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Challenges in teaching math through problem-solving: reflections on potential actions to support primary school teachers

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Abstract

For decades, problem-solving has played multiple roles in mathematics education. Among these, teaching through problem solving (TTPS) is widely recognized for promoting authentic mathematical exploration and conceptual understanding. Despite its benefits, TTPS remains rarely implemented in primary classrooms. Why is this the case? What challenges do teachers face, and how can they be addressed? This paper draws on two complementary research projects. The first, involving pedagogical advisors, highlights systemic barriers to TTPS. The second, part of a research and development initiative, focuses on primary teachers' experiences using TTPS to introduce new mathematical concepts. Data include transcripts from four semi-structured interviews (grades 2–6) and 44 teacher questionnaires. The analysis of quantitative and qualitative data highlighted common challenges experienced by teachers in all grades. A key finding was that facilitating the discussion phase proved to be the most difficult aspect for them.Together, the results provide a nuanced understanding of the difficulties teachers encounter and inform practical recommendations to support the integration of TTPS in primary mathematics classrooms.

Keywords: mathematics, teaching approach, problem-solving, challenges, primary school teachers

1. Introduction

Although it is widely accepted that mathematics teaching should prioritize students' reasoning and understanding, classroom practices in primary schools do not always reflect this principle. As Seeley (2016) emphasizes, for students to develop mathematical thinking, they need to engage regularly in routines that focus on discussing their thought processes. To support students in making sense of their mathematical learning, Seeley (2016) further explains that teachers must first adapt their instructional approaches.

While it is still important to target the *what* of mathematics teaching - the concepts, computation, and problem-solving skills we identify through standards and goals - helping

> students make sense of what they're learning and helping them develop as flexible problem solvers also calls for a shift in terms of *how* we teach (Seeley, 2016, p. 29).

Among the recognized approaches to genuinely encourage students to think and give meaning to their learning in mathematics is *teaching through problem-solving (TTPS)*. This approach guides students into real mathematical exploration, where they are active and engaged, allowing them to build their knowledge rather than simply receiving mathematical rules and procedures passively (Cai, 2003; Takahashi, 2021; Van de Walle, 2003). The foundation of this approach, along with its definition and recognized benefits, has been well documented in scientific and governmental publications over the past decades (DeCaro & Rittle-Johnson, 2012; Kapur, 2014; Ministry of Education and Higher Education, 2019; Schroeder & Lester, 1989; Takahashi, 2021; Van de Walle, 2003). This paper examines the implementation of this approach in primary school classrooms and the challenges that primary teachers encounter when adopting it with their students. Identifying these challenges constitutes an initial exploratory step to gain deeper insight into the experiences of teachers using this approach, with the aim of suggesting possible solutions to support both those who are already using TTPS and those who wish to do so.

1.1 How to Conduct a Lesson Using TTPS?

The implementation of TTPS has been addressed in various pedagogical publications and governmental documents, which generally outline a three-phase progression (Kobett et al., 2021; Markworth et al., 2016; Ministry of Education of Ontario, 2006; Seeley, 2016). Drawing on these sources, a model consisting of three cyclical and iterative phases has been proposed (Goulet et al., in press): exploration, discussion, and synthesis.

The exploration phase is when students actively engage with the problem, allowing for deep involvement in the process of finding solutions. Problems are often introduced through a contextual scenario to help situate the task, but this is not essential—a well-designed, purely mathematical problem can be just as effective. Table 1 presents two examples intended for second-grade students (7–8 years old): one is purely mathematical, while the other is framed within a contextual scenario.

Table 1: Examples of Problems in Different Contexts: Purely Mathematical and Situational

Purely Mathematical Problem	**Situational Problem**
Using the digits 0 through 9 at most one time each, place a digit in each box to make a two-digit number that has a value between given numbers. ☐☐, 35, ☐☐, 41, ☐☐, ☐☐, 88, ☐☐, 107 https://sites.google.com/a/ocdsb.ca/emathphan/	The teacher acts and pretends that her new bracelet has broken. She holds the bracelet in her hands, which now only has 9 beads. She remembers that the bracelet originally contained 27 beads. She wonders how many beads have fallen.  www.reverbereeducation.com

Students may explore the problem individually, in pairs, in small groups, or as a whole class. We personally advocate for always including a moment of collaboration among students—either at the start of the exploration phase or following a period of individual work. During this phase, the teacher takes on the role of observer and guide, noting the strategies used by students and asking prompting questions to support those who may be running out of ideas.

The discussion phase lies at the heart of the approach. It is during this moment that the teacher acts as a mediator, supporting students not only in sharing the outcomes of their work and reflections but also in examining the relationships between their own ideas and those of others. These discussions foster a constructive and productive exchange of ideas, allowing students to deepen their understanding of the problem as well as the underlying concepts and processes.

Finally, the synthesis phase, as its name suggests, serves as a summary of the activity. During this phase, the teacher connects the ideas and solutions proposed by the students to the new learning objectives targeted through the problem. It is important to keep in mind that, although it is the teacher's role to *make mathematics visible* during this phase, they do so based on the discussions that took place in the previous phase. Therefore, the students have made significant contributions to it.

It is important to note that these phases represent one possible model for implementing TTPS in the classroom. Moreover, while any pedagogical model requires a starting point, the phases presented here are not intended to be followed in a rigid, linear sequence. Movement between them is often dynamic, depending on the nature of the problem and students' needs. Accordingly, the term *phase* is used rather than *step*. TTPS should be viewed as a cyclical and iterative process that requires ongoing adaptation to the learning context.

The three phases outlined above stand in contrast to more traditional forms of instruction, in which the teacher introduces new mathematical concepts first, followed by student practice through problem-solving. In TTPS, this sequence is reversed — students encounter and explore concepts through problem-solving. This inversion prompts important questions about how teachers perceive and experience this approach.

1.2 How do Teachers Perceive TTPS?

Based on a self-administered online questionnaire, 137 primary school teachers shared their views on TTPS by indicating their level of agreement with various statements (Forest, forthcoming). Specifically, 57.7% of respondents agreed with the following statement:

> *Mathematical problem-solving in primary school should serve to develop mathematical knowledge—that is, to learn new mathematical concepts and processes.*

Although this agreement rate is relatively high, it is noteworthy that nearly 40% of teachers disagreed with the statement. Another key finding reveals that few teachers associate their own practice with TTPS. Among the 137 respondents, only 25 (18.2%) reported using problem-solving activities with the aim of developing knowledge and introducing new mathematical concepts or processes.

Overall, while more than half of the teachers in Forest's sample expressed support for TTPS, fewer than 20% appear to implement it in their classrooms. This gap raises important questions about why TTPS remains so infrequently used in primary settings—a question explored in a recent research project conducted with mathematics education consultants in the province of Quebec (Goulet et al., in press).

1.3 The Main Challenges to Implementing a TTPS Approach

Goulet et al. (in press) conducted a study aimed at identifying the key challenges of implementing a TTPS approach in primary school classrooms, as perceived by educational consultants who support teachers. The 55 consultants who participated in the first quantitative phase shared their views on the three main challenges to implementing TTPS based on their experience. Through a self-administered online questionnaire, they were presented with a list of 11 challenges. This list was developed from a review of the scientific literature, consultation with a representative from regional support and expertise services, and a pre-testing phase involving three educational consultants. Respondents could select from the proposed challenges and had the option to specify additional challenges by choosing "Other."

Table 2: Main Challenges Reported by Educational Consultants (n = 55) (Goulet et al., in press)

Challenges	**Frequency**	**Percentage**
The insecurity that may be associated with leading an activity in a TTPS context	**29**	**52.7**
The current knowledge of teachers related to this approach	**24**	**43.6**
The assessment of mathematical skills in its current form in the Quebec Mathematic curriculum	**21**	**38.2**

The data in Table 2 reveal that the main challenge for teachers, as perceived by educational consultants, is the insecurity associated with leading activities. Consequently, classroom facilitation by teachers appears to be a barrier to the use of this approach.

As noted earlier, a TTPS approach can be understood as occurring in various phases. Therefore, it is crucial to explore how this insecurity manifests concretely when teachers lead an activity. Are certain phases more prone to insecurity than others? If so, why? These emerging questions form the foundation of the current research project.

2. Materials and Methods

To achieve our objectives, a research-development design was implemented (Bergeron & Rousseau, 2021). This design is characterized by a dual objective: a development objective—through the creation of a product—and a research objective—through the production of scientific knowledge. The development objective involved creating a reference tool on TTPS in primary schools (Goulet & Forest, 2024) to support teachers in implementing this approach. The tool takes the form of a diagram designed to explain the *what, why,* and *how* of TTPS (see Appendix). However, this paper focuses exclusively on the research objective, which is to better understand the challenges primary school teachers perceive when leading a mathematics activity based on TTPS.

The research objective was addressed through the product improvement phase (Bergeron et al., 2021), during which three empirical testing cycles were conducted. In these testing cycles, our product was "submitted to a small group of target users in a real-world usage situation" (Harvey & Loiselle, 2009, as cited in Bergeron et al., 2021, p. 37). Specifically, the research process employed both semi-structured interviews and a questionnaire, aligning with a mixed methods approach. As Creswell & Plano Clark (2018) point out, combining quantitative and qualitative methods enhances the understanding of the phenomena under study by integrating statistical data analysis with a deeper interpretation of their meaning.

2.1 Participants

A non-probability convenience sampling method (Fortin & Gagnon, 2022) was used to recruit participants for our three testing cycles. The sole inclusion criterion was being a primary school teacher. The main limitation associated with this type of sampling lies in the fact that volunteer participants may possess specific characteristics that make them unrepresentative of the target population—for instance, in this case, a greater willingness to approach problem-solving differently—which makes it impossible to generalize the results (Beaud, 2021). In our study, however, the objective was to gain a deeper understanding of the challenges perceived by primary school teachers when leading a mathematics activity based on TTPS, with the aim of identifying potential solutions. Generalization was therefore not an intended goal.

The first two cycles involved four teachers from Quebec—two per cycle—while the third cycle included 44 teachers from Nice, France. Thus, the total sample comprised 48 primary school teachers.

For cycles 1 and 2, Table 3 provides descriptive statistics outlining key sample characteristics, including the distribution of teachers by grade level and years of teaching experience. Table 4 presents the same information for the third testing cycle.

Table 3: Descriptive Statistics for Participants in the First Two Testing Cycles (n = 4)

	n
Grade Level Taught	
2nd grade (7-8 years)	1
4th grade (9-10 years)	2
6th grade (11-12 years)	1
Teaching Experience (All Grades)	
11 to 15 years	1
16 to 20 years	0
21 to 25 years	2
More than 25 years	1

Table 4: Descriptive Statistics for Participants in the Third Testing Cycle (n = 44)

	n	%
Grade Level Taught[1]		
CP (6-7 years)	21	38.9
CE1 (7-8 years)	16	29.6
CE2 (8-9 years)	15	27.8
CM1 (9-10 years)	2	3.7
Teaching Experience (All Grades)		
Experience Range	**n**	**%**
5 years or less	1	2.3
6 to 10 years	1	2.3
11 to 15 years	4	9.1
16 to 20 years	6	13.6
21 to 25 years	10	22.7
More than 25 years	22	50.0
Teaching experience (in the current grade level)		
5 years or less	16	36.4
6 to 10 years	8	18.2
11 to 15 years	9	20.4
16 to 20 years	7	15.9
21 to 25 years	4	9.1
More than 25 years	0	0

[1] The total exceeds 44 because some teachers work in multi-grade classrooms.

2.2 Procedure and Data Collection

For each testing cycle, teachers were first asked to facilitate a TTPS activity designed by the research team. Different activities were offered based on the students' age and mathematical knowledge. The teachers conducted the activities in their own classrooms, without cameras and without the presence of a research team member. They were informed that they would later report on the challenges they encountered while leading the activity. Data on these challenges were collected a few days afterward, through interviews for the first two testing cycles and a questionnaire for the third.

For the first two testing cycles, the research team developed a semi-structured individual interview guide tailored to the study's needs, aiming to address both development and research objectives. In addition to questions collecting sociological data, the guide includes six questions, two of which specifically target our research objective:

- Overall, how did the activity go with your students?
- What challenges did you face in leading the activity?

For each of these questions, sub-questions prompted teachers to discuss the challenges encountered in relation to the three facilitation phases: exploration, discussion, and synthesis. The other four questions focused on collecting data related to the development objective.

For the third testing cycle, the research team created an online self-administered questionnaire to again gather data on the challenges teachers faced, this time specifically to assess whether any facilitation phase posed more difficulties than others. The questionnaire included 14 questions divided into three themes: (1) sociological data (5 questions), (2) the TTPS activity as experienced in the classroom (6 questions), and (3) challenges related to the activity (3 questions). The results presented in the following section focus on the third theme and are drawn from three specific questions—one multiple-choice and two open-ended.

- What challenges did you face during the TTPS activity? (Check all that apply and/or provide an additional answer.)
    - Challenge(s) related to the exploration phase
    - Challenge(s) related to the discussion phase
    - Challenge(s) related to the synthesis phase
    - I prefer not to answer
    - Other: __________

- Briefly explain the challenge(s) you experienced.

- Do you have any other comments or suggestions regarding the TTPS activity you tested?

2.3 Data Analysis

The three testing cycles were conducted during the same school year, between November and March. For the first two cycles, semi-structured individual interviews lasting between 34 and 56 minutes were conducted via videoconference by the lead researcher. The audio recordings were transcribed verbatim, followed by a content analysis. For the third cycle, the self-administered questionnaire was distributed online via Google Forms, and the responses were exported to Excel for descriptive analysis. Content analysis was also performed on the open-ended questions.

2.4 Ethical Considerations

This study was approved on September 21, 2023, by the Research Ethics Committee of the Université du Québec à Trois-Rivières (CER-23-301-07.16). For each cycle, teachers signed an information and consent form. For the first two cycles, teachers' consent was also reconfirmed orally at the beginning of each interview. All collected data were treated confidentially, and individual teacher results were never disclosed.

3. Results

The results will be presented according to the different testing cycles. Testing cycles 1 and 2 will be discussed together, as both are based on data collected from individual interviews. In contrast, the results from the third testing cycle will be addressed separately, as they stem from quantitative data collected via a questionnaire. Connections will then be drawn across all the collected data.

3.1 Results from the First Two Testing Cycles: Individual Interviews

3.1.1 Challenges during the Exploration Phase

The exploration phase—particularly when the teacher guides students in their search for solutions—proved challenging for two teachers. Teacher 2 noted that differentiated instruction becomes difficult when moving around the classroom during students' independent work: *"It takes more effort to manage multiple students at the same time, which can be more difficult [...] both in terms of differences in students' work pace and ensuring all their needs are met."*

Teacher 4 also highlighted the challenge of asking effective follow-up questions rather than simply steering students toward the expected solution.

3.1.2 Challenges during the Discussion Phase

According to the teachers interviewed, the discussion phase is the most challenging part of leading a TTPS activity. Three out of four teachers reported difficulties during this phase.

Teacher 1 noted that managing the classroom becomes harder during whole-class discussions when students take the floor. She explained that some students act more as spectators than active participants, raising questions about how to proceed: How can all students be engaged in the discussion? How can we ensure everyone participates actively, even those who do not speak?

Teachers 2 and 3 also highlighted a challenge related to facilitating the comparison of students' solution strategies. How can different solutions be presented most effectively? How should the order of presentation be structured to encourage constructive debate? Should all solutions be shared? These are some of the questions teachers face during this phase.

Teacher 2 pointed out that this challenge is even greater the first time an activity is conducted. It becomes easier when the activity is repeated with a different group, benefiting from experience gained previously.

For Teacher 3, student age adds difficulty. Her 7- and 8-year-olds each wanted their individual solutions presented, while she had hoped they would select a standout team solution. She realized that for her students, their individual solutions still hold great importance.

3.1.3 Challenges during the Synthesis Phase

The synthesis phase was identified as a challenge by only one teacher (T3). According to her, the difficulty lies in students' decreasing attention toward the end of the activity, which limits their ability to fully benefit from this moment of reflection on emerging knowledge.

More broadly, three teachers (T1, T2, and T3) recognized challenges in adopting a problem-solving–based teaching approach. Teacher 3 believes that overcoming these challenges requires adequate support:

> *Honestly, I think mathematics can be very unsettling for some people. Following a textbook or a teaching guide [...] feels more reassuring. [...] To help teachers develop this [problem-solving approach], they need support—whether within a school team, with a pedagogical advisor, a researcher in the classroom, or through training. I believe this is much more effective than just reading documents, even if there are videos! For someone to transition from a [more traditional] practice to this approach, which is admittedly more destabilizing, they need to be guided and supported.*

Such support is crucial because, according to Teacher 1, this approach is "*one that teachers would benefit from using more [...] as it leads to more lasting learning*."

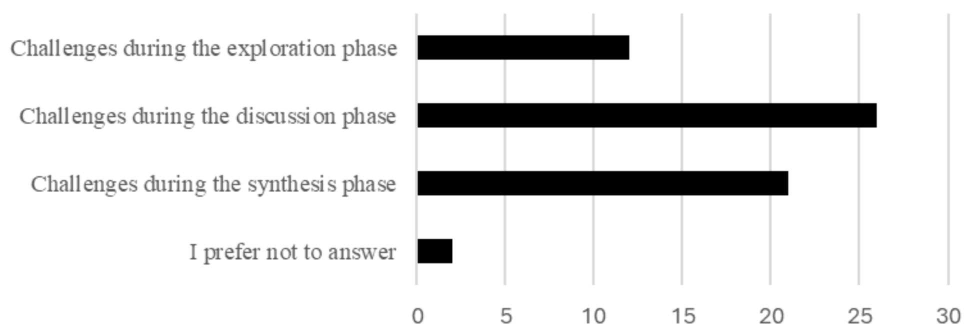
Finally, two teachers (T1 and T4) mentioned that they did not face major challenges in leading the activity, as they regularly facilitate similar ones. Teacher 4 emphasized that he often engages his students in mathematical discussions and problems that push them beyond their comfort zone—problems for which they do not immediately know the strategy to use and that allow for multiple solution methods. Experience with TTPS helps reduce potential challenges.

These insights align with those of Teacher 2, who noted that difficulties tend to decrease with experience.

3.2 Results from the Third Testing Cycle: Self-Administrated Questionnaire

According to the teachers who responded to the questionnaire, the discussion phase appears to be the most challenging when leading a TTPS activity. In fact, 59.1% of respondents (26/44) reported difficulties during this phase, compared to 27.3% (12/44) for the exploration phase and 47.7% (21/44) for the synthesis phase (see Figure 1).

Figure 1: Challenges Experienced According to Respondents (n = 44)



Analyzing responses to the open-ended questions provides a clearer identification of the challenges faced during each phase.

3.2.1 Challenges during the Exploration Phase

The challenges teachers faced during the exploration phase can be grouped into three categories: supporting students who do not understand the context, supporting students who do not understand the mathematical problem, and differentiating instruction—this last challenge was also mentioned by a teacher in an individual interview during a previous testing cycle. In the first two categories, the primary challenge is selecting appropriate questions to guide students back to solving the problem, a point also highlighted in the first two cycles. It is worth noting that all activities included situational problems, requiring students to understand the context, which explains the first category of challenge. One respondent commented: *"The first challenge was not to go off in all directions during the solution search. The students tested many hypotheses but sometimes strayed from the goal of the situation."*

3.2.2 Challenges during the Discussion Phase

For the discussion phase, reported challenges fall into two categories. The first relates to difficulties faced by students. Teachers noted challenges in understanding and responding to students' mathematical ideas, often because students struggle to express their thoughts clearly. They also highlighted difficulties managing collaborative work, as students may find it hard to collaborate effectively.

The second category concerns the approach itself, including analyzing students' methods and solutions, understanding and explaining errors, organizing the class discussion optimally (e.g., sorting, order of presentation), and maintaining students' attention. These challenges echo those mentioned by teachers in the first two testing cycles.

3.2.3 Challenges during the Synthesis Phase

Finally, for the synthesis phase, three challenges emerged: 1) allowing sufficient time for the institutionalization of mathematical knowledge; 2) making connections between students' solutions and the targeted mathematical concepts; and 3) maintaining students' attention. One respondent noted: *"The difficulty was conducting this activity in a short amount of time and ensuring that the students listened to others' reasoning, then collectively institutionalized the knowledge learned."*

Table 5 provides an overview of the challenges faced by respondents in the third testing cycle, organized by each phase of the TTPS approach.

Table 5: Key Challenges Encountered by Respondents of the Third Testing Cycle According to Each Phase

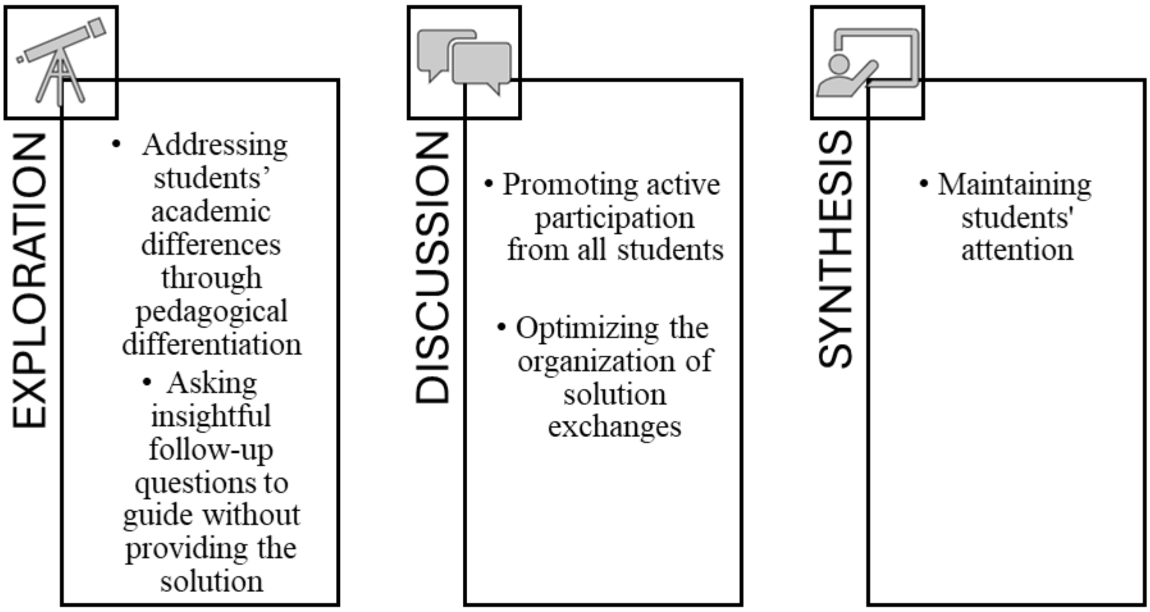
<table>
<tr><th colspan="2">Exploration Phase</th></tr>
<tr><td colspan="2">• Supporting students who misunderstand the context.
• Supporting students who misunderstand the mathematical problem.
• Ensuring pedagogical differentiation.</td></tr>
<tr><th colspan="2">Discussion Phase</th></tr>
<tr><td>Challenges Arising from Students' Difficulties</td><td>Challenges Inherent to the TTPS Approach</td></tr>
<tr><td>• Understanding and responding to students' mathematical ideas.
• Managing student collaboration.</td><td>• Analyzing students' proposed methods and solutions.
• Understanding and explaining students' errors.
• Organizing class discussions effectively (e.g., sorting, order of presentation).
• Maintaining students' attention.</td></tr>
<tr><th colspan="2">Synthesis Phase</th></tr>
<tr><td colspan="2">• Allowing sufficient time for the institutionalization of mathematical knowledge.
• Making connections between students' solutions and the targeted mathematical concepts.
• Maintaining students' attention.</td></tr>
</table>

3.2.4 Summary of the Three Testing Cycles

The analysis of both quantitative and qualitative data from the three cycles revealed common challenges faced by teachers across all groups. One major finding is that facilitating the discussion phase was the most challenging aspect for the teachers in our sample.

Teacher testimonies—both written and oral—helped identify the most frequently reported challenges in each phase. Figure 2 presents these key challenges, organized by phase.

Figure 2: Common Challenges Across the Three Testing Cycles by Phase



4. Discussion

The results obtained raise new questions, the answers to which could help teachers more effectively facilitate TTPS (Teaching Through Problem Solving) activities. To address the main challenges identified, four key questions will be explored in the following sections. These questions, along with proposed solutions, focus on the exploration and discussion phases of TTPS.

4.1 Exploration Phase: How Can We Support Students in Advancing Their Problem-Solving Process Without Explicitly Telling Them What To Do?

> Directing students to solve a problem in a certain way helps them get an answer. But they don't necessarily own those steps or procedures. The process, handed to them by their teacher, is disconnected from their understanding of the mathematics concept (SanGiovanni et al., 2020, p. 118).

This quote from SanGiovanni and colleagues (2020) underscores two types of responses available to teachers when students encounter confusion: the *Rescuing Answer*, which helps students reach a solution by guiding them toward a specific strategy or line of reasoning; and *Rescuing Thinking*, which aims instead to reignite the student's own thinking when they hit an impasse (SanGiovanni et al., 2020).

One initial lever to support teachers in adopting a *Rescuing Thinking* stance is effective time management. This simply means allowing students the necessary time to think, explore, and collaborate.

When it comes to reflection and exploration time, teachers should continually assess whether immediate intervention is necessary or if it would be more beneficial to wait. If teachers instinctively step in as soon as students say, "I don't understand" or "I don't know what to do," students may, over time, develop the habit of asking for help without first attempting anything themselves. It is often more beneficial to allow students the time to think and try before intervening. When intervention is appropriate, the teacher can pose open-ended questions that promote metacognition, such as: *"*What strategies have you tried already? How else could you represent the problem? What is something you know about the problem? Why are you stuck?" (SanGiovanni et al., 2020, p. 134).

It can also be helpful to prepare follow-up questions directly related to the specific problem at hand. By anticipating the difficulties students might encounter, the teacher can formulate questions that encourage deeper thinking rather than focusing solely on finding the correct answer.

Regarding collaboration time, Liljedahl (2024) emphasizes its importance and explains how a classroom dynamic centered on student collaboration fosters more effective knowledge transfer. This enables students to overcome obstacles and continue their work without relying solely on the teacher. Among the strategies he proposes to encourage knowledge transfer are sending a team member as a *scout* to observe another group's ideas and report back to their own team or engaging in discussions with members of another group to compare approaches or solutions.

These two examples illustrate that the exchange of ideas between groups can occur either silently (through observation) or verbally (through discussion). A third possibility is to have students continue another team's work by rotating between workspaces, attempting to understand the approach initiated by others and building upon it. As SanGiovanni and colleagues (2020) similarly argue, *"*there is a difference between directly telling students something and having them observe that same thing and 'acquire' it on their own*"* (p. 141). These various options offer students meaningful opportunities to sustain their thinking and advance their problem-solving process—without the teacher needing to explicitly tell them what to do or how to do it.

4.2 Exploration Phase: How Can We Adress Differences in Students' Understanding, Whether of the Context of the Problem Itself?

From the perspective of differentiated instruction, Tomlinson (1999) identifies four key areas where teachers can intervene: structure, processes, content, and products (as cited in Croguennec, 2023). This framework can help guide teachers in planning adaptations either before or during TTPS activities, ensuring they are responsive to students' diverse needs. Some examples include:

- **Differentiating the Structure**: prioritizing teamwork, encouraging the sharing of effective ideas, and working on erasable surfaces.
- **Differentiating the Processes**: providing students with a variety of physical tools (e.g., manipulatives, number lines, hundreds charts), or presenting the problem through multiple representations (e.g., visual, physical, symbolic, verbal).
- **Differentiating the Content**: varying the constraints or the numerical values used in the problem statement.
- **Differentiating the Products**: accepting different forms of student responses (written, drawn, oral, etc.).

Table 6 presents an example of a teacher action for each of the four areas of differentiation proposed by Tomlinson (1999), in connection with the following problem:

Problem Statement: A teacher explains to her students that she would like to organize her collection of 415 cards in a binder:

"I want to buy a binder that will help me display my card collection more effectively and prevent me from losing any of them. I've found two options:"

- **Binder A**: 6 pockets per page, 35 pages
- **Binder B**: 9 pockets per page, 25 pages

"I'm hesitating between the two. Which one would you choose, and why? Be careful! You must justify your choice by providing detailed traces of your reasoning."

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This task is designed for 9–10-year-old students who have not yet been introduced to the standard column multiplication algorithm. Its goal is to encourage them to develop their own written strategies for calculating the product of two natural numbers, drawing informally on the associative property of multiplication and/or the distributive property over addition or subtraction.

Table 6: Examples of Actions to Support Differentiated Instruction Based on Tomlinson's (1999) Four Areas of Differentiation

Area	Action
Structure	• **For the Entire Class**: Randomly form teams of three students at the beginning of the exploration phase, replacing individual work with collaborative problem-solving on a shared worksheet. Each student uses a different colored pencil to distinguish their contributions.
Process	• **For Students Who Need Additional Support**: Present the problem alongside the physical binders (A and B) and the 415 cards, providing a concrete, hands-on representation (see image for an example).  • **For Students Seeking Greater Challenge**: After calculating the total number of cards for Binder A, ask students to mentally calculate the total for Binder B and discuss the differences between their written and mental strategies.
Content	• **For Students Who Need Additional Support**: Provide the total number of cards for Binder B (450

Area	Action
	cards) and ask students to focus on determining the capacity of Binder A. • **For Students Seeking Greater Challenge**: Introduce a third binder option with two-digit numbers (e.g., 12 pockets per page, 18 pages).
Product	• **For Students Who Need Additional Support**: Invite students to explain orally how they arrived at their total, using the binders and cards as visual supports. • **For Students Seeking Greater Challenge**: Ask students to find two different ways to calculate the total number of cards each binder can hold.

Misunderstandings related to the problem's context can often be minimized by beginning the session with a general discussion that invites students to share their prior knowledge. In this regard, Markworth and colleagues (2016, p. 3) suggest posing broad questions that help students connect their personal experiences or beliefs to the theme or context of the problem, such as: *What do you know about…? Has anyone here ever…? How many of you like to…?* and so on.

Equally important is taking the time to help students reflect on the challenges their group encountered and the strategies they used to overcome them (SanGiovanni et al., 2020). When students collaborate and embrace the idea that learning arises from struggle and mistakes (National Council of Teachers of Mathematics [NCTM], 2014), differences in skill level become less of a barrier.

4.3 Discussion Phase: How Can We Keep All Students Engaged During the Discussion Phrase While Maintaining Their Attention?

To promote the engagement of all students during the discussion of solution strategies, one effective approach is to incorporate a *gallery walk* between the exploration and discussion phases (Markworth et al., 2016). In practice, students are invited to silently observe the work of other teams before the whole-class discussion begins. This step allows them to become familiar with a variety of strategies—even those that may not be explicitly addressed during the discussion. By gaining an overview of their peers' solutions, students can enter the discussion phase with more informed questions and reflections.

Incorporating a gallery walk requires minimal additional time but significantly enhances student involvement. It positions students as active participants in the discussion, while the teacher takes on more of a facilitator or mediator role. As Markworth and colleagues (2016) put it, *"*The teacher needs to know the map, but often the students are capable of choosing the route*"* (p. 7).

Another way to sustain engagement is to avoid systematically reviewing every strategy generated by the class. Instead, the teacher can select one or two strategies that align closely with the learning objectives and invite other teams to draw connections between those and their own approaches (Markworth et al., 2016).

The goal is not to limit participation in order to save time or maintain attention, but to optimize the quality and relevance of the discussion—ensuring it remains focused, meaningful, and cognitively engaging for all students.

4.4 Discussion Phase: How Can We Optimize the Time Dedicated to Comparing Solution Strategies?

To help the teacher feel prepared to take on the role of guide and mediator during the discussion phase, it is essential to adopt a proactive stance beginning in the exploration phase. In this regard, Takahashi (2021) recommends using a classroom plan to document the different approaches used by student teams. It is also helpful to note any recurring mistakes or misconceptions that arise during this phase. This approach enables the teacher to guide the discussion and comparison of solutions in a more structured and intentional way. By being aware of the strategies—whether correct or not—before the discussion begins, the teacher can more effectively anticipate the order in which they will be shared and discussed.

> Anticipating responses is also important for lesson management, especially during the phase […] where the teacher calls on students to explain their strategies. The goal is to determine a presentation order that promotes learning; for example, by avoiding the presentation of a very complete solution first. It is through this prior analysis of students' responses that the teacher can identify various strategies and organize their presentation (Miyakawa & Winsløw, 2009, p. 87).

This logical order of presentation can even be determined in advance, during prior analysis of the task. Doing so allows the teacher to envision how strategies might be presented if they emerge during the exploration phase.

5. Conclusion

This project has highlighted the challenges perceived by primary school teachers when facilitating a TTPS activity. As several teachers noted, these challenges tend to diminish with increased familiarity—both for the teacher and for the students. Indeed, a teacher who regularly implements TTPS activities becomes more confident in taking on the roles of guide, observer, learning mediator, and knowledge formalizer. Likewise, students who frequently engage in such activities begin to view mathematics as more than procedure, memorization, and arriving at the correct answer. They come to understand that struggling with a problem is an opportunity to learn and deepen their conceptual understanding (NCTM, 2014). They also learn to appreciate the process of engaging with challenging and unfamiliar tasks—embracing failure, struggle, and eventual success as essential components of learning (Markworth et al., 2016).

However, if these opportunities remain rare and occasional, the same difficulties are likely to resurface from one session to the next. On the other hand, the more problem-solving becomes central to students' mathematical experiences in the classroom, the more a culture of inquiry, discussion, perseverance, and collaboration is likely to emerge. Over time, students will improve their ability to articulate their processes and strategies, enriching classroom discussions and making it easier for teachers to access and respond to students' thinking. The same applies to their collaborative skills: the more opportunities students have to solve problems together, the more they will adopt the behaviors necessary to make the most of teamwork.

The development of such a classroom culture could therefore contribute to reducing the challenges identified in this project.

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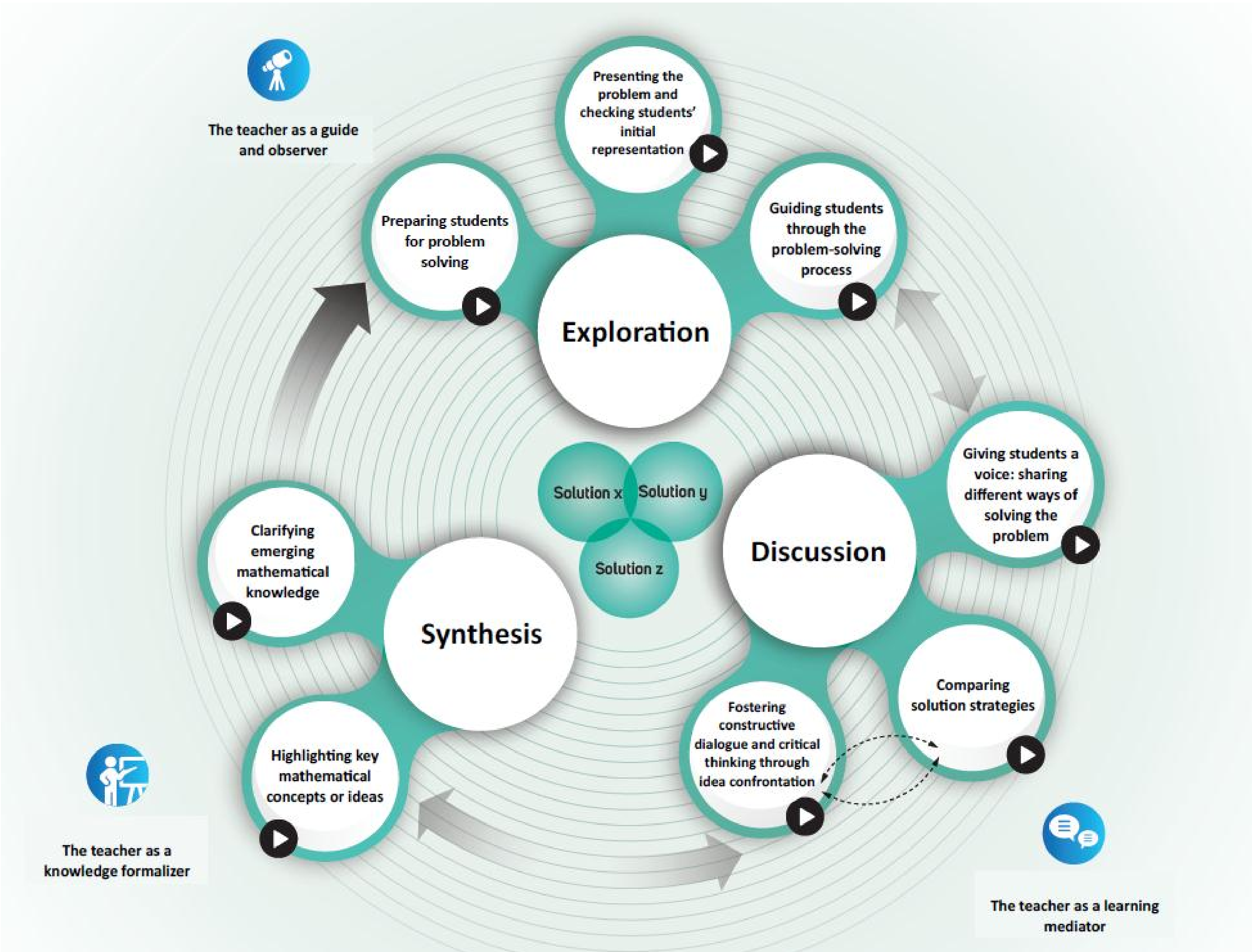
Appendix


The teacher as a guide and observer
Presenting the problem and checking students' initial representation
Preparing students for problem solving
Guiding students through the problem-solving process
Exploration
Solution x
Solution y
Solution z
Giving students a voice: sharing different ways of solving the problem
Discussion
Clarifying emerging mathematical knowledge
Synthesis
Comparing solution strategies
Fostering constructive dialogue and critical thinking through idea confrontation
Highlighting key mathematical concepts or ideas
The teacher as a knowledge formalizer
The teacher as a learning mediator