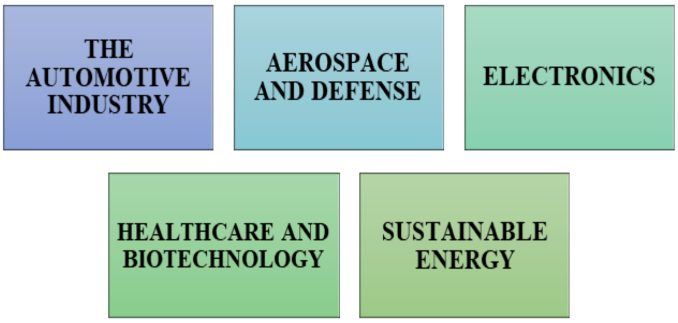

Figure 3. **Industries that adopted TRIZ**

The automotive industry has widely adopted TRIZ principles to enhance product design, reduce manufacturing costs, and improve reliability. Companies like Ford, Toyota, and BMW have integrated TRIZ into their innovation processes. Case studies highlight how TRIZ has been used to solve specific automotive engineering challenges, such as improving fuel efficiency, enhancing safety features, and optimizing vehicle performance.

Aerospace and defense industries frequently utilize TRIZ to drive innovation and streamline complex engineering processes. Significant patent filings in this sector reflect its application in developing advanced technologies and systems. TRIZ methodologies have been instrumental in addressing technical challenges related to materials, propulsion systems, aerodynamics, and mission-critical reliability.

Electronics and consumer goods companies leverage TRIZ to accelerate product development cycles, innovate new features, and improve manufacturing efficiency. Samsung and LG are notable users of TRIZ in this domain. Application examples include miniaturization of electronics components, extending battery life, enhancing user interface designs, and optimizing supply chain operations.

TRIZ is increasingly applied in healthcare and biotechnology sectors to address challenges in medical device design, drug delivery systems, bioprocessing, and healthcare management. Integration of TRIZ helps companies navigate regulatory requirements while innovating novel medical technologies and improving patient outcomes.

TRIZ principles are utilized to develop sustainable energy solutions, improve energy efficiency in industrial processes, and innovate renewable energy technologies like solar panels and wind turbines. Companies adopt TRIZ to reduce environmental footprint through innovative waste management solutions, cleaner production methods, and eco-friendly packaging designs.

2.4. Educational Integration

TRIZ principles are now being taught in numerous engineering and business schools worldwide. Many universities worldwide have integrated the Theory of Inventive Problem Solving (TRIZ) into their curricula to enhance students' problem-solving capabilities and prepare them for innovative roles in various industries. This educational integration aims to develop the next generation of leaders and innovators equipped with advanced analytical skills and creative thinking.

The University of California, Berkeley, offers courses that incorporate TRIZ principles within their College of Engineering. These courses focus on systematic innovation and problem-solving techniques, providing students with the tools to approach complex engineering challenges creatively and effectively (University of California, Berkeley).

MIT, renowned for its emphasis on innovation and research, includes TRIZ in its curriculum, particularly within the Department of Mechanical Engineering. The courses are designed to foster inventive thinking and equip students with methodologies to address and solve engineering problems (Massachusetts Institute of Technology).

The University of Cambridge integrates TRIZ into its engineering programs, emphasizing its importance in creative problem-solving and design. The university's approach to TRIZ helps students develop systematic strategies for innovation, crucial for their future careers in various engineering fields (University of Cambridge).

DTU incorporates TRIZ into its innovation and design courses, focusing on enhancing students' abilities to generate innovative solutions to technical problems. The TRIZ methodology is taught to develop a deep understanding of problem-solving processes and inventive principles (Technical University of Denmark).

The University of Tokyo has adopted TRIZ in its engineering and technology programs, where students learn to apply TRIZ principles to real-world problems. The integration of TRIZ aims to enhance the students' creative problem-solving skills, preparing them for careers in innovation and research (University of Tokyo).

Tsinghua University in China includes TRIZ in its engineering and business curricula. The courses are designed to develop students' inventive problem-solving skills, enabling them to tackle complex challenges in technology and management (Tsinghua University).

NUS incorporates TRIZ into its engineering and innovation programs. The university's focus on TRIZ aims to foster a culture of systematic innovation and equip students with advanced problem-solving tools necessary for the modern technological landscape (National University of Singapore).

Aalto University in Finland integrates TRIZ into its design and engineering programs. The university emphasizes the use of TRIZ to enhance students' creativity and systematic approach to solving engineering and design problems (Aalto University).

Seoul National University in South Korea includes TRIZ in its engineering curriculum, providing students with a comprehensive understanding of innovative problem-solving techniques. The TRIZ methodology is used to develop students' abilities to address complex engineering challenges (Seoul National University).

The University of Belgrade integrates TRIZ into its engineering and technology programs, focusing on developing students' inventive problem-solving skills. The university aims to prepare students for successful careers in innovation and technology development (University of Belgrade).

The integration of TRIZ into university curricula across the globe highlights the growing recognition of the importance of systematic innovation and advanced problem-solving skills. By equipping students with TRIZ methodologies, these institutions are preparing future leaders and innovators capable of addressing complex challenges and driving technological advancement.

3. MEASURING READINESS IN INNOVATIVE PROJECTS

Understanding the readiness of a project is critical for its successful implementation. Here, we outline methods to assess the technological, commercial, marketing, and management readiness of university-driven innovative projects.

3.1. Technological Readiness

Technology Readiness Levels (TRLs): Technology Readiness Levels (TRLs) are a systematic metric used to assess the maturity of a particular technology. The scale ranges from TRL 1, which indicates basic principles observed and reported, to TRL 9, which represents actual system proven in operational environment (NASA, 2012). This method helps in determining the current stage of development and the steps necessary to advance the technology to higher levels of maturity.

Feasibility Studies: Feasibility studies evaluate the practicality and potential success of a technology by considering technical, economic, and legal aspects. These studies involve detailed analysis to identify potential challenges and determine whether the technology can be successfully developed and implemented (Blank, 2013).

Prototype Testing: Developing prototypes and conducting rigorous testing is crucial to assess the functionality and reliability of the technology. Prototypes provide a tangible representation of the technology, allowing for practical evaluation and iterative improvements (Goehle, 2013).

3.2. Commercial Readiness

Business Model Canvas: The Business Model Canvas is a strategic management tool that helps in developing and visualizing business models. It consists of nine building blocks that describe a company's value proposition, infrastructure, customers, and finances. This tool is instrumental in understanding and designing sustainable business models (Morschheuser, 2019).

Market Analysis: Market analysis involves researching market needs, competitive landscape, and potential profitability. This includes gathering and analyzing data about customer preferences, market trends, and competitor strategies. Market analysis helps in identifying opportunities and challenges, thus aiding in strategic planning (Prpić, et al., 2014).

Financial Projections: Creating detailed financial projections helps in assessing the commercial viability of a project. Financial projections include revenue forecasts, cost estimates, and profitability analysis. These projections provide insights into the financial health and sustainability of the project Rantanen & Domb, 2008).

3.3. Marketing Readiness

SWOT Analysis: SWOT Analysis (Strengths, Weaknesses, Opportunities, and Threats) is a framework used to evaluate the internal and external factors that can impact a project. This analysis helps in identifying areas of strength to leverage and areas of weakness to address, as well as external opportunities and threats to consider (Hill & Westbrook, 1997).

Value Proposition Canvas: The Value Proposition Canvas is a tool used to ensure that the project's value proposition aligns with customer needs. It helps in defining how the project will create value for customers and how it stands out from competitors. This canvas is essential for developing effective marketing strategies (Osterwalder & Pigneur, 2014).

Customer Segmentation: Identifying and understanding different customer segments is crucial for targeted marketing. Customer segmentation involves dividing the market into distinct groups based on demographics, behavior, and preferences. This helps in tailoring marketing efforts to specific segments, thus improving effectiveness (Kotler & Keller, 2016).

3.4. Management Readiness

Project Management Maturity Models (PMMM): Project Management Maturity Models assess the maturity of project management processes within an organization. These models provide a framework for evaluating and improving project management practices, ensuring that the project is managed effectively and efficiently (Project Management Institute, 2017).

Resource Audits: Conducting resource audits helps in ensuring that adequate resources are allocated and managed for the project. Resource audits involve evaluating the availability and utilization of human, financial, and technological resources. This ensures that the project has the necessary support for successful execution (Kerzner, 2017).

Risk Management: Implementing a robust risk management plan is essential for identifying, assessing, and mitigating potential risks. Risk management involves continuous monitoring and proactive measures to address uncertainties that could impact the project. This helps in minimizing disruptions and ensuring smooth project execution (Hillson & Murray-Webster, 2017).

By employing these methods, universities can effectively assess the readiness of innovative projects, thereby enhancing their chances of success. These assessments provide a comprehensive understanding of the project's current status and the necessary steps to address gaps and improve readiness.

4. CASE STUDIES

To understand the application of TRIZ (Theory of Inventive Problem Solving) in enhancing innovative projects, an experiment was conducted within the University of Petrosani during the first-year Bachelor Entrepreneurship course. This experiment included 42 students participating over one semester. The focus was on three specific projects: SmartBuggy, UPets, and HuggyBear.

These projects were assessed based on four dimensions: technological readiness, marketing readiness, commercial readiness, and management readiness. The evaluation was crowd-sourced, relying on the students' responses to specific questions designed to measure each dimension. The insights gained from this assessment will help identify the weak traits of each project, providing a foundation to apply TRIZ principles to enhance the innovations.

Were created a comprehensive questionnaire that should assess the technological, commercial, marketing, and management readiness of innovative projects through students' perspectives which can provide valuable insights. Each question used a 5-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree).

For the Technological Readiness dimension were used the following questions from figure 4:

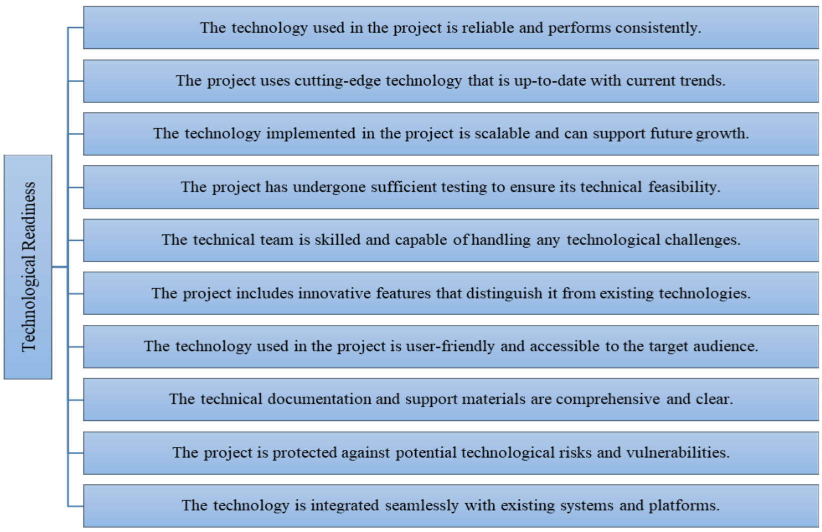

Figure 4. The questions used to assess Technological Readiness

For the Commercial Readiness dimension were used the following from figure 5:

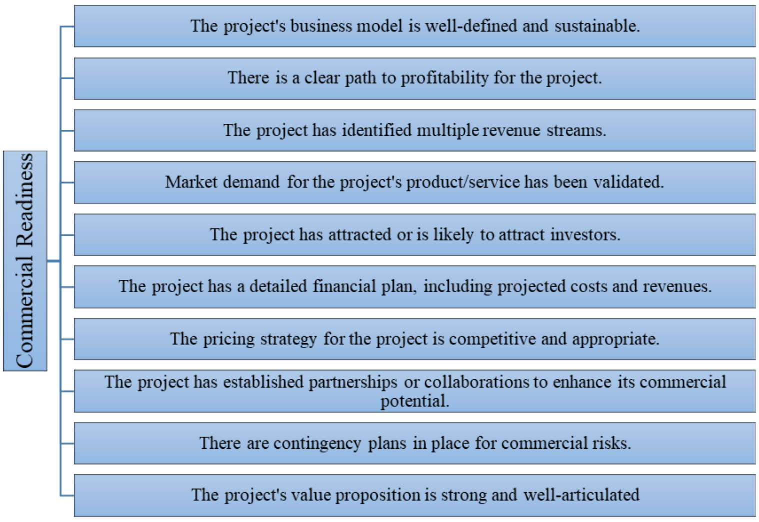

Figure 5. The questions used to assess Commercial Readiness

For the Marketing Readiness dimension were used the following questions from figure 6:

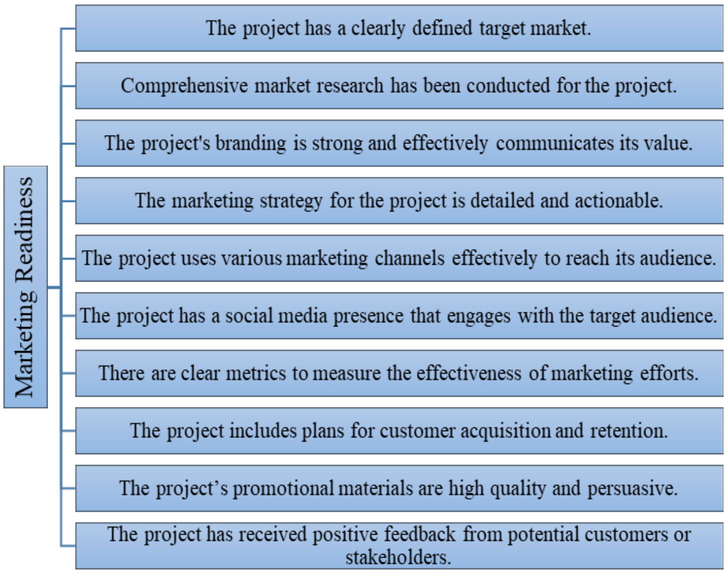

Figure 6. The questions used to assess Marketing Readiness

For the Management Readiness dimension were used the following questions from figure 7:

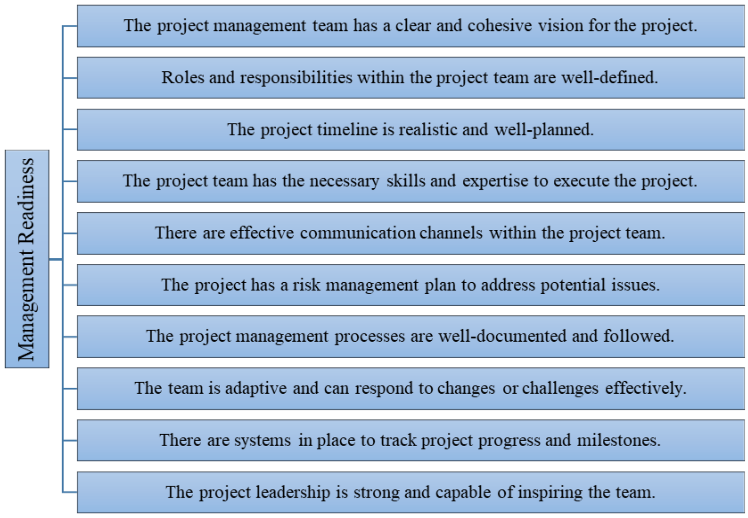

Figure 7. The questions used to assess Management Readiness

This questionnaire was administered both digitally and in paper format. Students were encouraged to answer honestly so the questionnaire could provide the most accurate assessment of the project's readiness across all dimensions. All 42 students were from the first year of the Engineering of Industrial Safety and Mining Engineering program. They were thoroughly informed about the three projects during the entrepreneurship course. The process was structured in stages so they could better understand each dimension of these projects, whether it was the technological dimension or the commercial one.

The detailed evaluation of the projects through the questionnaire provided a solid foundation for applying TRIZ principles. These results will be used to address and solve the problems identified in the project evaluations, offering innovative solutions that significantly enhance each analyzed dimension. The insights gained will allow for the optimization of the technologies used in the projects, ensuring they are at an adequate level of maturity and functionality. Commercial evaluation will help identify and address challenges related to product commercialization, as well as develop effective market strategies.

The marketing readiness analysis will enable the adjustment of promotional and communication strategies to maximize impact on the target market. Insights into management will facilitate the improvement of management and organizational processes, ensuring efficient project implementation.

The experiment conducted at the University of Petrosani demonstrated the importance and effectiveness of combining gamification with fuzzy evaluation to obtain a clear and detailed picture of the readiness level of innovative projects for crowdfunding. The crowd-sourced evaluation, based on the students' responses, provided valuable insights that will guide the application of TRIZ principles to enhance these projects.

This innovative process not only improves the educational experience but also significantly contributes to the development of future entrepreneurs capable of transforming their ideas into reality, prepared for the challenges of the modern business world. By implementing these technologies and methodologies, the University of Petrosani positions itself at the forefront of entrepreneurial education, offering students a learning environment that is not only effective but also motivating and engaging.

5.1. TRIZ Principles for Enhancing Readiness in Technological, Marketing, Commercial, and Management Aspects of Innovative Projects

Below, in table 3 we outline relevant TRIZ principles for projects lacking technological, marketing, commercial, and management readiness.

Table 3. TRIZ Principles for Enhancing Readiness

TRIZ Principles for Technological Readiness	Segmentation (Principle 1): Divide an object or system into independent parts to simplify development and troubleshooting. Taking Out (Principle 2): Remove a problematic part or property from an object, or separate the only necessary part Local Quality (Principle 3): Transition from homogeneous to heterogeneous structure to improve functionality Combined Solutions (Principle 5): Combine multiple functions into a single solution. Universality (Principle 6): Make a part or object perform multiple functions.
TRIZ Principles for Marketing Readiness	Segmentation (Principle 1): Divide the market into distinct segments and tailor marketing strategies accordingly. Universality (Principle 6): Make marketing messages versatile to appeal to a broader audience Dynamicity (Principle 15): Allow marketing strategies to adapt dynamically to changing market conditions Feedback (Principle 23): Implement mechanisms to receive and act on customer feedback promptly. Self-service (Principle 25): Enable customers to access information and services on their own.
TRIZ Principles for Commercial Readiness	Prior Action (Principle 10): Prepare critical elements of a system in advance to ensure readiness. Beforehand Cushioning (Principle 11): Provide advanced protection or backup to mitigate potential commercial risks. Periodic Action (Principle 19): Use periodic actions to sustain commercial activities and customer engagement. Intermediary (Principle 24): Use intermediaries to facilitate commercial transactions and market penetration. Self-service (Principle 25): Enable customers to complete transactions independently, improving efficiency
TRIZ Principles for Management Readiness	Segmentation (Principle 1): Divide management tasks into smaller, manageable units to improve oversight Taking Out (Principle 2): Remove unnecessary management layers to streamline decision-making processes Local Quality (Principle 3): Tailor management practices to specific team needs or project requirements Feedback (Principle 23): Establish continuous feedback mechanisms within the management system Self-service (Principle 25): Empower teams to make decisions and manage tasks independently

4.2. Identifying weak traits and analyzing results

Based on the assessments, the weak traits of SmartBuggy, UPets, and HuggyBear were identified in the four dimensions. For instance, if a project showed low technological readiness, it might indicate issues with scalability or reliability. Similarly, low marketing readiness could reveal a lack of market research or unclear value proposition.

For example, related to SmartBuggy project, one of the students average scores suggested moderate technological readiness (3.5), strong marketing readiness (4.1), moderate commercial readiness (3.7), and relatively strong management readiness (3.8). We then compared these individual averages to the overall student responses to derive a more comprehensive picture of each project's readiness.

By examining the aggregated data, we could pinpoint specific areas where each project excelled or needed improvement. For instance, if the overall average score for technological readiness across all students was low for SmartBuggy, it indicated a need for further development in this area. Conversely, high scores in marketing readiness suggested effective promotional strategies. The results for each of the 3 analyzed projects of the University of Petroșani are shown in the following figures.

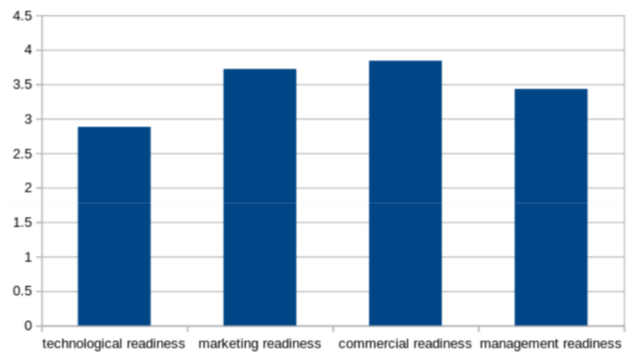

Figure 8. Results for SmarttBuggy

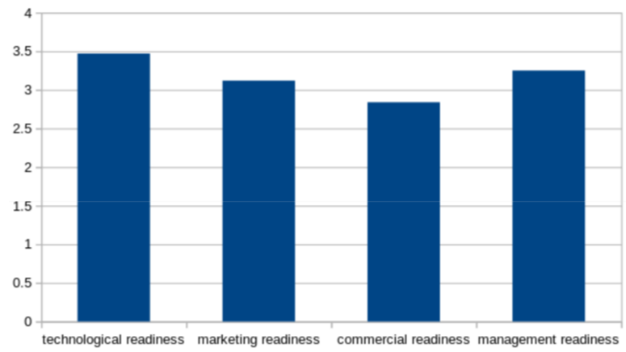

Figure 9. Results for HuggyBear

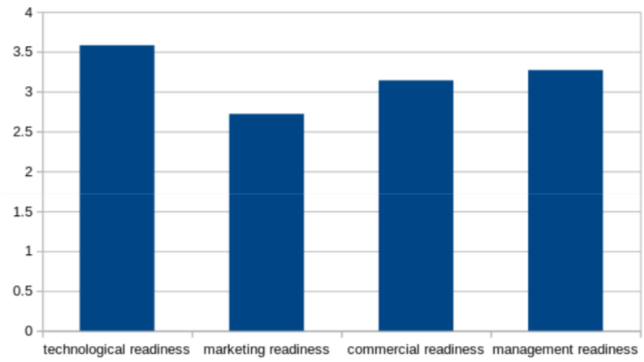

Figure 10. Results for UPets

The findings indicate that leveraging TRIZ principles could be beneficial for enhancing the development of each project. For the SmartBuggy, which currently faces deficiencies in technological readiness, with a score of 2.88, applying TRIZ principles such as 1, 2, 3, 5, and 6 may prove instrumental in addressing these challenges effectively.

Similarly, for the HuggyBear project, where commercial readiness with a score of 2.84 is identified as the primary area needing improvement, employing TRIZ principles like 10, 11, 19, 24, and 25 could significantly bolster its market viability and operational effectiveness.

Moreover, in the case of the Upets project, which requires enhancement in marketing readiness (a score of 2.72), the application of TRIZ principles such as 1, 6, 15, 23, and 25 could facilitate the development of robust marketing strategies and improve overall market positioning.

By strategically applying these TRIZ principles tailored to each project's specific weaknesses, stakeholders can enhance their technological, commercial, and marketing readiness, thereby maximizing their potential for success in their respective markets.

Our ongoing research aims to precisely identify and explore the most suitable TRIZ principles for the SmartBuggy, HuggyBear, and Upets projects, along with detailing the methods for applying these principles effectively. The forthcoming paper will present our findings and recommendations based on this analysis. We anticipate that this focused approach will provide actionable insights into enhancing technological, commercial, and marketing readiness across these diverse projects.

5. CONCLUSIONS

The TRIZ methodology stands out as an effective tool for bolstering the success of innovative higher education projects. By meticulously assessing and enhancing technological, marketing, commercial, and management readiness, and strategically applying TRIZ principles, projects can reach higher levels of achievement. This dual approach not only benefits the projects themselves but also enriches the educational process, better preparing students for the dynamic challenges they will face in the modern world.

The experiment conducted at the University of Petrosani underscores the significance of evaluating various readiness dimensions in university-led innovative projects. By understanding technological, marketing, commercial, and management readiness, weak areas can be pinpointed and addressed using TRIZ principles. This method not only gears projects up for real-world challenges but also heightens their innovative potential, paving the way for successful implementation and commercialization.

The next step is to apply TRIZ principles to these identified weak areas. TRIZ, a problem-solving methodology that harnesses patterns of innovation and creativity, provides systematic approaches to surmount technical and managerial challenges. By incorporating TRIZ, the goal is to boost the projects' readiness across all dimensions, fostering innovation and significantly increasing their chances of success.

The integration of TRIZ in higher education not only prepares projects for market challenges but also enriches the learning experience for students. It equips them with advanced problem-solving skills and innovative thinking, essential for thriving in today's fast-paced world. This holistic approach ensures that innovative projects are not only feasible but also robust, impactful, and ready for successful commercialization.

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This article was reviewed and accepted for presentation and publication within the 11th edition of the International Multidisciplinary Symposium „UNIVERSITARIA SIMPRO 2024".