Journal of Pedagogical Sociology and Psychology
Volume 7, Issue 2, 2025
https://doi.org/10.33902/jpsp.202532651

Research Article

The role of classroom discussions in shaping pre-service mathematics teachers' video analyses and pedagogical perspectives

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Received 5 December 2024; Revised 22 August 2025; Accepted 25 August 2025

The purpose of this study is to explore how the comments made by pre-service mathematics teachers during individual video analyses evolve through classroom discussions, and how these discussions contribute to the development of new pedagogical insights. In this context, the aspects that pre-service mathematics teachers focus on while analyzing a lesson video, as well as their comments on these aspects, have been systematically identified. In this study, the reflections of pre-service mathematics teachers during video analysis were categorized into four main areas: teacher pedagogy, students' mathematical thinking, student participation, and communication. While pre-service mathematics teachers generally expressed positive views regarding the teacher's instructional approach in their individual analyses, classroom discussions often elicited contrasting perspectives, encouraging pre-service mathematics teachers to critically evaluate aspects such as the effectiveness of teaching materials, questioning strategies, and student engagement. Significant changes in pre-service mathematics teachers' perspectives were observed after these discussions, highlighting the dynamic interaction between individual reflection and collaborative dialogue. These findings suggest that video analysis provides pre-service mathematics teachers with the opportunity to observe and evaluate classroom practices in a structured manner, while classroom discussions facilitate deeper engagement, enable the reconsideration of prior evaluations, and promote the development of more nuanced and pedagogically informed insights. Overall, this study underscores the complementary role of video analyses and classroom discussions in supporting the professional growth of pre-service mathematics teachers.

Keywords: Classroom discussions, mathematics education, pre-service mathematics teachers, video analyses

1. Introduction

Mathematics classrooms are complex environments where multiple events occur simultaneously. Teachers cannot attend to all these occurrences at once; therefore, they must be able to discern which situations require their attention and direct their instructional focus accordingly. A critical component of teaching is observing the classroom and making sense of these pedagogical aspects. In this regard, "noticing" becomes an essential part of teaching, particularly in the context of mathematics education. Mason (2002) defines noticing as: "Every act of teaching relies on noticing: noticing what the student is doing, how to respond, what is said, or assessing what is done against expectations and criteria, and considering what to do next." Additionally, Goodwin (1994), and Sherin and van Es (2009) refer to this skill as "professional vision" conceptualizing it as the ability to perceive and interpret key features of the complex classroom environment. In this view, the ability to interpret what is noticed takes on significant importance. During instruction, teacher noticing involves focusing on an event that captures their attention and interpreting it within their knowledge framework.

For instance, a teacher may use students' immediate thoughts to improve instruction in real time. In this process, teachers need to be flexible in their attention. The ability to think flexibly during teaching is closely related to teaching experience (Baxter et al., 1988). Research suggests that PMTs, in particular, require more experience to develop this skill (Star & Strickland, 2008).

Therefore, teacher education programs must support PMTs in developing the ability to focus on critical moments in the learning process and generate alternative instructional strategies based on their limited teaching knowledge. In this context, the use of video case studies has gained prominence in teacher education programs (Santagata & Guarino, 2011). Videos provide PMTs with the opportunity to observe the classroom as a whole, while discussions around their observations offer deeper reflection on the instructional process. Building on this idea, the present study examines how the comments made by PMTs during individual video analyses evolve during classroom discussions, and how these discussions contribute to the development of new pedagogical perspectives.

2. Literature Review

2.1. Learning through Video-Based Classroom Analysis

Practice-based opportunities, as highlighted by Ball and Cohen (1999) and Cochran-Smith (2001), emphasize the importance of utilizing real classroom teaching as a platform for inquiry and exploration, allowing pre-service mathematics teachers [PMTs] to learn how to teach by observing and reflecting on the practices of more experienced educators. In this context, the integration of video into teacher education serves as a critical mechanism for bridging theoretical knowledge and practical application in the classroom. By providing PMTs with repeated access to instructional scenarios, video facilitates the development of a shared vocabulary and common experiences that are essential for discussing and analyzing classroom practices (Ball & Cohen, 1999). Furthermore, video-based instruction has been shown to enhance PMTs' ability to conceptualize subject matter, recognize student misunderstandings, and formulate effective instructional responses (Franke et al., 2001; Mumme & Seago, 2003; Roth McDuffie et al., 2014). This approach not only aids PMTs in developing their pedagogical skills but also enables them to gain a deeper understanding of the instructional processes (Sherin & van Es, 2009). Video-based lesson analysis in teacher education contributes to PMTs' learning from real classroom experiences and deepens their pedagogical knowledge through discussion of these experiences (Lampert et al, 2013). For instance, watching a classroom teaching video allows one to observe the types of questions the teacher asks and the various types of thinking those questions evoke (Roth McDuffie et al., 2014). This method is considered an effective tool, particularly for critical thinking, reflection, and professional development (Cochran-Smith & Lytle, 2009).

Research indicates that engaging with video-based cases fosters substantial growth in teachers' analytical capabilities. For example, programs such as the MATH project and the Cognitively Guided Instruction initiative have demonstrated positive outcomes, with participants reporting improved understanding of students' mathematical thinking and effective teaching strategies (Carpenter et al., 1999; Lampert & Ball, 1998). Similarly, international studies have shown that video analysis can transform teachers' observational skills from mere description to an in-depth explanation of instructional dynamics (Goffree & Oonk, 1999; Sullivan & Mousley, 2001). The practice-based opportunities created through video not only promote inquiry into teaching practices but also provide a structured way for PMTs to navigate the complexities of instruction (Grossman et al., 2009). Sherin and van Es (2009) stated that teachers participating in studies involving video analysis were better able to interpret the situations they observed over time, providing evidence from the videos to support their interpretations, which had previously been limited to description and evaluation. Similarly, Borko et al. (2008) found that after participating in video club sessions where video analyses were conducted over two years, teachers engaged in more qualitative discussions about the teaching processes depicted in the videos and paid closer attention to students' thoughts. Furthermore, video can motivate PMTs to focus more on students' individual perspectives and developmental processes, thereby better preparing them for their future teaching practices (Sherin & Han, 2004). In conclusion, the studies offer a comprehensive understanding of how video-based learning can significantly enhance the observational skills of PMTs, particularly those with limited professional competence and practical experience (Barnhart

& van Es, 2015; Castro et al., 2018; Seidel et al., 2011; Star & Strickland, 2008). However, additional support is needed in the process of repeatedly viewing, describing, and analyzing videos (Teuscher et al., 2017). In this study, PMTs engaged in classroom discussions based on the same video after their individual video analysis. The aim was to explore how the comments made by PMTs during individual video analyses evolve during classroom discussions, and how these discussions impacted the PMTs' understanding and learning.

2.2. Learning from Whole-class Discussion

Classroom discussions are a significant pedagogical strategy that fosters collaborative learning and critical thinking among students. These discussions create a rich environment where diverse perspectives can emerge, allowing students to engage deeply with the content and with one another. Mercer and Sams (2006) highlight that such dialogic interactions promote cognitive development, as participants are encouraged to express their thoughts, listen to peers, and co-construct knowledge. In classroom discussions, PMTs can confront and develop multiple perspectives on teaching and learning (Reznitskaya & Gregory, 2013; Sedova et al., 2014). These aspects of discussion-based pedagogy make it a powerful strategy for preparing future teachers for the profession. This approach enables PMTs to acquire teaching skills and gain new perspectives through active participation in discussions and reflective activities (Herrington & Oliver, 2000). Moreover, discussions with teachers during video analysis sessions have shown that interactions between teachers positively influence their approaches to recognizing students' mathematical thinking and play a crucial role in developing multiple perspectives (Chamberlin, 2005; Hawkings, 2016; Lee, 2006; van Es & Sherin, 2008).

One of the key aspects of classroom discussions is the role of the listener. Listening to others can also serve as an active learning experience, as students can selectively gather information that helps them bridge gaps in their knowledge, leading to a deeper understanding of mathematical concepts (Nunokawa & Ohzeki, 2004). Indeed, during discussions with teachers in video analysis sessions, it was observed that comments from one teacher helped other participants recall different pieces of information. This allowed the teacher to contribute new perspectives or interpretations to the discussion. This suggests that teachers, while learning something new, inadvertently serve as stimuli for the learning processes of their peers. Burney (2004) supports this view, stating that teachers not only learn from each other when openly sharing their ideas but also when they express themselves to defend their perspectives and arguments. In the context of this study, teachers who expressed their thoughts on a particular issue were observed to question their own knowledge as learners through discussions on the mathematical accuracy and validity of their statements. As a result, teachers are thought to develop a more critical perspective as they engage in mathematical inquiry from different angles. Therefore, when participants openly share their ideas in a discussion, they contribute to the learning process of others while simultaneously reflecting on and refining their own viewpoints, thus actively constructing their own learning process. Both participation and listening can thus be defined as active learning experiences. Based on this understanding, the present study examines how the comments made by PMTs during individual video analysis sessions evolve during classroom discussions, and how these discussions contribute to the development of new pedagogical perspectives among the PMTs.

3. Method

3.1. Research Design

This study employed a qualitative case study design (Yin, 2014) to explore how the comments made by preservice mathematics teachers during individual video analyses evolved in subsequent classroom discussions, and how these discussions contributed to the development of new pedagogical perspectives. The case study approach was considered appropriate because it allows for an in-depth examination of participants' interpretations within a bounded context. In this study, the bounded system was a single classroom video and the subsequent discussion.

3.2. Participants

This study involved 30 pre-service middle school mathematics teachers enrolled in a teacher education program at universities in Türkiye, where the researchers were employed. Among the participants, who volunteered to take part in the research, 19 were female (68%) and 11 were male (32%). All participants were in their final year of the 4-year teacher training program, ranging in age from 21 to 22. These PMTs were being prepared to teach mathematics to students in grades 5 through 8 (ages 11 to 14). By the time of this study, they had completed most of their coursework in mathematics teaching, pedagogy, and instructional methodologies. No specific preparation regarding the content of the implementation was conducted with the PMTs prior to the study. To ensure confidentiality, pseudonyms such as PMT1, PMT2, etc., were used for all participants mentioned in this paper.

3.3. Data Collection

The data for this study consists of the written evaluations of the PMTs regarding the lesson video and their discourse during the in-class discussions about the video. In this context, information about the lesson video and procedures related to the implementation process will be described in order.

3.3.1. Procedure

Before the discussion, the PMTs were asked to individually analyze a lesson video from a real learning environment within the framework of specific questions and to report their analyses in writing.

The lesson video is a 40-minute recording that covers the topic of polygons for 7th-grade students. The content of the lesson focused on the properties of polygons and the learning outcomes related to finding the sum of interior angles. The teacher began the lesson with an activity demonstrating that polygon examples could be created manually using models. In the subsequent parts of the lesson, the teacher utilized projected images of polygons displayed on the board and magnetic polygons on a whiteboard. Throughout the instructional process, a teacher-centered approach was evident, with the teacher assuming the role of the primary disseminator of mathematical knowledge. Although the teacher posed appropriate and effective questions to the students, they did not sufficiently listen to the students and seemed to be focused on eliciting specific answers from them. In doing so, the teacher overlooked the diverse perspectives offered by the students. While the teacher in this video does not represent the ideal model envisioned by the researchers, it can be characterized as a conventional teaching model commonly applied in schools.

Teachers were asked to evaluate the lesson video based on specific questions. These questions included, "*Provide a description/explanation of the lesson in the video*," and "*Write an explanation about the lesson for someone who has not had the opportunity to watch the video but wants to know what the lesson is about and what happened during the class. In your explanation/comment, discuss the aspects you found interesting from the perspective of student learning and teaching strategies*." The PMTs were given one week to conduct their video analyses, and their written analyses were collected. The written reflections of the PMTs were examined based on the analytical framework developed from the works of Star and Strickland (2008), and van Es and Sherin (2008). According to this framework, the situations the PMTs focused on were identified, and questions were created for each category to be used in the classroom discussion. These categories included teacher pedagogy, student thinking, student participants, and communication context. The questions developed for these categories are presented in Table 1.

Although this study was limited to a single discussion session, which may restrict the breadth of the findings, prior research has shown that even one carefully designed video analysis session can provide valuable insights into preservice teachers' interpretive practices (Sherin & Han, 2004; van Es, 2011).

3.4. Data Analysis

The written reflections of the PMTs regarding the video analysis and the analysis of the classroom discussion utilized qualitative content analysis. The situations identified by the PMTs were analyzed based on the framework developed from the works of Star and Strickland (2008), and van Es and Sherin (2008). This framework consists of four categories: teacher pedagogy, mathematical thinking, student participants, and communication. The teacher pedagogy category primarily includes actions that contribute to the teacher's instructional process. The questions posed by the teacher and the descriptions of the materials used in instruction were evaluated within this category. The mathematical thinking category encompasses the mathematical thoughts of students that emerged during the teaching process, as defined by the PMTs. Student participation includes the teacher's procedures for giving students the floor, students' engagement in the lesson, and the processes the teacher uses to manage student participation. The communication category involves teacher-student communication, the language used by the teacher, and descriptions related to student-student communication.

Table 1
Categories and their descriptions

Category	*Descriptions*	*Sample questions for discussion*
Teacher Pedagogy	Includes comments on the materials used by teachers in teaching, and the questions asked by teachers to students.	Did the teacher effectively use the materials? What would be the alternative to the materials used by the teacher? Can the teacher ask effective questions? Can the questions asked by the teachers elevate the students' learning?
Mathematical thinking	Includes comments on the mathematical ideas, student discourse, and questions.	Did the teacher ascertain the students' mathematical thinking? What would be the next step after ascertaining the students' mathematical thinking? Was it the students who developed the formula?
Students Participants	Includes comments on student participation in the lesson, opportunities for student discourse, and the opportunities provided by the teacher to the student.	Was the student actively involved enough? What should the student have done in order to be considered actively involved?
Communication	Includes comments on teacher-student communication, teacher's language, and student-student communication	Did the teacher hear the students? What message did the teacher want to give to the students by saying that? Was there an interaction between students?

In the analysis process, the discussion was transcribed, and the students' statements were divided into meaningful units. These units often encompassed students' expressions, questions, and relatable sequential statements and sometimes included dialogues between the researcher and students or among the students themselves. Consequently, some units illustrated a process of interaction and two-way communication.

To ensure the reliability of the coding, the author and an external researcher independently analyzed randomly selected transcripts, which accounted for 25% of the data based on the framework (Table 1). Their coding showed a consistency rate of 89%. The researchers then discussed any discrepancies in their coding and reached a consensus. Additionally, data triangulation was achieved by analyzing both written reflections and classroom discussions, and thick descriptions were used in reporting the findings to enhance transferability. After completing the coding for the entire dataset, the percentage and frequency of codes for each category were

calculated, and the analysis results were presented in the findings section, supported by examples from the students' expressions.

4. Findings

The PMTs' reflections on the video analysis were examined under four headings: pedagogy, mathematical thinking, student participants, and communication. This section will present the PMTs' written evaluations and the insights obtained from the classroom discussions under these headings.

4.1. Teacher Pedagogy

The PMTs focused on the teacher's use of materials and questioning approach within the scope of pedagogy. The PMTs' views on the use of materials are presented in Table 2.

Table 2
PMTs' views on material usage

Description	*f*	*%*
Positive Views		
The use of materials (such as tangram and GeoGebra) has helped students understand the topic by making it more concrete and visual.	5	10
The use of materials facilitated learning through hands-on experiences, making it easier for students to learn.	6	11
The use of materials (like GeoGebra) supported students' spatial thinking.	4	8
The use of materials has assisted students in retaining knowledge more effectively.	7	13
The use of different materials (such as a pinboard) has helped students actively participate in the lesson.	7	13
The teacher actively utilized materials and technology.	5	10
The teacher provided opportunities for students to use materials (such as the GeoGebra program).	4	8
The lesson was enriched and made enjoyable with materials (such as geometry boards and GeoGebra).	7	13
Negative Views		
The lesson is rich in terms of material usage, but the use of materials did not serve its intended purpose.	3	6
While the use of materials is good, students sometimes remained passive observers and could not evaluate their own learning.	4	8
Total	52	100

As shown in Table 2, 66% of the PMTs' reflections were positive, while 14% were negative. The PMTs expressed more positive opinions regarding the teacher's use of materials, particularly noting that the materials made the relevant concepts more concrete and visualized them, thereby facilitating the students' learning process. Some students stated that the materials supported more active participation from the students and made the lesson more enjoyable. However, students who expressed negative views indicated that the material selection was good but did not serve its purpose, and at times, students were merely in a passive listening role. In light of these reflections, the discussion included the teacher's use of materials. Based on the questions posed to the PMTs, they reassessed the teacher's use of materials by watching the video again. During the discussion, the PMTs predominantly presented negative views regarding the teacher's material selection and usage. Notably, it was observed that PMTs who had previously expressed positive opinions changed their perspectives. In this context, a dialogue between two students is as follows:

> **Lucy:** The teacher could have used more concrete and real materials. For instance, maybe a triangular board. By placing such items and asking the students to investigate how many sides there are and to discuss them among themselves, students could work in groups. Each group could be

given a list, and students could fill it out on the board, which could foster interaction and discussion. There could have been more interactive groups.

Suzan: I agree with Lucy on this point. When I first watched it, I thought it was good material, but distributing a geometry board rather than polygon materials would have been more logical. When we say polygon, we typically think of hexagons and pentagons; instead, we should enable children to engage with irregular polygons with any number of sides and vertices they desire.

Researcher: Was the geometry board a good tool for showing the diagonals of the polygons they created, or could a different tool have been used?

Robert: I think it got confusing. With the rubber bands they used on the geometry board, it was difficult to distinguish between which was a side and which was a corner. They could have used something colorful instead. It could have been visually enriched, providing more support for the students.

As evidenced by the dialogue above, the PMTs criticized the teacher's use and selection of materials. While suggesting alternative materials that could have been used, one student stated, "By placing such items and asking the students to investigate how many sides there are and to discuss it among themselves," indicating that the teacher did not provide the students with opportunities to think and thus did not effectively use the materials in this context. Moreover, the students highlighted that discussions could be fostered among the students, pointing out that the teacher did not offer such an opportunity. Therefore, while the PMTs initially expressed positive views about the teacher's material usage, their detailed analyses indicated that the materials were not used effectively enough by the teacher in the learning process and were insufficient in supporting student learning.

In the context of pedagogy, another important aspect is the questions posed by the teacher. Very few PMTs commented on the teacher's questions in their written reflections. The comments made were superficial, suggesting that the teacher asked appropriate and correct questions. Before discussing the PMTs' statements, the distribution of positive and negative opinions regarding the teacher's questioning is presented in Table 3.

Table 3
PMTs' views on the teacher's questioning

Description	*f*	*%*
Positive Views		
The teacher engaged students in the lesson by asking questions.	9	28
By asking the right questions, the teacher has helped students understand.	8	25
The teacher has guided students to reach the general formula with the questions he/she asked.	7	22
The teacher assists students in how to think through the questions he/she asks.	5	16
Negative Views		
No questions were asked that would encourage students to think differently; only questions that could utilize the algorithm were posed.	3	9
Total	32	100

As shown in Table 3, 91% of the PMTs' reflections were positive, while 9% were negative. Most PMTs believe that the questions asked by the teacher contribute to students' learning. They particularly noted that the questions helped students reach the formula for the sum of the interior angles of polygons, which was the focus of the lesson. Thus, they indicated that this facilitated students' active participation in the class. Only one PMT criticized the teacher for not asking questions that would encourage different thinking among students. However, during the class discussion, guided by the researcher, the PMTs were encouraged to think more deeply about the teacher's questions. Contrary to their written reflections, negative opinions emerged. They noted that the teacher often asked questions aimed at eliciting students' knowledge rather than prompting them to think. For example, they argued that the teacher's questions to assess students' prior knowledge should not have been framed as "What is a polygon?" but rather as "What was a

polygon? What do you remember about it?" to better reveal their thoughts. Additionally, PMTs emphasized that the questions asked by the teacher were at a basic level and that more challenging questions should have been posed. An example of a dialogue that illustrates these thoughts is as follows:

> **Researcher:** Was the teacher able to ask effective questions? Were the activities or problem situations used capable of drawing out and supporting the students' thoughts?
> **Sarah:** For example, the teacher didn't have to provide the formula right away. When explaining the topic, the teacher should have asked a question that would allow students to come up with different solutions without knowing the formula. Even if the students couldn't reach the formula, they would be able to reason.
> **Researcher:** Do you think the children could have reached it?
> **Class:** They would reach it.
> **Sarah:** I believe the students could have figured it out.
> **Yasmine:** I share the same thoughts as Sarah. The teacher gives problems that directly apply the formula. It's like making them practice the formula. Instead, they should have posed problems that would allow the child to reason, enabling students to incorporate their own thoughts into the solution.
> **Sarah:** The teacher is only asking questions that will convey that algorithm. If more varied questions had been asked, we might have been able to discuss where the students were making mistakes. The questions seem to prevent the students from thinking and are focused solely on performing the algorithm on the board.
> **Yasmine:** So, looking at it this way, the level of the problems the teacher used was low.

As illustrated in the dialogue above, PMTs indicated that the questions used by the teacher were not conducive to supporting student reasoning and were instead aimed at eliciting students' knowledge. In this regard, they expressed that the teacher could ask higher-level questions that would elicit students thoughts and prompt them to think critically.

4.2. Mathematical Thinking

The views on mathematical thinking are presented in Table 4.

Table 4
PMTs' views on mathematical thinking

Description	*f*	*%*
Positive Views		
The teacher allowed students to express their opinions during the lesson. The lesson was student-centered rather than teacher-centered.	7	19
The teacher took the student's thoughts into account.	4	11
Negative Views		
The teacher did not provide opportunities for students to express themselves and intervened excessively.	6	16
The teacher did not allow sufficient opportunities for students to think	5	14
The teacher did not adequately consider the students' ideas.	4	11
The teacher provided too many hints to the students. When the students were unable to respond, the teacher directly gave the correct answer.	4	11
The teacher did not guide students toward alternative solutions.	3	9
The teacher ignored the students' mistakes and directed them toward the desired answer.	3	9
Total	36	100

As shown in Table 4, 30% of the views from PMTs are positive, while 70% are negative. Unlike other categories, PMTs expressed more negative thoughts regarding student thinking. In this context, negative views emerged regarding the teacher not valuing students thoughts sufficiently and disregarding them. The general opinion of the PMTs in this regard is that the teacher does not provide enough opportunities for students to express their thoughts and does not consider them

adequately. Furthermore, PMTs noted that the teacher does not encourage students to think alternately and always decides what is correct. Similar thoughts also emerged during class discussions. However, unlike the written evaluations, PMTs expressed their ideas about how the teacher could elicit student thoughts and how these thoughts could be utilized in the teaching process. One of the dialogues that developed in this context is as follows:

> **Lucy:** Sir, contrary thoughts came up. For example, the teacher asked, "What is this?" One student said "diagonal" while some others said "corner". There were contrary voices, but the teacher could have paused and asked, "Oh, did you say diagonal? Why do you think that? Could it be diagonal?" to actually engage the class in discussion.
> **Yasmine:** He could have turned those contrary thoughts into an opportunity. He could have asked questions like, "You think it is diagonal; why do you say corner?"
> **Claire:** In addition to your friend's opinion, for students with opposing views, you could say, "You convince your friend; you say corner, and he says diagonal. Try to convince each other." The teacher could briefly be an observer there. Students would try to convince each other, express opposing views, provide examples, and perhaps draw and show polygons on the geometry board, convincing each other in the process.

Some PMTs indicated that while contrary thoughts emerged in the classroom, the teacher did not question these thoughts or turn them into learning opportunities. They suggested that the teacher could share a student's thought with the class, thus allowing for discussion of that thought. Furthermore, they emphasized that the teacher could create opportunities for students to justify their thoughts, but did not do so.

Some PMTs also expressed that the teacher should provide opportunities for students during the activity process to develop their thoughts and allow them to explore. The discussion regarding what the teacher did not do and what he/she could have done developed as follows:

> **Robert:** The teacher tries to involve students in activities, but it doesn't work. For example, he could have planned activities that would allow students to discover the properties of polygons, meaning he could have asked them for their thoughts. Instead, he only asks them to show the shape on the geometry board. He could have conducted activities that would allow them to discover its properties and asked what they found.
> **Researcher:** So, the activity doesn't go beyond a certain level. You're saying he could have allowed children to discover the properties of polygons.
> **Lewis:** I agree… For example, he gives the information directly to the students without giving them the opportunity to compare the polygons, and without giving them time to think. He did not allow them to reach or discover. When a student asked about the diagonal, he defined it as 'connecting the edges." Without focusing on that definition, he just provided his own information.
> **Suzan:** For example, when the teacher asked, "If I take a point from the polygons that children created, which point can't I form a diagonal from?".He immediately picked a neighboring corner and said, "This one." So, he immediately gave the answer himself. Then, when he asked "why," the students could only say, "Because this is an edge." Therefore, if the teacher had given students the opportunity, they would have been able to express their opinions.
> **Researcher:** You're saying he didn't give the children time.
> **Carlos:** Thinking from the opposite perspective is also very important. For example, he wanted the students to find the dodecagon. The child looked at the above, did n-2, multiplied by 180, but the teacher could have given the interior angle and prompted them to think in the opposite way. He could have challenged the student a bit.

In the discussion that developed among the PMTs, they emphasized that the teacher did not encourage discussion about students' thoughts in the lesson. Instead, he asked many questions and received the answers he wanted to hear. They also noted that when the expected answers did not come from the students, the teacher disregarded their thoughts. Along with this discussion, the PMTs developed suggestions on what the teacher could do in this context, such as revising the problem regarding the number of edges, in addition to questioning the properties of polygons or directly applying the interior angle formula. They expressed that these suggestions were primarily aimed at supporting student thinking.

4.3. Student Participants

The views on students' participation in the lesson are presented in Table 5.

Table 5
PMTs' views on students' participation

Description	*f*	*%*
Positive Views		
The teacher engaged students in the lesson by asking questions.	10	26
The teacher facilitated the students' active participation in the lesson.	8	21
The teacher ensured students' active participation by providing appropriate hints and guidance.	7	18
The teacher engaged each student by asking questions and using a question-answer format to promote active participation in the lesson.	6	15
Students actively participated in the use of materials and activities.	2	5
Both the teacher and students were active in the lesson, but the students should have participated more actively	6	15
Total	39	100

As shown in Table 5, some PMTs highlighted students' participation in the lesson. The majority of these PMTs stated that the teacher provided opportunities for students to be actively involved in the lesson by asking appropriate questions and guiding them with hints. However, during the discussions, the prevailing view among most PMTs was that students were not sufficiently active. At this point, some PMTs who initially held positive views in their written reflections have changed their opinions. When evaluating the teaching process based on the emerging views, they noted that while students were physically active in class, they were not mentally engaged. The ensuing discussion and the PMTs' thoughts are detailed as follows:

> **Researcher:** Were the students sufficiently active?
> **Amy:** The students were more like robots; they were not active and were just doing what was expected of them.
> **Lucy:** I think they were active, teacher. After all, they are creating the properties of polygons using a lot of materials, but they just weren't given enough time.
> **Robert:** Teacher, that's not what being active means. It feels like the teacher is always on alert, wondering if they will say something wrong so that she can intervene. A student says something, but the teacher immediately provides feedback with the correct answer.
> **Eric**: There should have been a discussion using the materials. There should have been an exchange of ideas; it shouldn't just be the teacher asking questions and the students answering. If they had been given the opportunity to express their own thoughts, then...

Then Eric expressed that the teacher should create discussions using materials, thus allowing students to express their thoughts. In contrast, Yasmine stated that while students were physically active during the activities, they were not mentally engaged:

> **Yasmine:** I think the students were active in terms of the activities. The teacher used GeoGebra and demonstrated it in a different way, which made the children physically active. However, because the teacher did not ask the right questions to lead them to the ideas they needed to reach, they were not mentally engaged.
> **Researcher:** So, you're saying they were physically active but not mentally active. What would make them active?
> **Yasmine:** The children are doing the activities, but they don't know the purpose. If the teacher had asked the right questions, the students could have made inferences or generalizations. Because they were not given that opportunity, they were not mentally active.

In the dialogue above and the views expressed by the PMTs, it is evident that there was a significant shift in their thoughts regarding active participation during classroom discussions. In their written evaluations, the prevailing belief was that merely participating in activities constituted active engagement. However, with the discussion, they highlighted that active

participation is not solely about physical involvement. They particularly advocated for the idea that listening to students' thoughts and shaping the lesson based on those thoughts is a crucial action for promoting active participation. Consequently, when they evaluated the lesson, they concluded that teachers did not support students' mental engagement.

4.4. Communication

One of the aspects that PMTs paid attention to in their written feedback is the communication between teacher-student and student-student. The findings regarding the PMTs' written opinions are presented in Table 6.

Table 6
PMTs'views on communication

Description	*f*	*%*
Teacher-student communication		
Positive Views		
The teacher's interaction with the students (body language, voice, etc.) was good.	5	39
The teacher made the students feel valued by listening to them.	6	46
The teacher-student dialogue was effective. The students did not feel bored during the lesson	2	15
Total	13	100
Student-student communication		
Positive Views		
The teacher used the collaborative learning method by dividing the students into groups.	8	27
She fostered a sense of responsibility among the students through group work.	7	23
She provided students with the opportunity to work with their preferred classmates, which supports communication among students.	3	10
Working in groups allowed students to build their self-confidence and provided opportunities for collaboration with their peers.	3	10
The peer work enabled students to evaluate each other.	4	13
She offered students the chance to help each other with their weaknesses.	5	17
Total	30	100

As shown in Table 6, all of the PMTs' views regarding teacher-student and student-student communication are positive. In their written feedback, PMTs stated that the teacher-student communication was good, noting that the teacher sometimes encouraged students and made them feel valued through their behavior in the lesson. Similarly, they expressed that communication among students improved with the group assignments given by the teacher. Similar views also emerged during the classroom discussion. However, some PMTs reported a lack of interaction among students. One PMT who thought student-student interaction was insufficient expressed their views as follows:

> **Yasmine:** I paid more attention to the fact that there was more interaction between the teacher and the students in class, while there was no interaction among the students.
> **Researcher:** So there was more teacher-student interaction?
> **Yasmine:** Exactly. The teacher couldn't engage the students in that interaction. It was more of a question-and-answer format between the teacher and the students.

Additionally, during the discussion, some PMTs felt that the communication between the teacher and students was also insufficient. Many PMTs shared a common perspective that the teacher did not listen to every student, but only responded to those who provided the answers they wanted. One PMT's opinion regarding this was:

> **Yasmine:** I don't think the teacher values the students very much. The way they directly receive the answers they want from the students, both towards the students and their ideas, shows this. When communicating with the students, they adopt an approach of "Come on, give me what I want." They

also do not provide equal opportunities to those participating in the lesson; there is no equal opportunity in the classroom.
Robert: So the teacher is more concerned with getting the answers they want rather than the students' thoughts.

Another issue that the PMTs noted was the teacher's discourse towards the students. They stated that some of the teacher's comments were harsh and should have been more gentle. As a result, when the PMTs conducted a detailed evaluation of the teaching process during classroom discussions, most of them concluded that the teacher-student communication and student-student interaction were insufficient.

5. Discussion

The purpose of this study is to examine how the comments made by PMTs during individual video analyses evolve during classroom discussions, and how these discussions contribute to the development of new pedagogical perspectives. In this context, the aspects that PMTs focus on while analyzing a lesson video and their comments on these aspects have been identified. Subsequently, how these interpretations are shaped through classroom discussion activities has been revealed.

The findings of this study indicate that the factors considered by PMTs in video analysis are shaped around themes such as teacher pedagogy, mathematical thinking, student participants, and communication. In this context, within the scope of teacher pedagogy, the materials used by the teacher and questioning techniques were particularly prominent topics of discussion. In their individual analyses, PMTs pointed out that the materials used during the lesson aided students' learning. However, in classroom discussions, they emphasized that these materials were not used effectively, especially in terms of encouraging students to think and providing sufficient opportunities for them to form their own ideas. It was highlighted that using materials like a geometry board, which allows students to create their own geometric shapes, could lead to the emergence of richer thinking. These findings align with the existing literature. For instance, it is known that the use of concrete materials helps deepen students' understanding of abstract mathematical concepts (Hiebert & Grouws, 2007). Considering that learning processes are experience-based (Bransford et al., 2000), teaching materials play a critical role in facilitating students' processing and understanding of information (Kirschner et al., 2006; Mayer, 2010). However, the effective use of materials depends on whether they align with the teacher's pedagogical goals, how well they support students' conceptual understanding, and how much they foster critical thinking skills. In this study, PMTs discussed that the use of materials should serve a purpose and lead students to active thinking, concluding that the teacher's use of materials was not sufficiently effective.

PMTs' comments on the teacher's questioning behavior in their individual analyses were also significant. Initially, they noted that the teacher asked a sufficient number of questions. However, during classroom discussions, it became apparent that the questions mostly focused on procedural knowledge and did not support students' thinking processes or encourage critical thinking. This finding is also consistent with the literature, which argues that teachers' questioning strategies should be structured to develop students' higher-order thinking skills, rather than merely testing procedural knowledge (Black & Wiliam, 1998; Cayton et al., 2017; Kreide et al., 2015). Similarly, Franke et al. (2001) demonstrated that teachers' use of questions that elicit students' thinking deepens their conceptual understanding and increases student engagement. Therefore, the classroom discussion provided a platform for PMTs to reevaluate the quality of the questions asked by the teacher, shifting their focus from the quantity to the nature of the questions. This finding illustrates how video analyses can transform PMTs' pedagogical knowledge and skills. Sherin and Han (2004) also argue that teachers reassess their pedagogical approaches through video-based analyses, thereby improving their teaching strategies.

Another aspect that drew the attention of PMTs was students' mathematical thinking. In their written reflections, some PMTs noted that the classroom environment allowed students to express their thoughts and share their ideas. However, others provided negative feedback, stating that the teacher did not give sufficient value to student thinking and that students had limited opportunities to generate alternative solutions. In the classroom discussion, most PMTs agreed that the teacher preferred hearing specific answers rather than encouraging student thinking and tended to provide the correct answers themselves. This approach, which the PMTs critiqued, reflects the teacher-centered methods often criticized in the literature (Boaler & Staples, 2008; Brodie, 2011). During the classroom discussion, PMTs suggested that students should have more opportunities to express their ideas and generate alternative solutions through discussions and that the teacher should take on a facilitative role. The suggestions made during the discussions advocated for a teaching approach that promotes more intellectual autonomy among students. Specifically, they proposed that the teacher should encourage students to develop their thoughts through mutual discussions without directing their responses, an approach that is often referred to as an effective inquiry-based method in the literature (Walshaw & Anthony, 2008). In this regard, PMTs concluded that teachers should act not only as information transmitters but also as guides who facilitate students' thinking processes.

The findings regarding student participation reveal that PMTs' initial views on active student participation evolved. Initially, they considered students' physical involvement in the lesson activities sufficient for engagement. However, after the discussions, they emphasized that active participation should involve not only physical but also mental engagement. Students' participation in activities using materials during the lesson does not necessarily mean they are mentally involved in the process. Mental engagement requires a teaching approach that activates students' thinking processes and encourages critical thinking and problem-solving skills (Chi & Wylie, 2014). In this context, one of the main ways to strengthen mental engagement is by asking the right questions that prompt students to generate ideas, probe their thoughts critically, and open these thoughts up for discussion. Supporting mental engagement ensures that students are not merely passive observers or participants but individuals actively constructing their thoughts throughout the lesson. The PMTs concluded that, in this regard, the teacher did not sufficiently accommodate students' thinking processes and did not support their mental engagement in the lesson. They recognized that effective participation is achieved by listening to students' thoughts and shaping the lesson based on those thoughts. This realization, where PMTs highlighted the importance of mental engagement, reflects a significant development in their teaching practice, as their initial tendency to view classroom participation as purely physical evolved into a more comprehensive understanding after the discussions.

These findings reveal that PMTs offered different perspectives on teacher-student and student-student communication. While teacher-student communication was generally evaluated positively, some PMTs stated during classroom discussions that this communication remained superficial and that the teacher only sought the answers they wanted to hear. Additionally, there were criticisms that the teacher did not give equal opportunities to all students and did not listen sufficiently to some students' ideas. Although student-student communication was encouraged through group work, the classroom discussions revealed that this interaction was insufficient. Some PMTs emphasized that there was not enough communication between students and that the teacher was not effective in promoting this interaction. Overall, the PMTs concluded that both teacher-student and student-student interactions should be further supported. These findings suggest that PMTs developed an understanding of the critical role classroom communication plays in student success and engagement. Mercer and Howe (2012) argue that collaborative dialogues among students promote problem-solving and deep learning. Teachers can foster richer and more meaningful learning experiences by encouraging students to interact with each other rather than limiting classroom communication to a question-and-answer format (Webb et al., 2009). In this regard, the PMTs' critiques highlight the need to structure classroom communication processes more thoroughly and enrich them with a student-centered approach.

Taken together, the findings suggest a broader pattern. This study examines how PMTs developed their pedagogical perspectives through individual video analyses and whole-class discussions. The findings indicate that while PMTs initially provided limited or superficial evaluations in their written reflections, their views shifted and deepened during the class discussions. In particular, the discussions on the use of instructional materials, teachers' questioning techniques, student participation, and communication enabled PMTs to develop a more critical and pedagogically rich understanding of teaching practices. These results clearly demonstrate that the combination of video analyses and class discussions played a pivotal role in shaping and enhancing PMTs' pedagogical thinking.

Based on the above findings, two important conclusions can be drawn from this study. First, teaching videos provide a valuable resource for PMTs in developing new perspectives and understandings of pedagogical approaches. Notably, PMTs made numerous inferences regarding the contributions of the teacher's approaches to supporting student thinking. Additionally, they developed new insights into what is effective or ineffective in the teacher's questioning, teacher-student communication, student-student communication, and approaches to student participation. Teaching videos are, in this sense, a valuable resource. However, the most effective aspect of the lesson analysis for PMTs' development is classroom discussion. Through these discussions, PMTs evaluated the aspects they paid attention to in more detail and from a broader perspective. They incorporated their peers' comments into their own observations, leading to changes in the views of many PMTs. Therefore, it can be said that classroom discussions are a significant tool for the pedagogical development of PMTs.

The importance of teaching videos for PMTs' pedagogical development is widely addressed in the literature. Specifically, video-based lesson analyses provide PMTs with the opportunity to evaluate their own teaching practices and classroom interactions more deeply. Sherin and van Es (2009) argue that teaching videos are an effective tool for developing teachers' pedagogical knowledge and skills. Indeed, in this study, PMTs demonstrated increased awareness of classroom interactions through teaching videos and critically evaluated the teacher's questions, student participation, and teacher-student communication. Additionally, it was observed that they made important inferences regarding the ways the teacher supported student thinking and that these experiences enriched their pedagogical approaches. Thus, it can be said that video analyses contribute significantly to the pedagogical development of PMTs by enabling them to more effectively analyze classroom practices (Borko et al., 2008).

In addition to instructional videos, this study identified significant changes in the perspectives of PMTs through classroom discussions. Indeed, the contribution of classroom discussions to the pedagogical development of PMTs is frequently highlighted in the literature. These discussions encourage PMTs not only to reflect on their observations but also to compare their evaluations with their peers' perspectives (Korthagen, 2010). Such discussions enable PMTs to develop their pedagogical ideas not just individually, but within group dynamics. Classroom discussions can lead to changes in the PMTs' views and help them gain different perspectives (Little et al., 2003). In this study, PMTs had the opportunity to evaluate the points they focused on in the video from a broader perspective and reshape their pedagogical understanding with contributions from their classmates. Particularly, the questions posed by the researcher during the discussions had a strong impact on the PMTs' focus on reevaluating and commenting on the actions of the teacher in the instructional video. Furthermore, the PMTs' consideration and evaluation of each other's comments are also crucial factors in facilitating change. The development of mutual arguments among PMTs provided a discussion environment that allowed them to develop different perspectives, thereby offering opportunities to enhance their pedagogical knowledge (Lee, 2006; Posthuma, 2012). Thus, the results indicate the effectiveness of classroom discussions as a tool in the pedagogical development of PMTs.

In conclusion, the combined use of instructional video analysis and classroom discussions has a powerful impact on the pedagogical development of PMTs. Videos offer PMTs the opportunity to analyze classroom practices, while classroom discussions facilitate deeper engagement with these

analyses and allow PMTs to reevaluate their pedagogical approaches. The literature also indicates that significant progress is made in the professional development of PMTs when these two methods are used together (Santagata & Guarino, 2011).

6. Limitations and Recommendations

While the findings of this study provide important insights into the pedagogical development processes of PMTs, there are several limitations to consider. First, the research was conducted with a limited number of PMTs, which restricts the generalizability of the results. Future studies involving a larger participant pool could provide a more solid foundation for the findings and allow for broader inferences applicable to different teaching contexts.

Additionally, this study was based solely on PMTs' video analyses and classroom discussions. Employing various data collection methods could contribute to a more comprehensive examination of PMTs' pedagogical approaches. For instance, observations and feedback related to their own classroom practices could yield richer data on this process. Another limitation pertains to the temporal aspect of the study. The short-term effects of video analyses and classroom discussions on PMTs' pedagogical development were examined. However, more information is needed on how these developmental processes are sustained over the long term and how they are reflected in classroom practices. Future research could track PMTs' pedagogical development over a longer period to investigate whether these changes are lasting and how they impact their professional practices.

Furthermore, the quality of classroom discussions and their structuring can be a focus for future research concerning their impact on pedagogical development. Studies exploring which strategies are used to enhance the effectiveness of discussions and how PMTs are guided through these processes could provide valuable insights for more efficient implementation of this method. Finally, the balance between individual video analyses conducted by PMTs and group discussions should be investigated in more depth. Understanding how these two methods complement each other in fostering the pedagogical development of PMTs is essential. Future research should systematically analyze the advantages and challenges of each method in comparison to the other, providing comprehensive recommendations for establishing the most suitable combinations in teacher education programs.

Funding Statement: No funding was received for conducting this study.

Data Availability: The dataset analyzed during the current study is available from the corresponding author on reasonable request.

Declaration of Interest: The authors declare that no competing interests exist.

Ethical Approval: Author declares that the study was approved by Abant Izzet Baysal University Ethics Committee on February 15, 2018 with the approval number 2018/50. Additionally, informed consent was obtained from all participants.

Author contributions: All authors have sufficiently contributed to the study and agreed with the results and conclusions.

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