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Teachers Underutilize Their Learning Styles in Developing Thought-Provoking Questions: A Case Study

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Abstract: Teachers' learning styles are a crucial part of the learning process as they determine how teachers' brains capture and integrate information linked with the senses. Kurnia, identified as an auditory teacher, was expected to capture written information in a provided numeracy problem. Nevertheless, she prefers to capture visual information, like tables or figures, and utilize them to develop thought-provoking questions. Thus, this study intends to investigate her reasons and the factors affecting Kurnia's decision to utilize visual information as a reference in developing questions. This research adopts a qualitative design covering a case study. Kurnia was selected from 32 teachers from 28 schools; roughly 43% were from public schools, and 57% from private schools. Kurnia placed more emphasis on pictorial information before proposing questions, which was caused by situational factors: the subject matter, the grade level, the student's engagement in the class, the teacher's experience, the teaching experience, and the diversity of students' learning styles. This article recommends that teachers recognize their learning styles to know their strengths and weaknesses in teaching mathematics, and that they convey understandable information utilizing effective instructional methods that represent each learning style of students in the classroom.

Keywords: *Critical thinking, learning styles, thought-provoking questions.*

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Introduction

Nowadays, critical thinking is required in various aspects of life (Butler et al., 2017; Tican & Deniz, 2019). A recent study highlights that workers require critical thinking to solve problems and achieve suitable multi-solutions in the office (Pearl et al., 2019). Critical thinking skills also contribute to creating a quality decision-making process by reducing the chance of failure and forming self-motivated workers (Penkauskienė et al., 2019). In education, critical thinking skills significantly improve decision-making processes associated with real-world problems (Butler et al., 2017), and encourage students to analyze the relevance of information, compare information, and construct arguments using logical reasoning (As'ari et al., 2019; Atabaki et al., 2015; Basri et al., 2018; Kurniati et al., 2020). Hence, encouraging students to be critical thinkers in solving numeracy problems is necessary since they must link mathematics skills to real-life contexts including problem-solving and critical judgment (Geiger et al., 2014; Goos et al., 2018).

Questioning is necessary for critical thinking (Farmer et al., 2021), as questioning is one of the most effective instructional methods for students' thinking (Şeker & Kömür, 2008). Intentional questions play a leading role in encouraging students to develop critical thinking skills (Salmon & Barrera, 2021; Yusoff & Seman, 2018). Several existing studies confirm that students' thinking strongly depends on the level of teachers' questions (Monrat et al., 2022; Şeker & Kömür, 2008). Asking questions can provoke students to clarify information, identify problems from different perspectives, interrogate assumptions, evaluate information, and make the right decision (Phillips et al., 2018; Shanmugavelu et al., 2020; Yaakub et al., 2021). However, teachers possess their own learning style preferences by which they absorb information before asking questions to students.

The teacher's learning style forms a crucial part of the learning process since it determines how the teacher's brain cultivates information linked with the senses when capturing and integrating information (Abella et al., 2022). The ways

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in which teachers acquire information can be divided into three categories; they are called auditory, visual, and kinesthetic (Dunn & Dunn, 1978). However, everyone leans toward utilizing one of the three perceptual modes because it improves their performance and helps them better understand information (Cid et al., 2012). Teachers' learning styles affect how they learn and how they teach students (Aaron, 2017; Dunn & Dunn, 1979; Krueger & Sutton, 2001; Sheromova et al., 2020). Teachers consider how they learn most effortlessly, instructing students to master knowledge in the same mode (Dunn & Dunn, 1979). When teachers are aware of their learning styles, they can adjust their teaching methods and better understand their students (Dunn & Dunn, 1993). Sheromova et al. (2020) categorize teaching instructions based on teachers' learning styles, as presented in Table 1.

Table 1. A Sample of Instructional Methods Classified Based on the Learning Preference

Learning Style	Instructional Methods
Auditory	Teachers pose a series of questions. The questions asked are unusual. It is required to recognize certain letters. The letters that students choose are used to form a word for a mathematical term.
Visual	A crossence is a table of nine images in a 3×3 arrangement. There is a relation among the images. Students are asked to find which image must be in position 5. There are some methods to complete the crossence task.
Kinesthetic	Every group of students selects roles and equipment from those provided by teachers such as acting out a task when studying motion, or performing an exercise for fractions with accessible equipment.

Auditory teachers commonly focus on using verbal instructions or written directions in teaching their students, visual teachers prefer to involve pictures in classroom tasks, and kinesthetic teachers ask students to perform physical activities. Therefore, each learning style is reflected in the behavior used to promote information processing. In this research, auditory teachers are defined as individuals who possess an auditory learning style. Auditory learners find it easier to capture information from verbal instructions, guided readings, discussions, and loud explanations (Abella et al., 2022; Medina Velandia & Plazas-Gómez, 2018; VARK Learn Limited, n.d.).

The preliminary finding demonstrates that the orientation of an auditory teacher in capturing information for posing some questions comes from the picture presented in the problem. This observation is also contrary to the theory that claims that auditory teachers absorb written directions or verbal instructions to understand information (Abella et al., 2022; Medina Velandia & Plazas-Gómez, 2018; VARK Learn Limited, n.d.). Furthermore, this result is inconsistent with the findings in the literature that teachers utilize their learning style preferences to instruct their students in the classroom (Alhourani, 2021; Bostanci, 2020; Zeybek & Şentürk, 2020). This initial outcome is incompatible with research stating that teachers' learning styles impact classroom instruction (Aaron, 2017; Dunn & Dunn, 1979; Krueger & Sutton, 2001; Sheromova et al., 2020). Before asking several questions, auditory teachers thoroughly read and understand the problem given. However, different auditory teachers can have dissimilar methods of absorbing information. Some different methods of capturing information impact the questions generated. Examples of questions asked by auditory teachers are presented in Table 2.

Table 2. The Classification of Questions by Auditory Teachers in the Preliminary Study

Suitable Questions	Unusual Questions
How do you believe that the living room is truly spacious?	Look at the picture, what does the design tell you about?
Can you explain the association of the spacious living room and the size of the tiles in the room?	How can you detect where the position of the living room in the image is?
If you are offered 2 kinds of ceramics at different cost, which one do you prefer?	How many tiles does the picture have to cover the living room?
What efforts will you take if you have a limited budget, but want to obtain high-quality tiles?	What does the picture give information about one square being defined as one tile?
What is your strategy for the arrangement of tiles to reach minimum and maximum expenditures?	Pay attention to the design, which color tiles are used more frequently?
How can you predict the number of guests to come compared to the living room area?	Can you compare the number of red and white tiles in the figure?
Why do you consider that problem does not have a certain solution?	Look at the picture format, what do you think about the size of each room?

The source of information applied in generating questions by almost all auditory teachers is in written directions, except for Kurnia as an auditory teacher who focuses on pictorial resources. Kurnia was identified as a teacher who has an auditory learning style based on the results of a questionnaire containing statements about several specifications of learning preferences including visual, auditory, and kinesthetic. However, Kurnia reflects that she tends to do several activities that are appropriate with an auditory learning style preference. During the interview, Kurnia reiterated that

the easiest way to learn is to capture information and understand tasks through listening, and that while teaching she always highlights written instructions and focuses on sound so that her students can hear information clearly. Kurnia asked students to notice the figure provided, instructing them to pay attention or look at the picture. For the sake of investigating this problem, the research questions of this study are as follows: Why does she ask thought-provoking questions in such a way? What are the factors affecting an auditory teacher in compiling thought-provoking questions?

Currently, research investigating how teachers absorb information used to pose questions according to their learning style preferences is limited. An existing finding solely categorizes teaching methods according to teachers' learning styles to promote students' problem-solving, logical reasoning, and general learning skills (Sheromova et al., 2020). Taking advantage of the teacher's learning preferences as the easiest could lead an auditory teacher to propose a series of questions that ask students to recognize certain letters that form a mathematical term. This case indicates that the teacher's set of questions aligns with the learning preferences of auditory teachers who rely on written instructions. However, this study did not generate the types of questions asked by auditory teachers and the aspects that were considered in formulating questions. The work by Aaron (2017) discusses a relationship between teachers' learning styles and their teaching methods. The findings indicate that there is a significant relationship between the two that causes teachers to adjust teaching methods to their learning preferences. This study concluded that if the teacher's teaching style does not match the teacher's learning preferences, then further investigation is required. Boström (2011) focuses on the connection between the learning styles of teachers and students. Several studies have been primarily concerned with the learning styles of pre-service teachers (Cavas, 2010; Dalaman et al., 2019; Elban, 2018; Zeybek & Şentürk, 2020). Yet, these studies provide no information regarding teacher questions categorized by their learning styles. This study will contribute to providing broad knowledge about recognizing questions that provoke students' mathematical thinking by analyzing questions asked by teachers. The findings should help teachers present effective classroom instructions and practice intentional questions for improving critical thinking according to students' learning style preferences. This study could also be adopted as an evaluation material in schools to facilitate teacher training.

Methodology

Research Design

This qualitative research used a case study because the research question sought to understand why Kurnia experienced a mismatch between the way she absorbs information used to ask questions and her learning style. A case study is a descriptive and exploratory approach to obtaining information (Creswell, 2008), and provides the best approach to building a specified and profound understanding of relevant issues while accounting for the complexity of real-life events (Stake, 1994; Yin, 2003).

Participants and Context

Kurnia is a female auditory teacher. She taught in Malang's middle high school for almost 19 years. She was purposively selected among 32 teachers from 28 schools across each of the 20 districts. Roughly 43% of the teachers were from public schools, while 57% were from private schools. Most teachers were male (56%), with a minority of female teachers (44%). Kurnia was selected for this case study through three stages. In the first phase, all teachers were asked to fill out questionnaires regarding their preferences in learning. After the data were collected, all teachers were classified based on their learning preferences as visual, auditory, or kinesthetic. In the next stage, the teachers were given a questionnaire containing four numeracy tasks, and then were asked to write as many thought-provoking questions as needed to help students solve them. Subsequently, we evaluated their proposed thought-provoking questions and generated similar characteristics. We identified that when visual teachers asked thought-provoking questions that originate from pictorial objects such as pictures, tables, or graphs, they also mentioned similar specific sentences, for example, "Look at the existing picture" or "Pay attention to the figure design." Furthermore, we recognize the pattern of thought-provoking questions submitted by auditory teachers from the use of written information, which they emphasize with questions such as "What is the implied meaning of a sentence?" "Is there any written information stating that...?" or "Does the written information provide specific criteria?" We found that the kinesthetic teachers focused on thought-provoking questions that asked students to conduct practical activities, like trying to use a ruler to measure the circumference and area of a tile, collecting information about the area of a house and its rooms, or designing home layout modifications in a group. However, Kurnia generated several different thought-provoking questions from the other auditory teachers involved in this research. Her questions reflect the characteristics of those posed by visual teachers. In the next stage, we decided to conduct interviews with Kurnia and two other auditory teachers to compare several thought-provoking questions generated and confirm the reasoning underlying them. After the interview session, we finally determined the phenomenon experienced by Kurnia as a case study.

Research Instruments

A questionnaire was deployed to discover how teachers learn and conceive of their learning, and how their perceptions regarding their learning preferences influence their classroom instruction. It was composed of four sections: the first section asks about personal information, the second section highlights teachers' ways of learning, the third section

presents four numeracy problems and asks teachers to pose several thought-provoking questions to guide students to solve those problems, and the fourth section focuses on the teachers' beliefs about their classroom teaching using thought-provoking questions. There are 24 questions exploring how teachers learn, eight of which are related to each learning style: visual, auditory, and kinesthetic. We referred to the VARK modalities website to develop each statement item in the questionnaire. We adjusted each statement item for the characteristics of the learning styles, and each available statement provides a choice of answers: "never," "occasionally," and "often." We provided a sample of a statement item for every learning style in the questionnaire. For auditory learning, an example of one of the statements is "I create recordings when my teacher explains mathematics lessons in front of the class, and then I listen to it many times to gain comprehension." For visual learning, one of the statements was "I convert statements into color illustrations in my notes to clarify a mathematical concept that is abstract in nature." For kinesthetics, an example is "I watch a learning demonstration given by the teacher, then I try to apply what I learn." In addition, the provided numeracy problems had unstructured, superfluous, or missing information. They provided both written and visual information and could have multiple solutions. The problems also provided numerical and geometric content in the context of personal and socio-cultural problems that require students to be at the cognitive level of reasoning.

Before utilizing this instrument, the content validity was verified by two experts. The first expert to assess and evaluate the instrument is a professor in mathematics education who emphasizes teaching numeracy, critical thinking, and questioning. He has published numerous books and articles on how to stimulate students to think critically through numeracy problems. Furthermore, he is interested in improving teachers' questioning abilities in teaching numeracy problems and simulating what teachers must do when students give a variety of reactions in response to teachers' questions. The second validator is a senior lecturer in the field of psychology, who is more concerned with teacher and student behavior in learning. She has published several book chapters on teacher and student learning preferences, as well as on how teachers accommodate the diversity of students' learning preferences. The questions exploring how teachers learn were classified into three groups based on the theory created by Dunn and Dunn (1978): visual, auditory, and kinesthetic.

Data Collection

The data were collected over six weeks. The data sources utilized for this research comprise the questionnaire and three primary interviews of 30–45 minutes each along with a follow-up interview. In the first stage, we distributed a questionnaire to all teachers containing a list of statements that could be answered by three options— "never," "occasionally," or "often"—to identify their preferences in learning. Afterward, we analyzed and classified teachers who have visual, auditory, and kinesthetic learning styles from the collected questionnaire data. Subsequently, we provided teachers with a questionnaire containing four numeracy problems, and then we asked the teachers to write down as many thought-provoking questions as needed to help students solve them. After obtaining the output, we evaluated and identified the characteristics of the thought-provoking questions generated by visual, auditory, and kinesthetic teachers. Visual teachers posed thought-provoking questions that focused on visual design, auditory teachers mostly proposed questions about written information, and kinesthetic teachers asked more questions that required students to carry out specific activities. We recognized that visual teachers mentioned the specific commands, "Look at the picture" or "Pay attention to the figure design." Moreover, we noticed that auditory teachers direct their questions to written information, for example, "What is the implied meaning of a sentence?" "Is there any written information stating...?" or "Does the written information provide specific criteria...?" We highlighted that kinesthetic teachers lead their students to perform several specific activities: "Try using a ruler to measure the circumference and area of one tile in this class," "Collect information about the area of the house and available rooms to your classmates," or "Please generate complete home layout modifications in a group." In addition, we also calculated the frequency of thought-provoking questions posed by visual teachers, auditory teachers, and kinesthetic teachers for each of the available numeracy problems. We evaluated that teachers asked thought-provoking questions according to their learning preference or the easiest way to capture information. However, Kurnia did not do that. Therefore, we decided to investigate her further.

We conducted an interview with Kurnia by posing the principal questions designed. Semi-structured interviews were used to provide Kurnia with space to reveal her perceptions. The first interview section was conducted to confirm how Kurnia captured information when she read some provided numeracy problems and explore why she only focused on specific parts of the numeracy problem presented. Several questions were asked of her: "What is the first impression when receiving this numeracy problem? Can you point out the specific part in question? What made you immediately focus on this part? What activities can be done with the section? Do you tend to always focus on that section even if given a different problem? Is this activity an easy way for you to grasp the problem? Is this related to your learning preferences when accepting and understanding problems? Do you tend to use your learning preferences in reading and understanding information?" In the second interview, Kurnia was asked to express her preferences in posing several questions with the purpose of developing students' cognitive skills. Several questions were asked during the interview: "What basis do you use in asking thought-provoking questions? What are your considerations for focusing more on visual teaching? Is there any other reason? Why don't you focus more on the written information? Do you pose such thought-provoking questions according to your preferences in learning? Why don't you customize it? Why do mathematics lessons require a visual representation? Is it useful for students? Can you give an example of using visual representations? Why

Table 4. The Validity Outcome of the Auditory Learning Style Questions

	Item Question							
	2	6	10	15	17	21	23	24
r_{xy}	.593	.627	.506	.662	.615	.586	.613	.544
r_{table}	.396	.396	.396	.396	.396	.396	.396	.396
Criteria	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid

Table 5. The Validity Outcome of the Kinesthetic Learning Style Questions

	Item Question							
	3	5	7	8	12	14	16	19
r_{xy}	.675	.501	.516	.664	.579	.674	.630	.548
r_{table}	.396	.396	.396	.396	.396	.396	.396	.396
Criteria	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid

After verifying the validity of all items in the learning style questionnaire, the next stage was the reliability, measured by using the Cronbach's alpha formula. Referring to Tavakol and Dennick (2011), acceptable alpha values are in the range 0.6–0.7. The outcome of the reliability test obtained from several teachers is shown in Table 6.

Table 6. The Reliability Outcome of Learning Style Questions

Type of Instrument	Alpha Coefficient	Category
Visual learning style	.671	Good
Auditory learning style	.646	Good
Kinesthetic learning style	.682	Good

Frequency of Teachers' Questions

All questions proposed by teachers were classified according to their learning styles and their context within the numeracy problems, and the frequency of each question was counted. Auditory teachers proposed 191 questions in total for the four numeracy problems. Afterward, thirteen visual teachers proposed questions for each numeracy problem. The total number of questions they posed was 298. Kinesthetic teachers provided 256 questions in total. Some categories of questions proposed by auditory teachers, visual teachers, and kinesthetic teachers are summarized in Table 7.

Table 7. The Frequency of Teachers' Questions

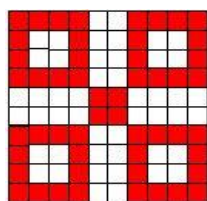
Respondents	Total	Teachers' Question Frequency (%)			
		Problem 1	Problem 2	Problem 3	Problem 4
Auditory teachers	8	31	26	19	24
Visual teachers	13	32	15	22	31
Kinesthetic teachers	11	31	18	21	30

A Description of Kurnia as an Auditory Teacher

Kurnia frequently spoke aloud when reading the text of mathematics problems provided by moving her lips and utilizing different tones to comprehend what she read. She prefers to learn by using assistance tools such as YouTube, which can stimulate her mind by allowing her to hear explanations from other individuals, which helps her digest challenging subject matter, particularly in mathematics. Furthermore, she frequently lectures students using knocking sounds to emphasize the meaningful words students should understand.

Sample of Kurnia's Questions

Problem 1



The colors of some tiles in Mr. Warno's house are red and white. In his living room, the arrangement of some tiles follows the design of a 40 cm × 40 cm square, as shown in Figure 1. Ani said that Mr Warno's living room is extremely spacious. As a result, the living room can accommodate many guests. Do you agree with Ani's opinion?

Kurnia proposed various thought-provoking questions to guide students in solving Problem 1. She also considered students' thinking levels in generating the questions. The purpose of Kurnia's questions associated with the cognitive domain of students was grouped according to Bloom's Taxonomy. The questions

posed by Kurnia for the first problem included low-order (knowledge, comprehension, application) and high-order questions (evaluation).

Table 8. Summary of Kurnia's Questions Classified by Bloom's Taxonomy

Code	Question	Purpose	Category
Q1	Look at the picture; what does the design tell you about?	Interpret what is depicted	C2 (Comprehension)
Q2	How can you detect the position of the living room?	Judge which location should be used	C5 (Evaluation)
Q3	How many tiles does the picture have to cover the living room?	Identify the structure of an existing image	C1 (Knowledge)
Q4	How do you know that a square is defined as a single tile?	Criticize the existing representation	C5 (Evaluation)
Q5	Pay attention to the design; which color tiles are more frequently used?	Compare between color tiles	C2 (Comprehension)
Q6	How do you compare the number of red and white tiles in the figure?	Execute the process to make a comparison	C3 (Application)

Problem 2

A pizza restaurant offers pizza to customers with two basic toppings, cheese, and tomatoes. Customers can order pizza with extra toppings. There are four extra topping options: meat, mushrooms, salami, and olives. Dina would like to order a pizza with two different toppings. How many options for topping combinations can Dina choose?

Kurnia mostly posed thought-provoking questions to visualize the concept of probability. She asked students to represent their solutions as tables by putting down some number codes. After students created the table, she further questioned their work.

Table 9. Summary of Kurnia's Questions Classified by Bloom's Taxonomy

Code	Question	Purpose	Category
Q1	Can you present the pizza combination by using tables?	Sketch tables from the presented data	C3 (Application)
Q2	Why do you put down the number code in the table?	Determine intent of the number code	C4 (Analysis)
Q3	How do you know that you don't have any combinations that are the same based on your table?	Critique the existing representation based on available data	C5 (Evaluation)
Q4	How many combinations did you find that differed from the table?	Identify the total number of combinations	C1 (Knowledge)
Q5	What is your alternative strategy for creating pizza combinations aside from tables?	Produce alternative methods to represent information	C6 (Synthesis)

Problem 3

SAYUR	KALORI	BUAH	KALORI	KARBOHIDRAT	KALORI	PROTEIN	KALORI
1 mangkuk kecil sayur berkuah (100 gram)	75	1 buah sedang pear (100 gram)	40	6 sdm nasi Putih (100 gram)	160	1 ptg sdg ayam tanpa kulit (55 gram)	160
1 piring kecil sayuran tumis (100 gram)	100	1 gelas jus semangka (100 gram)	28	2 bh sdg kentang (210 gram)	160	1 ptg sdg daging rendah lemak (40 gram)	90
Sayur bening bayam (50 gram)	36	1 gelas jus sirsak (100 gram)	40	3 lembar roti gandum (70 gram)	150	1 ekor sdg ikan (- sebesar telapak tangan/40 gram)	65
Sup kacang merah + daging, wortel (25 gram)	146	1 buah kecil apel merah (85 gram)	50	5 ½ sdm havermut (45 gram)	160	2 potong sedang tempe (50 gram)	80
Sup kimlo, aneka sayuran + kaldu ayam (25 gram)	41	1 potong besar pepaya (110 gram)	50	4 buah crackers gandum (40 gram)	140	1 buah besar tahu (110 gram)	85
Sayur asam, aneka sayur + bumbu (50 gram)	90	2 buah sedang jeruk manis (110 gram)	50	1 buah jagung manis (50 gram)	65	2,5 sdm kacang-kacangan (20 gram)	50
				1 buah sedang ubi jalar/ singkong (sebesar 1 kepala tangan-100 gram)	80	Telur ayam negeri (1 butir besar-60 gram)	95

Anto and Tini bring lunch to school. Anto brings 100 grams of rice, 40 grams of meat, and 2 oranges, while Tini brings 3 slices of wheat bread, 1 slice of tempeh, and 1 piece of papaya. Using Figure 2, what is the ratio between the amounts of calories in these lunches?

Kurnia did not use written information to ask questions, and instead focused on a table's content. Kurnia asked students to mention the displayed topic, each food category, the position of each item asked in both rows and columns, and the amount of calories.

Table 10. Summary of Kurnia's Questions Classified by Bloom's Taxonomy

Code	Question	Purpose	Category
Q1	What does the table contain?	Interpret what is presented	C2 (Comprehension)
Q2	What are the categories of rice, meat, wheat bread, tempeh, papaya, and oranges on the table?	Classify foods based on features	C2 (Comprehension)
Q3	Can you mention the column and row of rice, meat, wheat bread, tempeh, papaya, and oranges on the table?	Recognize the place of rice, meat, and orange	C1 (Knowledge)
Q4	How many calories of rice, meat, wheat bread, tempeh, papaya, and oranges are on the table?	Identify the calories in each food	C1 (Knowledge)
Q5	What if the weight of one papaya fruit exceeds 110 grams, so does not match the table?	Predict what would occur if one item was modified	C4 (Analysis)

Problem 4

Based on the data in Figure 3, choose the correct statement:

- On May 23, 2020, the number of patients with COVID-19 was 21.745.
- For one day on May 23, 2020, there were an additional 5 districts or cities that were infected with the COVID-19 virus.
- On May 23, 2020, the number of patients with COVID-19 who were declared cured was 5.555.
- For one day on May 23, 2020, there were an additional 21 people who died from the COVID-19 virus.



Kurnia asked thought-provoking questions for this numeracy problem, which were directed at asking students to identify information obtained from an available poster, define the symbols listed on the poster, and predict the effects that would happen if there was a change.

Table 11. Summary of Kurnia's Questions Classified by Bloom's Taxonomy

Code	Question	Purpose	Category
Q1	Can you identify the information presented in the poster?	Interpret what is presented	C2 (Comprehension)
Q2	What is the meaning of this symbol?	Define the symbol illustrated on the poster	C1 (Knowledge)
Q3	Look below the numbers; do you know about ODP and PDP?	Define the abbreviations presented on the poster	C1 (Knowledge)
Q4	When was the poster published?	Identify the poster's date of publication	C1 (Knowledge)
Q5	What is the effect on the number of cured people if the number of people affected by COVID-19 is reduced on the poster?	Predict what would occur if one item were modified.	C4 (Analysis)

The Factors Influencing Kurnia's Questions

The themes formed from the codes grouped in the method section including subject matter, student grade level, student engagement, and teacher experience can be described as follows.

Subject Matter

Kurnia decided to focus more on visual teaching because of the subject matter itself. She argued that students would more easily understand the mathematics lessons if she provided pictures or graphs rather than explaining only by using words and symbols.

Researcher : Why did you select those questions to provoke students' thinking?

- Teacher : I intended to facilitate students in quickly understanding the problems by using their visual representation to get solutions. Mathematics is challenging to learn if we only depend on words and symbols.
- Researcher : Can you provide me an example of how utilizing pictorial objects makes it easier to understand mathematics lessons than solely using verbal?
- Teacher : If we solve a problem about the layout of the house, then we have to visualize it with pictures according to the specifications mentioned. For example, there is a description of a living room measuring 3 m × 3 m between two rooms, a kitchen of about 2 m × 3 m located next to the bathroom, and a main bedroom about 3 m × 4 m close to the family room. If students have to understand the problem only from the existing description, they will find it hard to solve it. A visual object helps students fully grasp the representation of the house layout, and then they are able to complete the exercise properly.
- Researcher : Please state about the differences between the mathematical representations provided by visual teaching and verbal teaching!
- Teacher : For instance, a living room is designed in a certain way in the first problem. A pictorial representations helps us clearly clarify whether this single square represents multiple tiles or only one tile. If we possess a clear view of the representation of how many tiles are represented by on square, then it will be easier for us to calculate the required number of tiles. While if a description mentions that the living room is very spacious without a visual representation how do we define “very spacious”, because there is no definite size?. These comparisons I have mentioned imply that visual objects help students more easily define a concept precisely than using only descriptions because it is difficult to visualize it.

Student Grade Level

The grade level of students determined the type of her questions. She claimed that students have cognitive development stages based on age, with no exception for middle school students. They are in the concrete operation stage, especially for students in the seventh grade. Therefore, she helps students learn mathematics quickly by asking questions that lead them to create visual representations.

- Researcher : Why do you consider some questions that emphasize visual representation as a crucial foundation for students in junior high school?
- Teacher : Because I know that each student experiences the development of cognitive during certain periods. Hence, I adapt their development by allowing students to make connections between the concepts they have and their activities. I help them in grade seven to understand abstract mathematics by providing chances to create their representation according to their development stage in concrete operations.
- Researcher : What are the significant differences between teaching at the lower grades and at the upper grades in the middle school?
- Teacher : The lower grade is a transitional period for students who are still not separated from real objects, while the upper class can already imagine information that is conveyed verbally. For example, students learn about a linear equation that contain coefficients and variables. For ninth-grade students, if given $2x + 3y$, they understand that $2x + 3y$ cannot be simplified as the variables are different. This is different from grade seven, where they must first be introduced to a concrete object that represents the two variables. For example, they were given a picture of two apples and three mangoes, then two apples could be denoted as $2x$ and three mangoes as $3x$. This makes it easier for them to distinguish between the two variables that cannot be operated on.
- Researcher : What are the specific activities that you usually conduct especially for seventh graders in order to have a good representation of the problem given?
- Teacher : Presenting problems involving real-world situations as a first step in learning. For example, Ani ordered one ordinary menu package containing two portions of chicken and two of rice, then she ordered one complete package menu containing seven chicken portions and five rice. Next, I asked the students, “What information did you get from the illustrations given? What is the difference between the two menus? Can Ani choose the

type of chicken on each menu? What size of rice portion is available, is it medium or large? Can the rice portion size be upgraded? I coach students on truth-seeking and showing their inquisitiveness. I also encourage them to be active and answer confidently. Furthermore, students are required to be able to analyze properly, interpret information, and organize data systematically.

Student Engagement

Kurnia revealed that the crucial factor encouraging her to provide visual learning by applying questions proposed to her is the student's engagement in the lesson. She believed that students would be more interested when they observe several images rather than only listening to their teachers' explanations about the subject matter. Accordingly, visual learning helps students to easily comprehend the mathematical concepts and actively participate in the class because students' attention is distracted by illustrations presented, whereas relying solely on verbal communication creates boring situations to which students do not respond well.

Researcher : What is another consideration affecting your decision to propose questions that provoke students to develop visual representation?

Teacher : Imagine that I just invite students to talk about something in the large class. It will be boring, and students will be less responsive. The way to grab students' attention is by visual teaching because then they will attempt to connect with the problems and finally understand what they learn with ease.

Researcher : How can your questions that emphasize visual representation engage them?

Teacher : Let me tell you, I first grab their attention by providing them with illustrations in the form of a picture or video that they can view. I sometimes provide them with visual demonstrations. After they see the illustration, I can ask several questions, ranging from basic questions to more open-ended ones, to explore their understanding. In this case, students began to open up and answer questions, propose questions, and ask other students about their views of this existing illustration. Students tend to engage in discussions that involve visual representations since what they see will make them curious.

Researcher : Could you provide me an example illustrating the lack of student engagement when teaching in verbal-focused instruction?

Teacher : I once started teaching about linear equations with a definition, and students ended up seeming less enthusiastic and more passive. I first gave the definition that a statement is an open sentence that contains the value true or false, and then I asked, what are examples of sentences that contain the value true?. They took a long time to answer my question, so I asked other questions: how can a sentence contain the value false? Can anyone answer?. When observing illustrations of a real object, they were more attentive and curious.

Teacher Experience

Kurnia mentioned that she applied those questions by considering visual learning because she experienced it in the past, and it effectively helped her understand the subject matter. Her past learning and teaching experience shaped her to deliver mathematics lessons in a visual style to help students overcome the difficulties they have in solving word problems.

Researcher : What is your reason for asking multiple questions that encourage students to have visual learning in class?

Teacher : When I was in middle school, like my students, I encountered difficulties in understanding mathematics lessons, and my teacher helped me to learn by using visual representations. Based on my experience, visual learning is the best way for me to learn mathematics. When teaching a class, I observe that my students have the same experience as me. I pose questions based on visual learning based on my own learning experience and my teaching experience.

Researcher : How did your teachers' questions concerning visual representations help you solve word problems?

Teacher : Okay, I will present you with an example. My teacher first provided me with illustrations or demonstrations involving a real-world situation such as the layout of a house. Next, all students were asked to observe what was presented. My teacher started asking what did

you get from the illustrations given? Does the house already have the necessary rooms? If not, what room should there be? Is every room the ideal size? Does the size of the house match the land area? These questions encouraged me to think critically about the problems given, then I can analyze, evaluate and make the right decisions.

Researcher : How do your past experiences relate to your current teaching?

Teacher : As an experienced teacher, I encounter various situations when teaching takes place. I have recognized the difficulty students have in learning mathematics. They ascertain it difficult to transform abstract information, so they need the help of visual representations in order to solve the provided problem. Since I experienced something similar in the past, I tried to apply the best teaching I received. After I observed them during the lesson, they were greatly helped by the questions that tended to lead to visual representations.

Discussion

This investigation demonstrates that an auditory teacher focused on visual information for asking several questions rather than written directions. This finding provides evidence against a conclusion from another study that teachers will be more sensitive to the information given in their preferred sensory learning modality (Mirza & Khurshid, 2020). This research also contradicts a recent finding that people engage better with information consistent with their learning style (Mahdjoubi & Akplotsyi, 2012). Likewise, it is inconsistent with the work by Zeybek and Şentürk (2020), which concluded that many teachers provide learning according to their learning style since teachers perceive that students learn efficiently in the same manner. In addition, this result is in opposition to the recent study by Alhourani (2021), which found that teachers adopt their own learning styles when teaching students, as well as the conclusion of Sheromova et al. (2020) that teachers' instructional methods are customized according to their learning style, for example, so that auditory teachers base everything on written directions. The results also disagree with Aaron's (2017) conclusion that teachers' classroom instruction significantly correlates with their learning style, and with Dunn and Dunn (1979) and Krueger and Sutton (2001), who found that teachers teach in their own learning style. Which they believe to be the easy or correct way, and so direct learners to master knowledge in almost the same way.

This study found that Kurnia emphasized visual teaching for several reasons, even though she was identified as an auditory teacher. This result is consistent with Alhourani (2021), who found that teachers teach students regularly in secondary school, applying visual preference to stimulate students to receive the best understanding. Likewise, Ahmad et al. (2018) and Stirling (2017) claim that teachers prefer to instruct students to visualize concepts using figures, illustrations, graphs, tables, or graphics. Furthermore, this finding supports the view of Newton and Miah (2017) that teachers consider learning styles essential to improving students' performance, but that only a small number of teachers use them in their teaching. Similarly, Akbarzadeh and Fatemipour (2014) revealed that teachers identify the existence of the learning styles but neglect them as teachers are more focused on the subject matter and student understanding.

The selection of information used by Kurnia to propose questions is closely related to interactive decision-making: an interactive decision is defined as a conscious preference to conduct a specific action (Hu et al., 2018). Kurnia also makes several considerations about students, subject matter, and the best strategy to utilize visual information in an interactive decision. Six studies have reported a consistent pattern of findings on a few aspects that experienced teachers consider in making interactive teaching decisions (Brew & Saunders, 2020; Dehghan, 2022; Mandinach & Schildkamp, 2021; Wermke et al., 2019; Wherfel et al., 2022; Wise & Jung, 2019). They discovered that the largest percentage, from 39% to 60%, of teachers declared that they considered learner attributes such as comprehension, attention, participation, and behavior. The next largest group, between 20% and 30%, focused on instructional methods and processes. Comparatively small percentages emphasized subject matter, instructional purpose, or content. Other investigations confirm that experienced teachers produce more teaching planning decisions to determine the instructional task or activities applied by considering some aspects of the students and subject matter (Bakker et al., 2022; Cassibba et al., 2021; Chan & Yung, 2018; Wasserman et al., 2023).

Kurnia intends to utilize visual information to ask questions to help students quickly grasp the subject matter. Grieser and Hendricks (2018) argue that the teaching strategies applied by teachers to design lessons that students can grasp are closely related to pedagogical content knowledge (PCK). In this case, PCK plays a crucial role in teaching, as it associates subject matter knowledge and teachers' comprehension of how to deliver subject content to students (Ball et al., 2008; Greefrath et al., 2022; Guler & Celik, 2021; Shulman, 1987). This result is similar to the finding of research by Moh'd et al. (2022) that teachers' pedagogical knowledge related to the instructional method implements the representations, graphs, tables, and questions to involve students extensively in solving some tasks that need critical thinking skills. Muhtarom et al. (2019) reveal a similar result that teachers who possess good PCK can design learning that involves image representations to clarify the concepts of the problem presented, so that it is truly contextual for students and provides a table representation to help them in modeling the problem provided, giving them a clear overview.

Kurnia prefers to capture pictorial information considering students' understanding of abstract mathematics. Dostov et al. (2022), Lee and Hwang (2022), Lo (2020), Umbara et al. (2020), and Moffett and Eaton (2018) confirm that visual representation is needed in mathematics, as this subject matter contains a different set of related abstractions. The impact of teachers who cannot transform abstractions into a certain format allows students to link mathematics with what they learned, and then students study without understanding (Coskun & Bostan, 2022; González-Campos et al., 2022). Another consideration affecting Kurnia in emphasizing the use of visual objects is students' cognitive development during the period of concrete operations. This view is consistent with the conclusions of Doğan and Yıldırım Sır (2022) and Widodo and Wahyudin (2018) that students in the concrete operational phase must transform the abstract into concrete by being provided activities to explore ideas and concepts in several methods. They implement their ideas and concepts to solve problems and write their solutions using pictures, tables, graphs, symbols, and words to facilitate meaningful learning.

Kurnia also pays attention to student participation in mathematics learning by attracting their attention through visualization. The importance of this approach is confirmed by the findings of Bracci et al. (2020) and Zahner and Corter (2010) that students' involvement will be better when they generate visualizations of instructions as pictures or diagrams, and that this helps them to understand word problems, especially in finding probabilities. Several studies also support the view that the teaching strategy applied by teachers in teaching students is influenced by their own learning experience, which they consider the best way to learn (Akbarzadeh & Fatemipour, 2014; Dreyer & van der Walt, 1996; Shim & Shur, 2018). Sengsouliya et al. (2021) believe that teachers who understand the fundamentals of students' learning and experience in that area will have a comprehensive outlook on the learning process and a firm conviction that students will learn best from their method. However, teachers cannot avoid the diversity of learning styles that students possess when teaching in the same class (Alnujaidi, 2019; Geleta et al., 2022; Putri et al., 2022).

Conclusion

This research explores one case study on teachers' learning styles being underutilized in developing thought-provoking questions. Kurnia, as an auditory teacher, is supposed to absorb the written information or text in the problem provided. Nevertheless, she prefers to capture visual information such as tables or figures and use it as a reference for developing thought-provoking questions. Therefore, an auditory teacher only sometimes utilizes verbal instructions or written directions and sometimes uses pictures or other visual objects to pose questions instead. This was caused by several situational factors: the subject matter, the grade level of students, the engagement of students in the classroom, the teacher's own learning experiences, and the teacher's teaching experience. Subject matter that is abstract in nature, such as mathematics, requires visual representations to make it easier for students to understand. Moreover, students who are in the seventh grade will be in the transition phase, so they still rely on visual illustrations in constructing their comprehension. Students will pay more attention when teachers can provide visual demonstrations; observing these stimulates their curiosity to learn more. In addition, teachers reflect on easy ways that they experienced in the past to overcome similar difficulties experienced by their students. Teachers also consider the instruction given according to their teaching experience, according to which students are more interested in visual instruction than audio instruction as they can identify the details more easily. This finding contributes to the development of the literature, complementing studies on the aspects that teachers need to consider in teaching. Despite the views in the literature that teachers need to accommodate student learning preferences, teachers need to make allowances for content, student backgrounds, and teaching experience. In addition, this finding contributes to the literature on teacher learning preferences, which do not need to be utilized in the process of formulating questions as a teacher is concerned with understandable lessons by paying attention to the characteristics of the lesson content, student background, and teaching experience. Teachers mostly propose questions to provoke low-order rather than high-order thinking. Regardless of the limitations, this finding has implications for applying teacher training policies. Institutions can put more emphasis on developing teachers' questioning skill and providing teaching simulation that accommodates all learning styles. It is crucial to spotlight that teachers must recognize their learning styles for their instruction and performance. Ultimately, the usage of each learning style in creating thought-provoking questions from auditory teachers, visual teachers, and kinesthetic teachers should be further investigated and compared.

Recommendations

The findings of this work lead to the recommendation that teachers should not only consider their learning preferences in asking thought-provoking questions, but also pay attention to student thinking levels and how students capture information easily. Teachers should also be able to accommodate various student preferences in learning mathematics because the problems given contain both written and visual information. Teachers should provide learning that involves illustrations or demonstrations for visual students, audio or video playback for auditory students, and group measurements or role-play for kinesthetic students. Furthermore, teachers should not only absorb information from visual sources, but must also capture from written resources to train students to interpret, organize, and analyze information. Moreover, we recommend further research to examine the extent to which the factors mentioned above influence how teachers pose thought-provoking questions. Future researchers can also discuss how the way teachers pose thought-provoking questions contributes to students' critical thinking dispositions in numeracy learning.

Limitations

This study has several limitations in the investigation of selected cases and the interpretation of results. Considering that this research focused on teachers' thought-provoking questions according to their learning style preferences, additional factors related to the characteristics of teachers should be considered in future studies, such as their cognitive learning style, education level, duration of teaching, gender, PCK, and beliefs in teaching. This study reports the thought-provoking questions proposed by a specific teacher, and their implications may generate different results in other settings.

Ethics Statements

The studies involving human participants were reviewed and approved by institutions. The participants provided their written informed consent to participate in this study.

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Conflict of Interest

All authors declare no conflict of interest.

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Authorship Contribution Statement

Putri: Drafting manuscript, Data Acquisition. As'ari: Conceptualization, Securing funding. Purwanto: Data Analysis. Osman: Critical revision of manuscript. Kharis: Supervision.

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