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Teaching creativity through mathematical lateral thinking problems: A pilot study

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Abstract

The integration of creativity in mathematics has been the subject of extensive scholarly and applied discourse. The positioning of learning that fosters creativity through mathematical lateral thinking problems (MLTP), or problems with multiple or unexpected solutions, has, however, not disclosed much about the exploration of teachers' orientation and action. Semi-structured interviews and teaching observation were used in this qualitative descriptive study. Two mathematics teachers were chosen using purposive sampling techniques. Six categories on orientation components of pedagogical content knowledge, i.e., teachers' knowledge about the concepts, aims, topic and students' category, examples, procedures, and integration of MLTP, are used as interview and observation guidelines. By classifying the findings, the data were descriptively examined. MLTP can fosters students' creativity and aligns with the curriculum. The fundamentals of number operations were a crucial first ability. Learners with intermediate to upper cognitive capacities will benefit more from the dynamic integration of MLTP. The dynamic stage of perception, challenge, alternatives, and harvesting could be used to foster creativity through the solving of open-ended, semi-unexpected, and unexpected problems. Supporting the effective use of creativity in the classroom requires professional development for teachers that focusses on problems development that addressing creativity.

Keywords: teacher's orientation, pedagogical content knowledge, creativity, lateral thinking

INTRODUCTION

Many countries and researchers have established mathematical thinking as an important educational goal for learners (Er, 2024; Liang, 2022; OECD, 2023). The standard math curriculum also highlights the importance of creative thinking (Bicer et al., 2024). However, students' high order thinking skills remain low (Juniati & Budayasa, 2024). Many teachers struggle with classroom learning practices, and teachers' diverse beliefs about creativity hinder the development of creativity in schools (Bereczki & Kárpáti, 2018). Teachers often only train students' creative thinking through open-ended question exercises (Leikin & Sriraman, 2022). Though, creativity can also be trained through lateral thinking problems that demand several alternative solutions or unusual single solutions (de Bono, 2018). Therefore, de Bono's (2018) idea of teaching creativity through lateral thinking problems deserves to be carried in mathematics as a mathematical lateral thinking problem (MLTP), i.e., mathematical problems with many solutions or a single unexpected solution that was solved through the process of perception, challenge, alternative, and harvesting (PCAH) (Shodiq et al., 2024).

There has been much academic and practical discussion over the incorporation of mathematical creativity into mathematics. A lot of research on students' mathematical problem solving and creativity has been published, such as Wahyuni et al.'s (2024) research on mathematical anxiety and Hasan et al.'s (2024) on analogical reasoning, but how mathematics teachers orient in teaching creativity has not been explored much. Mainly, they explored teachers' orientation in positioning learning mathematics that teaches creativity through MLTP. Teachers' orientation plays an essential role in leading the learning process

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Contribution to the literature

- This article adds reference to educators on how and in what way teachers teach creativity in mathematics learning environment.
- The current study explores one of the PCK components that has a great influence on other components, namely the orientation component using a case study of senior and junior award-winning mathematics teachers.
- This study provides descriptive exploration of teacher orientation in teaching creativity using mathematical lateral thinking problems (multiple or unexpected solutions).

that ensures students' success in mathematical creativity. As finding of Sevinc and Galindo (2022), stated that a prospective teacher who has a teaching orientation that noticing student mathematical thinking, has succeeded in developing his learning media despite experiencing many challenges and suggests that future research needs to investigate how the teaching practices are. Award-winning teachers generally have a good orientation. So, it's important to explore their orientation and action in teaching creativity through MLTP.

Orientation is closely related to teachers' beliefs, and beliefs have a great influence on the success of teaching mathematical creativity in the classroom. Orientation (O) is a component that affects the other four components of pedagogical content knowledge (PCK), namely Knowledge of students' understanding (S), instructional strategies (I), and assessment (A) (see Park & Oliver, 2008 for the description of these five components). Suh and Park (2017) concluded that orientation in science learning is closely related to the components of I and can also inhibit interaction with other components. Thus, one of the important aspects of understanding a teacher's actions is to understand the orientation that influences those actions. This shows the urgency to conduct research on the orientation of teachers about teaching creativity, especially teaching that uses MLTP.

PCK is generally not influenced by gender but is influenced by training experiences (Aydın & Turhan, 2023; Hanifah et al., 2024), quality of working life (Rahimi et al., 2024), and the enthusiasm of teachers (Xue, 2024). Award-winning teachers are generally teachers who have a lot of training experience, have a good quality of work life, and are always enthusiastic teachers. Therefore, the orientation of award-winning teachers towards teaching creativity through MLTP is very worthy of being explored to be used as an example of good practice for other mathematics teachers. Thus, this study wants to answer several questions: how do we conceptualize MLTP as a source of mathematical creativity? How are the results of exploring the orientation of award-winning mathematics teachers on teaching mathematical creativity in junior high school using MLTP? More specifically, how are the teachers' orientations on the concepts, goals, material and student goals, examples of problems, and MLTP problem-solving procedures, as well as the process of integrating MLTP into mathematics learning?

LITERATURE REVIEW

Conceptualization of MLTP as a Mathematical Creativity Source

Given our focus on exploring teachers' orientation towards the use of MLTP as a resource during whole-class instruction, we explain our conceptualization of MLTP as a tool for mathematical creativity in the classroom. We consider MLTP a valuable tool for implementing the concept of teaching creativity. Our work focuses on creative subsets that productively uses MLTP as a resource during the teaching of the whole class.

MLTP is obtained through an in-depth analysis of examples of problems and their solutions using the lateral thinking process introduced by de Bono (2010). For example, the problem

> "A gardener is ordered to plant four trees arranged so that each pair of trees is the same spacing. How does the gardener grow them?"

> "There are six glasses lined up in a row on a table, labeled 1 to 6. Glasses 1, 2, and 3 are filled with water, while glasses 4, 5, and 6 are all empty. How can you make the full glasses and the empty glasses alternate by moving just one glass?"

The results of our theoretical studies and lateral thinking problems are synthesized into types of MLTP and their solution procedures are alternatives type (multiple solutions, open problems), semi unexpected type (forces one unconventional solution), and unexpected type (demand unconventional solution).

After the discussion and validation process, it was concluded that MLTP is a mathematical problem that demands several alternative solutions or unusual/unexpected single solutions with a solution process through the steps of PCAH (see **Figure 1** for an explanation). Bicer et al. (2021) stated that mathematical creativity relates to generating new mathematical ideas, processes, or products for students with the classification of task categories of creativity emphasized

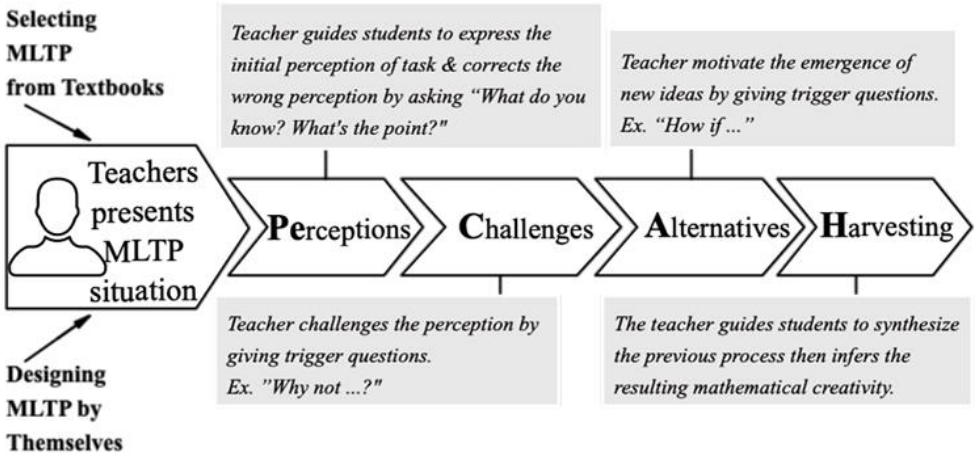


Figure 1. Instructional design of MLTP solving process (Source: Authors' own elaboration)

on different dimensions (i.e., open-ended exercises, formulation of problems, links, expansions, visuals and conversation). The results of our classification are simpler, namely, three types of MLTP questions with many solutions and problems with a single solution, including alternatives, semi-unexpected, and unexpected types, as shown in **Figure 1**. The classification we did was slightly different from what Bicer et al. (2021) had done. However, it is in accordance with the general indicators of creativity that have been agreed, namely fluency, flexibility, and novelty (Leikin & Pitta-Pantazi, 2013). The alternatives type can explore the fluency indicator (multiple solutions) and the flexibility indicator (multiple approaches), while the semi-unexpected type requires a single way outside the usual way, and the unexpected type is a problem that requires a single unexpected solution. The last two types of questions require students to use a new method or solution (novelty).

Teacher' Orientations

Orientation is seen as a "disposition to action"; it implies that orientation influences how educators see, comprehend, and respond to the learning environment (Leatham, 2006). Thus, comprehending the orientation that shapes a teacher's activities is crucial to understanding those acts. In science, the term "orientation" refers to a teacher's knowledge and perspectives regarding the teaching of science, which influence "decisions made during instruction regarding topics like goals, the nature of homework assignments, the utilization of textbooks and other educational resources, and the assessment of students' learning." (Magnusson et al., 2002). In other words, the teacher's orientation affects their instructions.

Remillard and Bryans (2004) defined orientation towards the math curriculum as a collection of attitudes and viewpoints regarding mathematics, education, learning, and the curriculum that work together to affect how a teacher works with and engages with a specific set of curriculum materials, and as a result, the curriculum that is imposed in the classroom and the learning opportunities that follow for both teachers and students. The orientation to teach mathematics refers to the teacher's beliefs about mathematics and the goal to teach mathematics at different grade levels. So, teachers' orientation towards teaching creativity using MLTP as teaching and learning practice in the classroom is influenced by instructors' knowledge and ideas regarding creativity and MLTP.

In general, teachers' knowledge and beliefs about the nature of mathematics, learning mathematics, teaching mathematics, and mathematics knowledge for teaching are presented. Beliefs are divided based on the nature of mathematics, learning style, teaching focus and types, and student activity (Beswick, 2012; Mosvold & Fauskanger, 2013). Meanwhile, the philosophical view of the role of teachers in learning with an orientation to teaching consequences divides teachers into three types (Ernest, 2003), and McDuffie et al. (2018) concluded that the orientation of secondary school mathematics teachers is categorized into three kinds, namely direct, dialogical, and contingent orientation. In this study, we used the information in **Table 1** to explore teachers' knowledge and beliefs in teaching mathematical creativity using MLTP. We divided them into six categories, namely teachers' knowledge of material and student concepts, objectives, material and student objectives, MLTP problem examples, and procedures, as well as the MLTP integration process in mathematics learning.

We acknowledge, nevertheless it is possible that educators are not consciously aware of their orientation (Leatham, 2006), therefore asking a teacher to explain their orientation and expecting a comprehensive response is not feasible. Instead, orientation should be concluded using other means, such as by observing teachers' practices or by interviews that reflect on their practices. For example, Stockero et al. (2020), takes the perspective that teachers' orientation is their disposition, beliefs, values, tastes, and preferences to use students' thinking as a resource to support teaching and classify

Table 1. Teacher's knowledge and belief as an orientation

Knowledge & belief	Teacher orientation
Nature of mathematics	Instrumentalist, platonic, and problem solver
Teacher types	Instructor, explainer, and facilitator
Learning style	Memorization & practice, understanding, and knowledge exploration
Teaching focus	Content, content with understanding, and focus on learners
Teaching types	Teacher centered, teacher explanation, and student centered
Student activity	Passive-remember-imitate, construct understanding, and independence of exploration
Instructional activity	Direct, dialogic, and contingent

Table 2. Analytical scheme of teacher orientation and learning activities' observation

Orientation components code	Questions protocol
O1. Concept of MLTP	What is your perception of MLTP?
O2. Aims of MLTP	What do you think are the benefits of using MLTP to students?
O3. Topics & learners' category of MLTP	What are the characteristics of the material or appropriate students in MLTP?
O4. Examples of MLTP	Can you provide an example and not an example of MLTP? Please explain!
O5. Procedure of MLTP	How do you solve the following MLTP1? How is the scoring process?
O6. Integration of MLTP	If you are asked to use MLTP on certain mathematics materials, how do you plan to teach? How is teacher orientation (nature of mathematics, teacher types, learning style, teaching focus, teaching types, student activity, and instructional activity) during the learning process?

Note. Developed and modified from Magnusson et al. (2002)

orientations with different levels of potency (low, medium, and high). Other researchers put forward the same perspective. Herbst and Chazan (2012) described the sensitivity of teachers' actions depending on elements like their disposition as a duty to the mathematics teaching profession using the phrase practical rationality. *Thus, the process of concluding orientation is the process of understanding the teacher's actions and the reasons for those actions*.

METHOD

Research Design

After the researchers constructed the MLTP framework through the process of focus group discussion (FGD), the next case study was carried out. Yin (2014) defined a case study as an in-depth investigation used to explore and analyze contemporary situations such as phenomena, people and communities, in a real-world context. The design of this study was intended to achieve new insights through the case of two special subjects, namely, to see the orientation of the subject towards teaching creativity using MLTP. The results of the exploration were expected to be an example and pilot study. The goal is not to generalize the findings, but to explore a special case in two award-winning teachers.

In their previous work, Stockero et al. (2020), and Stockero and Van Zoest (2013) employed scenario-based interviews, instructional video recordings, and classroom observation as tools to promote teacher reflection and uncover instructors' underlying orientations. We improved the above method by using MLTP-based methods and video-based interviews for teaching scenarios (scenario interviews) which were conducted twice for each research subject to produce credible data (Denzin, 2012). This research was qualitative descriptive with semi-structured interview approach. The participants were two award-winning mathematics teachers at a junior high school in East Java, Indonesia. The research instrument used an interview guideline that includes six question items based on orientation components of PCK theory in **Table 2**. There is teacher orientation about concepts, goals, material and student objectives, problem examples, solving procedures, and the process of integrating MLTP in mathematics learning. Data collection was conducted through deep interviews and observation of classroom learning. The data collected were analyzed descriptively by grouping interview and observation results based on indicators.

The Participants

The special subjects were selected using the purposive sampling technique and is a member of the FGD which has been carried out with researchers four times during January-February 2024. The first criterion is senior-junior high school mathematics teachers. This criterion aims to see the results of exploration from teachers with different lengths of experience. Second, teachers must have the best achievements in the field of mathematics learning innovation with the highest academic qualifications in one region of Indonesia. This is related to the possibility that outstanding teachers have an orientation that can be imitated by other teachers. From 4 potential candidates, two subjects with personal identities were selected, as shown in **Table 3**.

Table 3. Participants' personal background

Participants	Education	Age	Teaching years	Observation class
Mr. Senior	BEd & MSc	57-year-old	26 years	▪ 25 grade VIII students with moderate ability ▪ Topic 1. Relation concept ▪ Topic 2. How to present relation
Mr. Junior	BEd & MSc	38-year-old	14 years	▪ 27 grade VIII students with moderate ability ▪ Topic 1. Concept and presenting relation ▪ Topic 2. Function values

Data Collection

In order to infer the teacher's orientations in relation to using MLTP, the MLTP interview and scenario interview were designed to show how a teacher thinks about using MLTP both before and during instruction to teach creativity. We employed interview data in the current analysis to concentrate on teachers' orientation. We presented MLTP-type alternatives in question (1), semi-unexpected in question (2), and unexpected in question (3) below to test participant comprehension about MLTP, as mathematical creativity source.

MLTP1. Kiki bought 6 pieces of 1 m × 1 m square wire boards that can be connected and folded into each other. The wire will be used as the divider of the Rabbit's play area in the yard, which measures 4 m × 8 m.

(1) What is a possible play area?

(2) Is it possible to circumnavigate the play area more than 6m? Explain!

(3) Taking advantage of the environment of the yard, sketch the maximum area of Rabbit play! How m^2 is the area?

MLTP1 is a part of the main source of MLTP interviews. The chance to respond and pose questions was granted to the teachers after they have done the solutions of all the questions, which is followed by an interview session using the guide of the MLTP interview in **Table 1**. Subsequently, we gave inquiries that shed light on the potential mindset guiding their choice of how to use MLTP to teach creativity to kids. Scenario interviews were conducted as supporting data that corroborated the findings in the MLTP interviews. Lesson plans and learning video recordings are used as the basis for scenario interviews. Scenario interviews are used to clarify the findings.

Identifying Orientations

After two recordings of interviews and two recordings of instruction on each subject were transcribed, the teacher's responses were used as the analytical unit to break down the discourse. At least three researchers independently examined each teacher's response to see if it contained evidence of orientation, using the video analysis as supporting evidence. They then created a hypothetical statement that encapsulated each orientation. After comparing and debating their claims, the researchers agreed on the possible orientation sent by each teacher's response. This analysis demonstrated how teachers are utilizing MLTP to teach creativity.

Next, a comprehensive set of possible orientations derived from a specific teacher's answer was arranged to correspond with the emergent subject. As an illustration, three interview replies from an educator proved that the educator thinks MLTP is crucial for students since it can help them develop their creative thinking skills. The following comment was one of the supporting documents: "I believe that many of my students still lack the opportunity to solve problems with multiple solutions. MLTP provides an opportunity for students to find several possible solutions'" and "Creativity is important to be taught because it fits the current curriculum." Together, the three responses provided evidence that supports that these teachers value creativity and believe that MLTP can be the mediator.

RESULTS

Teachers' MLTP Interview Results

MLTP-based interviews were conducted twice on each subject to see the validity of the data so that the conclusions obtained were valid and credible. The interview was conducted after two discussion group forums about MLTP and before the teacher carried out teaching. The results of triangulation of senior teacher's MLTP interview data are slightly different from junior teacher's (see **Table 4**).

The senior teacher believes that the goals of MLTP are aligned with the curriculum and its goal is to teach mathematical creativity to students. The MLTP concept offered by the researcher is believed to be a new concept and has been clearly defined. Based on his experience, he stated that MLTP problems are much more effective if applied to students with medium and high mathematical skills who are mature in the basic concept of number operations. He also believes that the completion procedure is a dynamic process. The senior teacher plans the teaching of creativity as an implicit process through oral instruction to each group. This is related to the teacher's orientation that the students he teaches are diverse and need directed instruction. The senior teacher defined MLTP as mathematical problems that are open-ended but have clear steps in the process of solving them. In addition, he stated the problem with the unexpected single solution was more suitable as a problem for ice breaking. Open-ended problems are

Table 4. Triangulation of MLTP interview

SO	Senior		Junior	
	MLTP interview 1	MLTP interview 2	MLTP interview 1	MLTP interview 2
O1	… in mathematical lateral thinking, it turns out that there are **stages** that we have to go through ...	… in accordance with **the step** of mathematical lateral thinking, it is already suitable ...	… solving **open ended problems** using perception, alternative, that is **fit with curriculum** ...	… regarding perceptions, challenges and others, according to the **curriculum** …
O2	… it is very useful because it will train children to **think creatively** …	… guiding for **creative** children …	… related to critical thinking, there are also **creative ones** …	… invite you to think **out of the box** …
O3	… if the students' ability is **normal**, it is feasible …	… but if it's math **ability in middle and upper**, this is very good …	… suitable to be given to **students according to ability mapping** …	… can be given to **all students** …
O4	… the **open problems.** So later the problem is a common problem in daily life …	… students' creative thinking will appear on the lateral side with **open questions** …	… **open ended questions** or math puzzles …	… questions that have **many correct answers**, for example determining the types of relation …
O5	… there are **4 steps**, namely perception, challenge, continuing to be an alternative and harvesting …	… but there is also the **possibility** of being able to find alternatives right away …	… doing things **in sequence** such as being able to give perception before challenge and alternatives …	… according to the **4 principles** of mathematical lateral thinking, students are given that instruction …
O6	… learning that is on the **centered of students** …	… the purpose of learning is "**students are able to explain** how to state relation in mathematics" …	… according to the principle, students are **guided** according to that step …	… since this is early, it is more suitable for **guided learning** with group student worksheets …

Note. SO: Orientation subcategories; O1: MLTP's concept; O2: MLTP's aims; O3: MLTP's learner & topics target; O4: MLTP's examples; O5: MLTP's procedure; & O6: MLTP's integration (**bold** sentences are the result of consistent data triangulation)

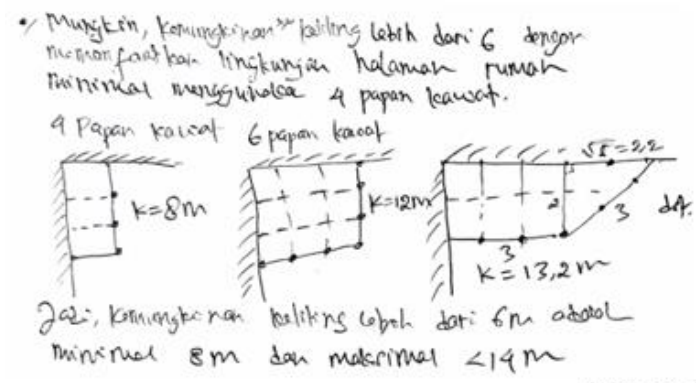
Table 5. Participants' orientation and action toward teaching creativity using MLTP

Participants	MLTP orientation
Mr. Senior	Belief that MLTP can train creativity, students must have moderate or high math skills, the process of completing MLTP is dynamic, implicit integration in teaching, and MLTP is similar to open-ended questions.
Mr. Junior	Belief that MLTP can train creativity, all students can complete MLTP, the process of completing MLTP is hierarchical, explicit integration in teaching, and MLTP is similar to open-ended questions.

considered more suitable according to the level of students being taught and through open-ended problems, teachers feel that they can teach concepts in addition to teaching thinking skills.

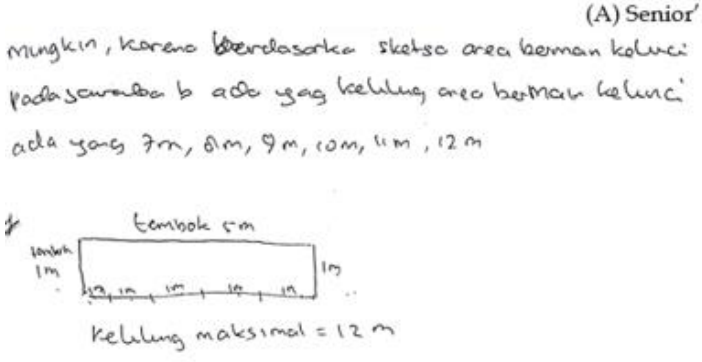
Demonstration of more concise results of the orientation profile of senior teacher and junior teacher in teaching mathematical creativity through MLTP briefly can be seen in **Table 5**. It summarizes six subcomponents of teacher orientation which is one of the components of PCK that researchers rarely pay attention to. In fact, the orientation of a teacher about teaching greatly affects the other three components of PCK, namely students' conceptual knowledge, instructional strategies, and assessment. The contrasting differences in teacher orientation between the six subcomponents are orientation on the target topic of MLTP and students who are worthy of teaching, MLTP procedures, and the integration of MLTP in mathematics learning. Senior and junior teachers both stated that not all topics can be used as MLTP material and they also agreed that integer operation skills are basic concepts that students must master before learning MLTP, especially on the topic of relation and functions. Senior teachers believe that the PCAH procedure can be dynamic and integrate MLTP implicitly in learning. Meanwhile, junior teachers believe that PCAH procedures are hierarchical and integrate MLTP implicitly.

The junior teacher stated that they teach creativity using MLTP in accordance with the mathematics curriculum used today. He believes that all students have the right to learn creativity; creativity is not only for smart students. MLTP is new knowledge for students and teachers, so they are more confident in applying a hierarchical process in completing MLTP, namely through perception steps, challenges, alternatives, and harvest. This belief affects the integration plan of creativity teaching, namely through an explicit process through the written steps on the student's worksheet. He defined MLTP as an open-ended problem and believes students are not ready for MLTP with a single solution.



Maybe, a circumference of more than 6 m takes advantage of the yard environment using a minimum of 4 boards. So, the possibility of circumference of more than 6 m is a minimum of 8 m and a maximum of < 14 m.

(A) Senior' answer



Perhaps, because based on the sketch of the garden area, there is a wall so that the circumference of the play area can be 7 m, 8 m, ..., 12 m. The maximum circumference = 12 m

(B) Junior' answer

Figure 2. Teachers' solution of MLTP1 question (2) (Source: Field study)

The junior teacher views MLTP with a Single Solution as a more complex problem for students. This corresponds to Chinofunga's et al. (2023) findings that content sequencing is very important in teaching mathematics.

Both senior and junior subjects can provide examples and non-MLTP examples appropriately. An example given is an alternative type of MLTP to determine various possible relationships in a family tree, In accordance with Spangenberg's (2021) research which states that it is important for real-life mathematical problems in learning. The difference is that the senior teacher presented family members in the form of charts, while the junior teacher only provided two groups of names and free students to make possible relationships. Interview data revealed that the senior teacher pays attention to student characteristics, while the junior teacher focuses more on students' freedom of thought. In completing and assessing MLTP, the two have many similarities but the senior teacher is still superior. The senior teacher has a broader and more planned view in completing the geometry MLTP (see **Figure 2**). The senior teacher presented a more comprehensive answer, for example, it contained a variety of answers with an oblique side and concluded that the circumference was at least 8m and the maximum was less than 14m. This is influenced by the content knowledge (CK) owned by both. The results of the interview revealed that the senior teacher had a better geometry CK. This is because both teachers have a high working memory capacity, according to the results of the study by Palengka and Juniati (2022), and CK affects the knowledge of mathematics teachers (Leta et al., 2021).

Analysis of Teaching Activity and Students' Creativity

The junior teacher uses group learning strategies with guided student worksheets. Learning begins with apperception and ice breaking. The process of PCAH is written directly on the worksheets given to students. During the learning process, the junior teacher actively guides each group verbally. Activities carried out during guiding strengthen problem understanding and feedback by giving easier oral questions to each group in accordance with the difficulties experienced in each PCAH process. Learning ends with a process of reflection.

In the junior teacher's 1st lesson, the level of satisfaction with the successful implementation was 60% and increased to 80% at the second meeting. The evaluation results on achieving learning objectives successively from the first and second meetings are 50% and 75%. Unlike the senior teacher, his satisfaction rate at the first meeting reached 80% and increased to 95% in the second lesson. This is comparable to the results of evaluating student learning outcomes, which reached 70% in cycle 1 and 95% in the next cycle.

The results of the analysis of teacher orientation during the teaching process using the design in **Figure 1** showed that the senior and junior teachers who won the award have almost the same characteristics (see **Table 6**). They are teachers with problem-solving and dialogical orientations that require students to explore knowledge independently, focusing on learning students. The difference is that senior teachers act as facilitators while

Table 6. Results of learning observations and scenario interviews

SO	Senior		Junior	
	Losi 1	Losi 2	Losi 1	Losi 2
O1	The concept of MLTP is understood as an open-ended problem with a **structured solution** through the PCAH process.	Single solution type MLTP is understood as a problem for ice breaking at the beginning of learning. The PCAH **process can be dynamic**.	MLTP is understood as an **open-ended math problem**.	MLTP is a math problem with **many solutions**, the **single solution** type can be given at a **higher level**.
O2	Train students to create **various ideas**.	Students are asked to provide **several solutions**.	Train students' **creativity**.	Train students to **think freely**.
O3	Understand the concept of relation and determine the **different types** of relation of a real problem.	Presenting the relationship between two sets in **various ways.**	Understand the concept of relationships and their presentation through **creative thinking**.	Define two **variables independently** on a function value problem.
O4	Given a family tree chart, students are asked to write down **various possible relationships**.	Given two sets of daily life problems, students were asked to present the relationship in **various ways.**	Given two sets of names, students are asked to determine **various relationships.**	Given a function with two **independent variables,** students are asked to determine the value of the variable.
O5	The teacher gives **oral instructions** to each group.	The teacher **gives provocative questions** to provoke new ideas.	Teachers provide **guided worksheets** according to PCAH procedures.	The teacher provided a **guided worksheet** that was written in detail about the PCAH process.
O6	Using student-centered, heterogeneous **cooperative** learning with a **complete** learning process of perception, PCAH dynamic instruction, presentation, reflection, and assessment.	Using **jigsaw** learning is student-centered with a **complete** learning process of perception–reflection.	Using **cooperative** learning with direct PCAH instruction with **a less complete** learning process.	Using **cooperative** learning with the PCAH process explicitly on student worksheets with **incomplete** learning processes.

Note. SO: Orientation subcategories; O1: MLTP's concept; O2: MLTP's aims; O3: MLTP's learner & topics target; O4: MLTP's examples; O5: MLTP's procedure; O6: MLTP's integration; & Losi: Learning observations and scenario interviews (**bold** sentences are the result of consistent data triangulation)

junior teachers act as explainers and facilitators. This difference is due to the misconceptions experienced several times by students in the group, so the junior teacher needs to give classical explanations. This means that the ability to suspect misconceptions of the junior teacher is still lacking.

The main objective of this study was to look at teachers' orientation towards teaching creativity using MLTP and empower award-winning senior mathematics teachers to design and implement cutting-edge teaching that suits the needs of students, materials, and the school environment. In the process of designing and implementing learning, the teachers rely on the knowledge they already have. In the final interview session, the senior teacher stated that the integration of teaching using technology may be used as a tool only. Teachers are the main key to helping students learn the mathematical lateral thinking process in the classroom. In contrast to the senior teacher, the junior teacher stated that the process of teaching creativity can also be through taxonomy, especially by utilizing artificial intelligence (Vinchon et al., 2023). The results of the above analysis showed that the teachers' pedagogical orientation greatly affects the teaching actions carried out in the classroom. This is in line with the findings of Mavuru and Ramnarain (2018) which stated that the teacher's orientation in teaching science affects the teaching actions taken.

In the final learning session, the researcher also took data on students' perception of teaching from each participant by providing a survey with questions:

1. *Do you feel your mathematics teacher has prepared you to learn creativity?*

On a scale of 1 to 5, rate your preparedness.

(1) Not prepared

(2) Minimally prepared

(3) Somehow prepared

(4) Prepared

(5) Well prepared

Why? Explain your choice!

2. *In which mathematics problems do you feel adequately prepared and why?*
3. *In which areas of learning instructional do you feel adequately prepared and why?*

4. *Write at least 2 relations of set A = {1, 2, 3, 4} and B = {5, 6, 7, 8} that can be made!*

The summary results of the survey are presented in line with the results of self-reflection conducted by teachers. In the first question, students taught by senior teachers felt better than students taught by junior teachers based on teaching methods and time allocation. Both students in the junior and senior teacher classes responded to the second question by stating that questions with many answers trained them to think more creatively. Meanwhile, in the 3rd question, the majority of students stated that there was guidance, triggering questions, and the steps of the process of finding alternative solutions made them think of ideas that they had not thought of before. In responding to the 4th question, both students in the senior teacher and junior teacher classes, more than 50% of the students were able to come up with two different correct solutions. This indicates that students are already able to generate diverse ideas, which means they are already able to think creatively. Experimental research is specifically needed to produce clearer and more valid evidence.

DISCUSSION

Senior Mathematics Teachers' Orientations

The following is a discussion of the orientation profile of senior teachers in the six subcomponents that have been introduced in **Table 1**, as well as valuable lessons that can be learned from the orientation that senior teachers have. Based on the data from MLTP interviews and observations of learning practices (one of researchers as observer in the class, scenario interviews, and learning tools), it can be said that senior teacher has a very good understanding of MLTP concepts. He realized the main point of MLTP based on the guidebook during the FGD with the researchers, which is to view MLTP as a mathematical problem that produces a single solution or multiple solutions. Senior teacher uses his experience to relate the concept of MLTP to various types of problems that they are familiar with, for example, MLTP problems with single solutions he uses as ice breaking in learning, and MLTP with many solutions he knows as open-ended solutions. This is in accordance with Murtafiah's et al. (2020) findings that senior teachers combine experience and knowledge in designing mathematical problems. In addition, the results of the MLTP problem test in **Figure 3** produce a very satisfactory solution, which shows that the conceptualization of the teacher's CK has an effect on his expertise in teaching mathematics (Copur-Gencturk & Tolar, 2022).

The senior teacher realized that the main goal of the MLTP was to train students' mathematical creativity, but he realized that creativity problems are usually

Figure 3. Senior teacher' using MLTP-type single solution as ice breaking (Source: Field study)

associated with students' outstanding abilities. In fact, through simple problems, it can also train mathematical creativity. This can be seen from the implementation of teaching carried out by senior teacher. It prioritizes students in learning mathematics, give fun learning, and introduces mathematical concepts through everyday problems to abstract concepts (Coles & Sinclair, 2019).

Considering that the concept of MLTP is a new concept for students, senior teacher believes that MLTP will be more appropriate if it is given to students with moderate to high mathematical skills through collaborative learning. This corresponds to the cognitive level of bloom's taxonomy which places creativity as the pinnacle of knowledge and collaboration as one of its components (Heller, 2022; Krathwohl, 2002). He also believes that MLTP can be given to students with low ability, but it will be a little more difficult and challenging. Teachers must be good at compiling MLTP that is in accordance with the characteristics of students' knowledge.

Senior teachers are able to present MLTP examples and non-examples in their entirety. For example, in the problems presented in learning, he makes relationship problems with diverse but correct answers. He also managed to present the single problem in the form of ice breaking, as shown in **Figure 3**. An example of the problem is "Andi has IDR1,200. Then he buys IDR400 candy. How much change does he receive?" Many students answered IDR800 because it was 1,200 minus 400, but the answer was not correct. There was one student who managed to answer correctly, namely IDR600, the reason was because Andi paid with a piece of IDR1,000 so the rest was IDR600. This is in line with Bicer's et al. (2021) findings, which states that mathematical creativity is different from mathematical ability.

The procedure for completing the MLTP which senior teacher believes is very comprehensive. He realized that to train students with low initial abilities it is necessary to do it step by step which is taken care of in accordance with the PCAH process, this is in accordance with the problem-solving steps introduced by Polya (2004). However, he also realized that especially for students with high abilities, the procedures carried out

by students can be more dynamic to produce creative solutions. The same findings with Shodiq et al. (2023), that mathematical ability affects the ability to solve MLTP.

The integration of MLTP in teaching carried out by senior teachers is implicit. He does it with mentoring and verbal instruction through each group because he has the view that students will understand more with direct mentoring. Occasionally senior teachers perform classical provocation techniques to provoke creative solutions produced by students. For example, a senior teacher gives a statement "what if the opposite" to determines the relation "half of" of two sets of numbers. Finally, students are able to find another solution, namely the relationship "twice off". This shows that teacher orientation has an influence in the teaching practices carried out, according to the findings Bakioğlu et al. (2022) which states that orientation has a positive influence and a negative influence.

Junior Mathematics Teachers' Orientations

The junior teacher has a good knowledge of MLTP concepts. He believes that MLTP has actually been known for a long time but through different terms, for example open-ended math problems, math puzzle problems, and some math games similar to the MLTP concept. However, he realized that the MLTP provides clearer and more structured concepts so that it is more in line with the current mathematics curriculum. That is to train students' creativity through mathematics. Junior teachers have the belief that to teach mathematical concepts, it is more suitable to use open-ended problems. Single solution type MLTP problems with unexpected answers are more suitable for game materials because if given to build math concepts, it is feared that it will mess up students' knowledge. As stated by Kattou et al. (2013) that basic mathematical concepts are important before students step on non-routine mathematical creativity problems.

Junior teacher participants believe that the purpose of preparing MLTP is in line with the curriculum, which is to train students' mathematical creativity. By providing several alternative solutions or some possible means, students are trained to realize that there are many solutions in math problems. He also realized that the term MLTP is a term that he is new to and needs to be socialized to mathematics teachers at large. As concluded by Shodiq et al. (2022) that MLTP is important to be taught, but there are still many math teachers who do not understand it.

Junior teachers have the view that all students deserve to be trained in their creativity through MLTP and believe that not all materials can be used as MLTP. This shows that young teachers are more open in teaching and pay less attention to students' prior knowledge. This is proven during the learning process, junior teachers lack the ability to anticipate misconceptions and difficulties that students may face, so that the teaching process plan is not all implemented effectively. In line with the findings of Amador et al. (2022) that novice teachers still need support to improve their abilities through teacher professional development.

The MLTP example given by junior teacher is almost the same as the example given by senior teachers, namely through the same context about family tree. Junior teacher gives MLTPs who have freer answers through commands to find some relationships from a set of names. Students need to form two sets first so that it seems more difficult. This shows that junior teachers more focus on the concept of freedom of thought in MLTP but pay less attention to the characteristics of students' knowledge. In fact, in compiling mathematical problems, it is necessary to pay attention to the characteristics of students' abilities (Newton, 2017).

The MLTP completion procedure carried out by junior teacher is more hierarchical and orderly according to PCAH principles. This can be seen from the way he solved the problem in **Figure 3** and in the process, he taught mathematics through MLTP in the two teaching sessions that were conducted. In every lesson, the junior teacher always uses worksheets that contain written instructions on PCAH steps. This shows that the objectives of the student activity are designed to construct understanding (Mosvold & Fauskanger, 2013).

The integration of MLTP in relationship and function learning is carried out by junior teacher through the explicit PCAH process on student worksheets. Teacher teach MLTP through a two-way dialogue process between students in the group and teacher. Occasionally students do learning with direct explanations, so junior teachers tend to integrate MLTP in learning with a contingent orientation (McDuffie et al., 2018).

Learn From Award-Winner Mathematics Teachers' Orientations

Several positive lessons can be taken in forming an orientation in teaching mathematical creativity through MLTP from the two special participants who won the award. Teachers should have a very adequate understanding of concepts. Understanding concepts related to CK that has a positive effect on mathematics teachers' PCK (Krauss et al., 2008). In teaching a topic, teachers need to have clear goals and targets and must have a strong belief based on relevant knowledge that these goals can definitely be achieved with certain procedures. In this case, the belief that MLTP can train mathematical creativity has proven to be effective and can be implemented through an implicit and explicit PCAH process. Teachers need to understand examples and not proper examples in teaching certain math problems to know more clearly the difference in concepts. Teachers need to have a broad view of the

procedure for solving mathematical problems, especially in MLTP. Through a broad view, teachers can adjust teaching patterns according to the characteristics of students and the characteristics of the material being taught. In integrating MLTP, teachers need to pay attention to possible misconceptions, relevant prerequisite knowledge, and need to use unique ways to anticipate them through fun math learning according to students' backgrounds.

CONCLUSIONS

Our analysis exposed a wider range of teacher orientations in teaching and characterized them according to their capacity to teach mathematical creativity to students, even though some can be inferred from the literature on math teachers' beliefs. The study's findings demonstrated that instructors think it's critically to incorporate MLTP into mathematics instruction since it fosters students' creativity and adheres to the curriculum. Basic concepts of number operations are an important starting skill before teaching mathematical creativity. They also believe that integration will be more optimal for students with intermediate to upper cognitive abilities. The teacher believes that MLTP is similar to an open problem but has clear steps according to the dynamic process of PCAH.

Suggestions

Overall, this study adds a useful method to the body of knowledge about the learning design framework that integrates mathematical creativity into the classroom. The results of the study contributed to new thinking about teaching mathematical creativity using the de Bono (2010) lateral thinking framework. The presentation of orientation and examples of its implementation is useful for other mathematics teachers as a practical example of teaching mathematical creativity through MLTP and instructional design of the process of solving it.

This research is a piloting study that describes the orientation of two special subjects namely a senior and a junior mathematics teacher at a junior high school, both of whom have won awards. Future research can explore a wider range of participants to obtain general information and characterize teachers' orientation towards MLTP. There is still a need to develop varied MLTPs, expand the exploration of creative teaching strategies using technology (Valquaresma & Coimbra, 2021), and explore the influence of PCAH phase on creativity using experimental research designs.

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