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Original Research Article

Developing Problem-Solving Competence for Primary School Students through Science Teaching Based on OTSM–TRIZ Theory

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Abstract: This paper focuses on studying the theoretical foundations and assessing the feasibility of applying the OTSM–TRIZ theory to develop problem-solving competence for primary school students through Science teaching. Based on a review of relevant literature, the study clarifies the nature of the OTSM–TRIZ theory, the role of problem-solving competence in the 2018 General Education Curriculum, and the potential for integrating OTSM–TRIZ principles into primary school Science instruction. To evaluate its practical feasibility, the research team conducted a survey with 139 primary school teachers using a five-point Likert scale. The results show that most teachers highly appreciate the relevance and potential effectiveness of OTSM–TRIZ, while also noting some challenges related to professional expertise and implementation conditions. From these findings, the paper proposes directions to support the application of this theory in educational practice.

Keywords: Competence, Problem-Solving Competence, Primary School Students, Science Subject, OTSM–TRIZ Theory.

I. INTRODUCTION

The Science subject in the primary education curriculum plays a particularly important role in the 2018 General Education Curriculum, contributing to the development of various student competencies, with a special emphasis on fostering logical thinking, creativity, and problem-solving skills. With its integrative nature, real-life relevance, and high practical applicability, Science provides favorable conditions for organizing exploratory and experiential learning activities, thereby fostering the comprehensive development of problem-solving competence. Students are introduced to natural phenomena, health issues, environmental concerns, and technology, through which they learn to observe, analyze, pose questions, make predictions, conduct experiments, and evaluate results—this forms the logical cycle of the problem-solving process.

Among various theories and creative approaches aimed at enhancing students' problem-solving competence, the OTSM–TRIZ theory (General Theory of Powerful Thinking – Theory of Inventive Problem Solving) stands out as a breakthrough method. Originating from the field of technical problem-solving, OTSM–TRIZ has been developed and widely applied in education in countries such as Russia, France, South Korea, and Japan. The theory provides a powerful set of thinking tools such as the Multi-Screen Model (MSM), Function System Analysis (FSA), and contradiction analysis, enabling learners to perceive problems systematically, identify core contradictions, and develop creative solutions that eliminate contradictions rather than compromise. Domestic studies have initially confirmed the feasibility and effectiveness of OTSM–TRIZ in developing systematic thinking and problem-solving competence for primary school students through Science education and STEM topics.

This study contributes to building a theoretical foundation for developing problem-solving competence in primary school students, explaining the OTSM–TRIZ theory, and exploring its application in fostering such competence through Science teaching.

II. LITERATURE REVIEW

2.1. Theoretical Issues of Problem-Solving Competence and OTSM–TRIZ Theory

Problem-solving competence (PSC) is one of the core competencies emphasized in modern education programs. According to the OECD (2019), PSC is the ability to mobilize, integrate, and apply knowledge, skills, experiences, and personal values to address new, complex, and unsolved situations, especially in the context of a rapidly changing society. Ennis (1997) stated that problem-solving is a process of logical and critical thinking, requiring learners not only to possess

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foundational knowledge but also to be capable of analyzing situations, making reasoned inferences, and reaching appropriate decisions. Similarly, Perkins, Jay, and Tishman (1993) emphasized that PSC is not merely reacting to difficulties, but rather involves identifying problems, planning actions, and evaluating the effectiveness of solutions through a structured thinking process. PSC can be understood as an individual's ability to recognize, analyze, and propose effective solutions to problematic situations in learning and daily life. Perkins, Jay, and Tishman (1993) asserted that developing PSC must be associated with organizing exploratory, creative, and practically oriented learning activities—where students are given opportunities to directly face and interact with open-ended problems.

The structure of PSC is commonly described through the following elements: (1) identifying and recognizing the problem; (2) analyzing causes and context; (3) proposing options and selecting the optimal solution; (4) implementing the solution; and (5) evaluating the results. According to Nguyen Thi Thai (2014), these steps should be integrated into specific teaching activities, linked to curriculum content and real-life student contexts. Developing PSC in primary school students can be effectively achieved through active, student-centered learning activities. Designing real-world problem-based scenarios and applying active learning models such as Project-Based Learning, Inquiry-Based Learning, or Problem-Based Learning (PBL) are considered optimal methods. According to Jonassen (2000), PSC includes three main components: (1) the ability to identify problems and define objectives; (2) the ability to reason and process information to select appropriate solutions; and (3) the ability to evaluate, adjust, and reflect on outcomes. This approach emphasizes that PSC is not just about directly responding to situations but is a cyclical process of critical thinking and self-regulation.

The OTSM–TRIZ theory—an extension of TRIZ initiated by Altshuller—was developed by Khomenko (2009) and applied in education to help students develop systems thinking and non-standard problem-solving competence. Tools such as the Multi-Screen Model (MSM), Function System Analysis (FSA), and contradiction-solving techniques in OTSM–TRIZ can be transformed into active learning activities for students, particularly in Science.

Studies have demonstrated the feasibility and effectiveness of this method. Nguyen Thi Hong (2022) affirmed that using OTSM–TRIZ thinking tools enables students to approach problems systematically and form creative solutions. Anh, Nguyen Thi Lan (2020) observed significant improvements in students' creative thinking and PSC through TRIZ-integrated STEM activities. Additionally, Tran Thi Phuong Dung and colleagues (2023, 2024) showed that organizing Science lessons with STEM approaches, such as topics like "Sound" and "Smart Refrigerator," helped students identify problems, propose and evaluate solutions—clearly reflecting the components of PSC.

The OTSM–TRIZ theory is an expansion and development of TRIZ—the Theory of Inventive Problem Solving—initiated by Genrich Altshuller in the 1940s in the Soviet Union. Initially designed for solving technical problems in industrial production, TRIZ was further developed by researchers like Khomenko into OTSM (General Theory of Powerful Thinking), an interdisciplinary theoretical framework with broad applicability in education, particularly in fostering systems thinking and problem-solving competence among school students.

2.2. Methods for Applying and Implementing OTSM–TRIZ in Teaching

The application of OTSM–TRIZ in education has been implemented in many countries such as Russia, France, Latvia, South Korea, and Japan. This research direction focuses on transferring thinking tools and models from engineering to education in order to enhance students' creative and problem-solving abilities. In France, Cavallucci and Khomenko (2015) developed the Problem-Centered Education (PCE) model, in which OTSM–TRIZ is used as a "meta-subject toolkit" to support students in approaching unconventional learning problems through system analysis, functional analysis, and contradiction modeling. In Latvia, the research team of Sokol, Jonina, and Lasevich developed the concept of "inventive thinking," affirming that OTSM–TRIZ plays a foundational role in developing creative competence. In particular, the ability to detect and model contradictions is considered central to the structure of students' problem-solving competence.

For primary school students, the experimental program "Thoughtivity for Kids," implemented by Khomenko and Sidorchuk (2006), provides simplified thinking tools based on OTSM–TRIZ through games, familiar situations, and concepts such as "goal – tool – object," and "simple contradictions," aimed at developing children's logical and flexible thinking. Nguyen Thi Lan Anh (2020) also affirmed the role of TRIZ in developing creative thinking and problem-solving competence through STEM topics in primary education. Students not only propose solutions but also evaluate, improve, and choose optimal options. Tran Thi Phuong Dung and colleagues (2023, 2024) applied this theory in practice through STEM lessons such as "Sound" and "Smart Refrigerator," aiming to enhance the ability of 4th-grade students to identify problems, propose, and evaluate solutions.

However, to effectively implement OTSM–TRIZ in primary education in Vietnam, further experimental studies and instructional materials tailored to the psychological and cognitive characteristics of young learners are needed, as well as teacher training in

systems thinking and OTSM–TRIZ tools. Applying OTSM–TRIZ in primary education helps students: Form goal-oriented thinking habits, with the ability to clearly define objectives in problem-solving; Strengthen system analysis skills and understand the relationships between elements of phenomena or objects; Identify contradictions in real-life learning situations—an essential skill that triggers the need for problem-solving; Apply creative tools and principles to find feasible and flexible solutions; Reflect and improve solutions, thereby developing critical thinking and evaluative skills.

2.3. The Role of the Science Subject in Developing Problem-Solving Competence (PSC)

The Science subject in the primary education curriculum not only provides foundational scientific knowledge but also plays an essential role in forming and developing students' problem-solving competence (PSC). It is one of the subjects that offers many opportunities for students to engage with real-life situations, practice analytical and synthetic thinking, and apply knowledge to concrete actions, thereby fostering their ability to solve diverse problems related to everyday life.

In the field of Natural and Social Sciences education and the primary Science subject, various studies have been conducted: Nguyen Thi Tuong Vi (2011, 2010) designed and used software to teach the topic *Humans and Health* in Grade 3; Do Huong Tra, Nguyen Thi Bich Loan, Nguyen Thi Mai (2001) and Nguyen Vinh Hien (2011) focused on applying the "Hands-on" (La main à la pâte) approach in Science teaching; Luong Viet Thai (2006) studied teaching Physics content in primary Science using constructivist theory; Nguyen Tuyet Nga and Nguyen Thi Thanh Tra (2010) applied project-based learning strategies to Grade 3 Natural and Social Sciences; Nguyen Tuyet Nga (1999) focused on discovery-oriented learning in teaching Geography in Grades 4 and 5; Bui Phuong Nga, Luong Thi Van, Nguyen Thi Tuong Loan, and Doan Van Hung (2006) studied teaching methods for primary Natural and Social Sciences; Vo Trung Minh (2015) addressed environmental education in primary schools through children's experiential learning in Science; Tran Viet Luu (1999) researched methods for forming historical concepts in primary students; Nguyen Thi Huong (2002) examined combining observation and discussion in teaching Natural and Social Sciences; Duong Giang Thien Huong (2007) worked on creating problem situations through multimedia in Grade 5 Science; Trinh Thi Huong (2013) guided learning based on the "Hands-on" method; Nguyen Thi Thu Hang (2013) studied life skills education for ethnic minority students in the northern mountainous areas through Science teaching.

These studies, though employing various terms—such as discovery, self-discovery, inquiry, experience, "Hands-on," lesson study—and using different techniques like observation, discussion, exercises, projects, themes, visual aids, and cognitive engagement, are fundamentally constructivist in orientation. Many researchers affirm that the Science subject not only imparts knowledge but also serves as an effective medium for developing higher-order thinking skills such as problem-solving, critical thinking, creativity, and collaboration. Thanks to its integrated and practical nature, Science offers favorable conditions for organizing exploratory, experiential, and knowledge-application activities—key elements for developing PSC in primary students.

According to the Ministry of Education and Training (2018), the Science subject is built on an integrative approach aimed at developing learners' competencies. Natural science competence includes: the ability to explore the natural world, apply knowledge to real life, and especially, the ability to solve problems. During learning, students are frequently placed in problematic situations—such as natural phenomena, health, environmental, and technological issues—that require them to observe, analyze, pose questions, make predictions, experiment, and evaluate outcomes. These steps form the logical cycle of the problem-solving process. One of the prominent roles of the Science subject is to develop the ability to identify and define problems—the first and critical step in problem-solving. Through natural phenomena, students learn to recognize contradictions, anomalies, or unknowns, thus forming cognitive needs and learning motivation. The competence to analyze and model problems is also developed when students organize information, compare data, and use diagrams, tables, or visual representations to clarify the nature of objects and phenomena.

Additionally, Science provides an environment conducive to the development of critical and creative thinking—two essential components in solving complex problems. In topics such as *Sound*, *Smart Refrigerator*, or *Waste Recycling*, students are encouraged to propose various solutions, experiment with ideas, accept failure, and revise their actions. This is a highly practical process of developing PSC that combines theory and application, individual and group work, cognition and action. Science is also a suitable context for integrating modern educational approaches such as project-based learning, STEM education, design thinking, and creative thinking theories like OTSM–TRIZ. All these methods place the student at the center, creating opportunities for them to actively face challenges and build solutions in a logical, flexible, and effective manner.

III. RESEARCH METHODS

The research involved reviewing philosophical, sociological, technical, psychological, and educational literature related to the research topic; conducting theoretical analysis (retrospective and comparative) and synthesizing existing studies on the development of PSC

in students; modeling and forecasting; and conceptual analysis.

The study also involved designing a Likert-scale-based questionnaire to survey primary school teachers on the feasibility of applying OTSM–TRIZ theory to develop students' problem-solving competence through Science teaching.

IV. RESEARCH RESULTS

4.1. The relationship between OTSM–TRIZ and problem-solving competence (PSC)

The OTSM–TRIZ theory and problem-solving competence (PSC) are closely interconnected, with OTSM–TRIZ considered an effective system of tools and methods to develop PSC in learners in general, and primary students in particular. Integrating the principles and thinking processes of OTSM–TRIZ into teaching enables students to approach problems in a scientific, systematic, and creative manner—key components of PSC in modern education. In OTSM–TRIZ, problem-solving is not merely about providing an answer to a specific situation; it is a comprehensive thinking process that includes: defining the thinking task, modeling systems and functions, identifying contradictions, selecting and evaluating solutions. These steps align with the structure of PSC as identified in numerous educational studies: from problem identification and cause analysis to solution development and evaluation.

Khomenko (2009) emphasized that powerful thinking—the goal of OTSM—is the ability to think in an organized, purposeful, and efficient manner in uncertain situations. This is the clearest manifestation of PSC in the real world, where problems are often complex, ambiguous, and have no single correct answer. Thus, OTSM–TRIZ can be seen as a foundational thinking tool and environment for the sustainable development of PSC. In primary education, students typically encounter simple, real-life problems. By engaging with OTSM–TRIZ thinking, they gradually learn to define clear thinking goals, analyze system structures, identify and resolve contradictions, and thereby construct logical and creative solutions. This not only helps students solve learning-related problems but also improves their adaptability and ability to apply knowledge in real life—one of the key goals of 21st-century education.

The relationship between OTSM–TRIZ and PSC is bidirectional: OTSM–TRIZ provides the theoretical foundation and operational tools for developing PSC, while the implementation of OTSM–TRIZ in education is an effective way to realize competency-based educational goals, especially the development of PSC in the new general education curriculum.

4.2. Developing Problem-Solving Competence in Primary Students through Science Teaching

The Science subject in the primary education curriculum is designed to provide students with foundational understanding of the natural world, the human body, living environments, and the relationship between humans and nature. It is an integrated subject, derived from natural science fields such as Biology, Physics, Chemistry, and Environmental Science. The main stages of PSC development based on OTSM–TRIZ include:

Problem Elicitation and Identification:

Teachers create situations with contradictions or surprises that pose scientific problems beyond students' existing knowledge. Students are encouraged to ask questions, observe, and reflect on "unusual" natural phenomena—this corresponds to the "problem identification" step in PSC structure.

***Problem Modeling – Information Systematization*:**

Students use the Multi-Screen Modeling (MSM) tool to examine problems across multiple levels (system – subsystem – supersystem) and timeframes (past – present – future), helping them develop analysis and generalization skills.

System and Function Analysis:

With the support of Function and System Analysis (FSA), students identify components, functions, and relationships within systems, reasoning about causes, conditions, and influencing factors.

Contradiction Identification and Thinking Task Definition:

Students detect key contradictions in the system (e.g., wanting to keep food fresh without using a refrigerator). This provides the basis for defining problem-solving objectives.

Solution Proposal and Selection:

Based on TRIZ's inventive principles, students are encouraged to use methods such as transformation, combination, and separation to find new solutions, which they then evaluate and select.

Testing and Reflection:

Students test their solutions (via experiments, models, discussions), gain experience, make adjustments, and self-assess effectiveness. This final stage fosters critical and reflective thinking.

4.3. Methods for Developing PSC

Shift Roles from Knowledge Transmitters to Facilitators:

Instead of delivering ready-made knowledge, teachers should design problem-based learning scenarios that prompt students to discover and construct knowledge through active engagement.

***Design Lessons Connected to Real-Life Situations*:**

For example, in the topic *Sound*, a question like "Why does the sound change when a train approaches and when it leaves?" can stimulate observation, analysis, and explanation.

Create Opportunities for Group Work, Discussion, and Debate:

This allows students to collaborate, analyze problems from multiple perspectives, and propose diverse solutions.

Guide Students in Using Modern Thinking Tools:

OTSM–TRIZ tools such as MSM, function analysis, and contradiction identification help students approach problems systematically and develop deeper thinking skills.

4.4. Strategies to Improve Science Teaching for PSC Development

Apply Active Learning Models*:*

Inquiry-Based Learning: Encourage students to ask questions and seek answers through experiments.

Problem-Based Learning: Present students with real-world problems and guide them to resolve them.

Project-Based Learning: Involve students in practical projects like building a smart refrigerator model or a mini wastewater treatment station.

Integrate STEM Education and OTSM–TRIZ Theory*:*

STEM connects interdisciplinary knowledge (Science, Technology, Engineering, Math) to solve real-world problems; OTSM–TRIZ offers powerful thinking tools that help students identify contradictions, analyze functions, and generate creative solutions.

Use Formative Assessment, Not Just Summative*:*

Track students' progress through problem identification, solution development, testing, and adjustment; Use diverse assessment tools such as observation checklists and rubrics based on the PSC criteria from the Ministry of Education and Training.

Enhance Teachers' Pedagogical Competencies*:* Teachers should be trained in competency-based teaching methods, using OTSM–TRIZ tools, and designing STEM-based lessons.

Current Research on PSC Development in Primary Education Focuses on Three Main Areas:

***Concept, Structure, and Role of PSC*:**

Many studies have clarified the definition of PSC, its components (problem identification, analysis, proposing/selecting solutions, implementation, evaluation/reflection), and its essential role in educational innovation—particularly in equipping students with adaptability and other core competencies such as critical thinking, self-directed learning, and collaboration.

***Application of OTSM–TRIZ in Teaching*:**

This research direction highlights the potential of OTSM–TRIZ as a powerful thinking tool for developing systems thinking and unconventional problem-solving. International and initial domestic studies have shown the effectiveness of integrating OTSM–TRIZ tools (e.g., MSM, function analysis, contradiction resolution) into education, particularly in inquiry-based and creative learning activities.

***PSC Development through Science Education in Primary Schools*:**

Science is seen as an ideal environment for developing PSC due to its integrative nature, real-life relevance, and capacity to create problem-based learning situations. Studies have proposed various strategies for enhancing Science instruction to support PSC, including the use of active learning models (inquiry, problem-based, project-based), integration of STEM and OTSM–TRIZ, process-based assessment, and professional development for teachers.

4.5. Survey on the feasibility of applying OTSM–TRIZ to develop problem-solving competence in primary students through science teaching

The study conducted a survey of 139 primary school teachers using a Likert scale, and the results are as follows:

Rating Level	Description	Percentage (%)	Feasibility Interpretation
5	Strongly Agree	81% – 100%	Very High
4	Agree	61% – 80%	High
3	Neutral / No Opinion	41% – 60%	Moderate
2	Disagree	21% – 40%	Low
1	Strongly Disagree	0% – 20%	Very Low

The survey results from 139 primary school teachers indicate a high level of agreement regarding the feasibility of applying OTSM–TRIZ theory in Science teaching to develop students' problem-solving competence. Specifically, the proportion of teachers selecting "Agree" and "Strongly Agree" ranged from 65% to 85% across most survey items, reflecting positive consensus and confidence in the method's effectiveness. Many teachers believe that OTSM–TRIZ can enhance students' creative thinking, critical thinking, and situational analysis skills. However, some expressed concerns about practical implementation conditions, particularly in terms of professional competency and infrastructure. Overall, the results suggest that applying

OTSM–TRIZ is feasible and should be supported through appropriate training programs and resource investment.

V. CONCLUSION

From both theoretical research and the feasibility survey results, it can be concluded that applying the OTSM–TRIZ theory in primary Science teaching to develop students' problem-solving competence is entirely feasible and has received strong support from the teaching community. Most teachers highly appreciate the alignment of OTSM–TRIZ with modern educational goals, especially in fostering creative and systems thinking in students. However, for effective implementation, professional support, instructional materials, and adequate infrastructure are essential. Therefore, organizing training workshops and professional development programs on OTSM–TRIZ for teachers, along with the development of learning resources tailored to primary students, are critical directions for the near future. These efforts will contribute to innovating teaching methods and improving the quality of primary education.

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