Scenario-Based Assessment of Productive Classroom Discussion Practices Among Middle School Mathematics Teachers: An Explanatory Sequential Mixed Methods Study

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Abstract

This study examined middle school mathematics teachers' implementation of productive classroom discussion practices using an explanatory sequential mixed-methods design. A scenario-based instrument was developed to assess seven dimensions of discussion practice within an integrated theoretical framework that combines planning-oriented practices for orchestrating classroom discussions with interactive discourse practices that support dialogic classroom interactions. The instrument was administered to a stratified random sample of 80 mathematics teachers in Jeddah, Saudi Arabia, followed by semi-structured interviews with six purposefully selected teachers representing high, moderate, and low levels of implementation. Quantitative findings revealed moderate to relatively high levels of implementation across the seven dimensions. Teachers demonstrated stronger implementation in planning-oriented practices, particularly in exploring mathematical tasks and anticipating student thinking, whereas lower levels were observed in dialogic practices such as encouraging explanation and connecting mathematical ideas. Statistically significant differences associated with teaching experience were found in the dimensions of selecting student responses and connecting mathematical ideas, while no significant differences were observed based on gender. Qualitative findings identified several contextual factors influencing teachers' implementation of productive classroom discussions, including time pressure, school culture, unclear instructional goals, and professional development opportunities. The integration of quantitative and qualitative findings suggests that teachers generally demonstrate greater competence in planning classroom discussions than in facilitating real-time mathematical discourse. The study highlights the value of incorporating scenario-based professional learning grounded in an integrated discussion framework into teacher preparation and professional development programs to strengthen teachers' planning and discourse facilitation competencies required for productive mathematical classroom discussions.

Keywords: productive classroom discussion, mathematics education, scenario-based assessment, teacher practices, classroom discourse, mixed methods

1. Introduction

Mathematics education has undergone significant transformations in recent decades. Educational goals have shifted beyond merely transmitting procedural or computational skills toward fostering deep mathematical understanding, critical thinking, and effective communication. In line with this vision, leading educational organizations—most notably the National Council of Teachers of Mathematics (NCTM, 2000)—have called for reshaping mathematics classrooms into productive learning environments where students engage in reflection, sense-making, and mathematically meaningful dialogue. These calls have been further reinforced by contemporary perspectives, such as critical mathematics education, which emphasize student agency and the socio-political dimensions of classroom discourse (Skovsmose, 2023).

Within this reform-oriented context, productive classroom discussion has emerged as a central component of high-quality mathematics instruction. Research consistently highlights its role in enabling students to articulate ideas, compare solution strategies, and construct coherent mathematical arguments (Wachira et al., 2013; Walshaw & Anthony, 2008). Empirical studies further demonstrate that engaging students in meaningful mathematical discussions

enhances both conceptual understanding and academic achievement (Kosko, 2012; Setianingsih et al., 2017), while also fostering more positive attitudes toward mathematics (Leatham et al., 2015).

Despite these reform efforts, classroom practices in many educational contexts—including several Arab educational systems—continue to follow traditional patterns. Research indicates that classroom discourse is still largely dominated by Initiation–Response–Evaluation (IRE) sequences, characterized by strong teacher control and limited student participation (Attard et al., 2018). In such environments, students often participate passively, focusing primarily on procedural responses rather than conceptual reasoning (Jansen, 2008). Radford (2016) interprets this phenomenon through the concept of educational alienation, suggesting that classroom routines may transform knowledge into a technical product and teachers into bureaucratic agents, thereby weakening students' engagement with meaningful mathematical thinking.

To address these challenges, several theoretical frameworks have been proposed to support teachers in planning and facilitating productive classroom discussions. One of the most influential frameworks is the Five Practices Framework (Stein et al., 2008, 2011), which identifies five key teacher practices: anticipating, monitoring, selecting, sequencing, and connecting students' responses. This framework provides a structured approach for orchestrating classroom discussions while maintaining the cognitive demand of mathematical tasks. Empirical studies support the effectiveness of the Five Practices Framework while also highlighting challenges in its implementation. For example, Heyd-Metzuyanim et al. (2019) found that teachers often struggled to align classroom discussions with lesson goals and to select and sequence student responses effectively. Similarly, Yılmaz and Yetkin-Özdemir (2021) reported that preservice teachers experienced difficulties incorporating all five practices into their instructional planning and classroom enactment. Bağdat and Yanık (2023) further emphasized that implementing cognitively demanding tasks successfully requires supportive classroom environments and careful instructional planning, conditions that are not always present in everyday teaching contexts.

To complement these structural aspects of discussion planning, King et al. (2022) proposed a framework that emphasizes teachers' interactive roles during classroom discourse. Their model highlights three main dimensions: conceptual questioning, facilitating peer interaction, and guiding discussions toward mathematical goals. This perspective expands the focus from planning discussions to managing the dynamic and dialogic nature of classroom interaction, positioning the teacher as a facilitator of mathematical discourse rather than merely a transmitter of knowledge.

However, the implementation of these frameworks remains inconsistent in classroom practice. Teachers frequently rely on drill-based instruction and often encounter difficulties initiating open-ended mathematical discussions (Mdladla, 2017). Likewise, Bağdat (2023) found that only one of four mathematics teachers successfully created opportunities for students to explore mathematical tasks and engage in meaningful dialogue. These findings highlight the limitations of traditional teacher preparation programs and underscore the need for context-sensitive assessment tools capable of capturing teachers' instructional decision-making in discussion-based environments. In response to this need, recent research has increasingly adopted scenario-based instruments that present teachers with realistic classroom situations requiring them to interpret and respond to instructional challenges, thereby revealing their underlying pedagogical reasoning (Grossman et al., 2009; Zembat & Yasa, 2015). DeLuca et al. (2019) further demonstrated that scenario-based assessments provide deeper insights into teachers' professional judgment, particularly in relation to formative assessment and instructional responsiveness.

Building on these developments, the present study addresses the lack of integrated assessment tools capable of capturing both the planning and interactive dimensions of productive classroom discussions within a single analytical framework. Accordingly, the study develops a scenario-based instrument that integrates the Five Practices Framework and the Interactive Discourse Framework to provide a comprehensive approach for assessing middle school mathematics teachers' implementation of productive classroom discussion practices. The study also examines whether implementation differs according to teachers' gender and teaching experience and explores the contextual factors influencing these practices through follow-up qualitative interviews. The study contributes to the literature by developing a scenario-based assessment instrument, integrating two complementary theoretical perspectives into a unified analytical framework, providing empirical evidence from the underrepresented Saudi educational context, and employing an explanatory sequential mixed methods design to generate a comprehensive understanding of teachers' implementation of productive classroom discussion practices and the contextual factors that influence them.

1.1 Theoretical Framework

1.1.1 Productive Classroom Discussion in Mathematics Education

Productive classroom discussion has become a central component of contemporary mathematics instruction, as it supports students' opportunities to articulate mathematical ideas, justify reasoning, and engage with multiple solution strategies. Rather than focusing solely on procedural correctness, discussion-oriented classrooms encourage students to participate actively in the construction of mathematical meaning through dialogue and collective reasoning. Research in mathematics education highlights that classroom discourse plays a critical role in fostering conceptual understanding, mathematical argumentation, and collaborative problem solving (Walshaw & Anthony, 2008; Wachira et al., 2013). In such environments, students are encouraged to explain their thinking, respond to peers' ideas, and evaluate alternative approaches, thereby transforming the mathematics classroom into a community of inquiry.

Despite the recognized importance of classroom discourse, implementing productive discussions in mathematics classrooms remains a challenging task for teachers. Managing multiple student responses, maintaining the cognitive demand of tasks, and guiding discussions toward meaningful mathematical goals require sophisticated pedagogical skills. Consequently, several theoretical frameworks have been proposed to support teachers in orchestrating effective classroom discussions and facilitating meaningful mathematical dialogue.

1.1.2 The Five Practices Framework

One of the most influential frameworks for organizing classroom discussions in mathematics education is the Five Practices Framework developed by Stein and colleagues (Stein et al., 2011). This framework provides a structured model that helps teachers manage classroom discussions while preserving the cognitive demand of mathematical tasks. The framework identifies five key teaching practices: anticipating students' responses, monitoring students' work during the task, selecting particular student responses for discussion, sequencing those responses in a purposeful order, and connecting students' ideas to key mathematical concepts.

The Five Practices Framework emphasizes the importance of careful instructional planning prior to classroom discussions. By anticipating possible student strategies and misconceptions, teachers can prepare to guide discussions in ways that highlight important mathematical ideas. During instruction, teachers monitor students' work to identify meaningful solution strategies and then select and sequence specific responses to support productive comparisons among different approaches. Finally, the connecting practice allows teachers to explicitly link students' contributions to broader mathematical goals, helping students develop deeper conceptual understanding.

Empirical research has demonstrated that the Five Practices Framework can help teachers organize productive classroom discussions and improve the quality of mathematical dialogue in classrooms (Stein et al., 2011). However, studies also indicate that teachers often experience difficulties implementing these practices effectively, particularly when managing discussions in real-time classroom situations (Heyd-Metzuyanim et al., 2019).

1.1.3 Interactive Discourse Framework

While the Five Practices Framework focuses primarily on the planning and orchestration of classroom discussions, other perspectives emphasize the interactive aspects of discourse during instruction. One such perspective is the Interactive Discourse Framework proposed by King et al. (2022), which highlights the teacher's role in facilitating dialogic interactions among students during mathematical discussions.

This framework identifies several discourse practices that support meaningful classroom dialogue, including conceptual questioning, facilitating peer interaction, and guiding discussions toward shared mathematical understanding. Through these practices, teachers encourage students not only to present their ideas but also to respond to and build upon the contributions of their peers. In this way, classroom discussion becomes a collaborative process of meaning-making rather than a sequence of teacher-led question–answer exchanges.

The Interactive Discourse Framework emphasizes the dynamic nature of classroom interaction, focusing on how teachers support student participation and sustain mathematical dialogue. By promoting questioning strategies, peer interaction, and reflective discussion, teachers can create learning environments where students engage more deeply with mathematical ideas and develop stronger reasoning abilities.

1.1.4 Integrating the Two Frameworks

Although both frameworks provide valuable insights into classroom discussion practices, they emphasize different dimensions of teaching. The Five Practices Framework focuses primarily on the planning and structural organization of classroom discussions. In contrast, the Interactive Discourse Framework highlights the interactive and dialogic processes that occur during the discussion itself.

Integrating these perspectives provides a more comprehensive view of productive classroom discussion. Planning practices such as anticipating and selecting student responses help teachers structure discussions effectively, while

interactive discourse practices support meaningful dialogue and student engagement during the discussion. By combining these complementary perspectives, teachers can better orchestrate classroom discussions that both maintain mathematical rigor and promote active student participation.

Building on this integrated perspective, the present study adopts a framework that combines planning-oriented discussion practices with interactive discourse practices. This integrated framework provides the conceptual foundation for developing a scenario-based instrument designed to assess middle school mathematics teachers' implementation of productive classroom discussion practices.

1.1.5 Linking the Integrated Framework to the Study Dimensions

Building on the integration of the planning-oriented discussion practices and the interactive discourse practices, the present study operationalizes this framework into seven analytical dimensions that reflect key aspects of productive classroom discussions. These dimensions include anticipating student thinking, exploring the task, monitoring and questioning, selecting student responses, facilitating peer interaction, encouraging explanation, and connecting mathematical ideas. Together, these dimensions capture both the structural organization of classroom discussions and the interactive processes that sustain mathematical dialogue. This integrated perspective provides a comprehensive lens for examining how teachers plan, facilitate, and manage productive mathematical discussions in classroom settings.

Based on the integration of the Five Practices Framework (Stein et al., 2011) and the Interactive Discourse Framework (King et al., 2022), the present study adopts an integrated perspective for examining productive classroom discussions in mathematics classrooms. Planning-oriented practices, such as anticipating student thinking and exploring mathematical tasks, provide the structural foundation for organizing discussions. In contrast, interactive discourse practices—including facilitating peer interaction, encouraging explanation, and connecting mathematical ideas—support the dynamic processes through which students construct mathematical understanding.

Accordingly, the present study conceptualizes productive classroom discussion as an instructional process that emerges from the interaction between planning practices and interactive discourse practices, while also being influenced by contextual factors such as teachers' professional experience, time constraints, and school culture

The integrated framework proposed in this study extends previous research by bringing together planning-oriented and interaction-oriented perspectives within a single analytical model. Rather than viewing discussion preparation and classroom interaction as separate processes, the framework conceptualizes productive discussion as a dynamic interaction between these complementary dimensions.

1.2 Statement of the Problem and Research Questions

Despite widespread calls in mathematics education to center instruction on reasoning, discussion, and effective mathematical communication (NCTM, 2000; Skovsmose, 2023), teaching practices in many middle school classrooms remain largely traditional. Instruction is often dominated by linear, teacher-centered approaches to classroom discussions, which limit meaningful learning opportunities and marginalize students' roles as active participants in constructing mathematical understanding (Attard et al., 2018; Jansen, 2008; Radford, 2016).

In response to these challenges, the literature has proposed several theoretical frameworks to support teachers in facilitating productive classroom discussions. Among the most influential is the Five Practices Framework (Stein et al., 2011), which focuses on planning and orchestrating classroom discussions through practices such as anticipating, monitoring, selecting, sequencing, and connecting students' responses. Complementing this perspective, the Interactive Discourse Framework (King et al., 2022) emphasizes teachers' interactive roles during classroom dialogue, particularly in promoting conceptual questioning, facilitating peer interaction, and guiding discussions toward mathematical goals.

However, despite the clarity and theoretical strength of these frameworks, empirical studies (Heyd-Metzuyanim et al., 2019; Yılmaz & Yetkin-Özdemir, 2021; Bağdat & Yanık, 2023) have documented persistent challenges in their effective implementation in real classroom settings. Factors such as limited instructional time, unclear learning objectives, and insufficient practical training often contribute to a gap between theoretical models of productive discussion and actual classroom practices. In addition, in many local educational contexts, there remains a lack of diagnostic tools capable of systematically assessing the extent to which teachers implement these discussion-oriented practices.

To address this gap, the present study seeks to assess the level of middle school mathematics teachers' implementation of productive classroom discussion practices using scenario-based classroom situations derived from an integrated

theoretical framework that combines the Five Practices Framework and an interactive discourse perspective. In addition, the study examines whether the level of implementation varies according to teachers' gender and teaching experience and explores the contextual factors that may influence these practices through follow-up qualitative interviews.

Accordingly, the study addresses the following research questions:

1. What is the level of middle school mathematics teachers' implementation of productive classroom discussion practices across the seven dimensions: anticipating, exploring the task, monitoring and questioning, selecting student responses, facilitating peer interaction, encouraging explanation, and connecting ideas?
2. Are there statistically significant differences in the level of implementation of these practices based on teachers' gender or teaching experience?
3. What contextual factors help explain the level of implementation of these practices as revealed through qualitative interviews?

2. Method

2.1 Research Design

This study employed an explanatory sequential mixed methods design (Creswell & Plano Clark, 2017), in which quantitative data were collected and analyzed first, followed by qualitative data to explain and interpret the quantitative findings. This design was appropriate for the purposes of the study because it first measured middle school mathematics teachers' implementation of productive classroom discussion scenarios and subsequently explored the contextual factors underlying these practices through teachers' experiences.

Integration between the quantitative and qualitative phases was achieved at two levels. First, the results of the quantitative phase were used to purposefully select participants for the qualitative interviews through a variation sampling strategy based on teachers' levels of implementation of discussion practices. Second, the qualitative findings were used to explain and interpret the quantitative results, particularly the observed differences between planning-oriented practices and interactive discourse practices. This integration allowed for a more comprehensive understanding of teachers' classroom discussion practices.

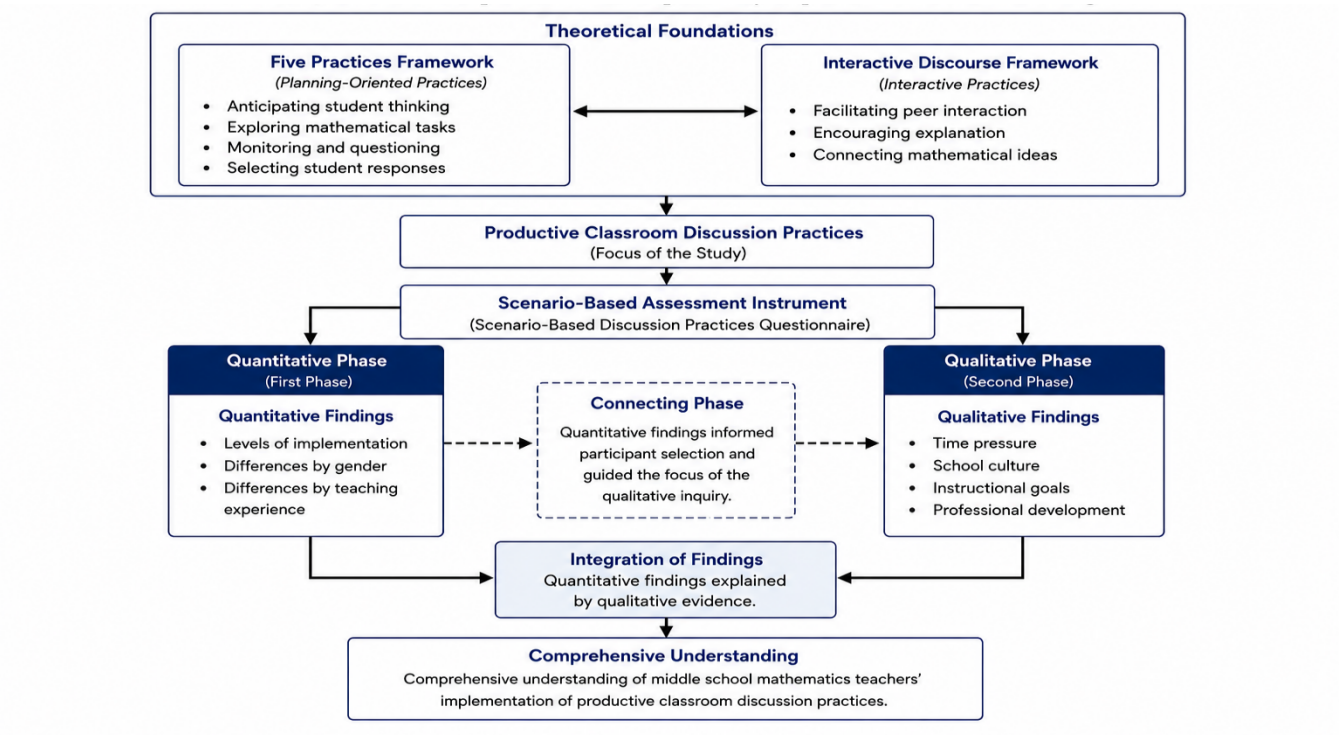

Figure 1. Integrated Conceptual Framework

Figure 1 Presents the Conceptual Framework of the Study. the Framework Illustrates How the Five Practices Framework and the Interactive Discourse Framework Informed the Development of the Scenario-Based Assessment Instrument and How the Quantitative and Qualitative Phases were Integrated Through an Explanatory Sequential Mixed Methods Design to Provide a Comprehensive Understanding of Middle School Mathematics Teachers' Implementation of Productive Classroom Discussion Practices.

2.2 Population and Sample

2.2.1 Quantitative Phase

The population consisted of all male and female mathematics teachers working in middle schools in Jeddah, Saudi Arabia, during the 2023–2024 academic year. A stratified random sample of 80 teachers was selected to ensure representation across gender and teaching experience categories (less than 5 years, 5–10 years, and more than 10 years). Stratified sampling was employed to enhance sample representativeness and to facilitate comparisons across experience groups.

2.2.2 Qualitative Phase

Following the quantitative analysis, a purposeful maximum variation sample of six teachers was selected to provide diverse perspectives on productive classroom discussion practices. Participant selection was based on their overall scores on the scenario-based instrument. Two teachers were selected from the upper score range, two from the middle score range, and two from the lower score range. This sampling strategy was intended to capture variation in instructional decision-making and to explore contextual factors that might help explain differences in teachers' responses to the discussion scenarios.

2.3 Instruments

2.3.1 Scenario-Based Questionnaire

A scenario-based questionnaire was developed to assess mathematics teachers' instructional decision-making in relation to productive classroom discussion practices. The instrument was designed to elicit teachers' professional judgments in response to realistic classroom situations derived from the integrated theoretical framework adopted in this study. Rather than directly observing enacted classroom practice, the instrument examined how teachers responded to discussion-oriented instructional scenarios that reflected common challenges in mathematics classrooms.

2.3.2 Scenario Development

The seven scenarios were developed through a multi-stage process. First, the literature on productive classroom discussions in mathematics education was reviewed, particularly the Five Practices Framework (Stein et al., 2011) and the Interactive Discourse Framework (King et al., 2022). Second, key dimensions representing productive discussion practices were identified and translated into realistic classroom situations reflecting common instructional challenges encountered by mathematics teachers. Third, the scenarios were reviewed by a panel of mathematics education specialists to evaluate their relevance, clarity, and alignment with the intended dimensions. Revisions were made based on expert feedback before the instrument was finalized.

The seven dimensions were:

1. Anticipating student thinking
2. Exploring the mathematical task
3. Monitoring and questioning students
4. Selecting student responses
5. Facilitating peer interaction
6. Encouraging explanation and justification
7. Connecting ideas and mathematical goals

Responses were measured using a five-point Likert scale ranging from:

1 = Much lower
2 = Slightly lower
3 = Similar
4 = Slightly higher
5 = Much higher

The class interval was calculated using the formula:

(Maximum score – Minimum score) ÷ Number of categories

Resulting in a class interval of 0.8.

The interpretation of mean scores was as follows:

Table 1. Interpretation of Mean Scores for Levels of Practice

Level of Practice	Mean Range
Much Higher	4.3 – 5.0
Slightly Higher	3.5 – 4.2
Similar	2.7 – 3.4
Slightly Lower	1.9 – 2.6
Much Lower	1.0 – 1.8

Representative Examples of Scenario-Based Items

To provide readers with a clearer understanding of the nature of the scenario-based instrument, Table 2 presents representative examples of items drawn from different dimensions of productive classroom discussion. These examples illustrate how the instrument operationalized the underlying theoretical constructs into authentic classroom situations requiring teachers to evaluate the extent to which each instructional practice reflected their own classroom practice. All responses were recorded using a five-point Likert scale ranging from 1 (Much Lower than My Practice) to 5 (Much Higher than My Practice).

Table 2. Representative Examples of Scenario-Based Items

Dimension	Representative Item
Anticipating	Before teaching a lesson, I anticipate the range of solution strategies, including common misconceptions, that students are likely to generate.
Monitoring and Questioning	While students are exploring a mathematical task, I monitor their thinking and pose probing conceptual questions that encourage them to explain and justify their mathematical reasoning.
Selecting	I intentionally select a variety of student solution strategies, including incorrect responses, to stimulate meaningful whole-class mathematical discussion.
Connecting	I connect students' ideas and solution strategies to the mathematical goals and key concepts of the lesson, helping students recognize relationships among different mathematical ideas.

Note. These examples are presented solely to illustrate the structure and content of the scenario-based instrument. The complete instrument comprised multiple scenario-based items representing all dimensions of productive classroom discussion. All items were rated on a five-point Likert scale ranging from 1 (Much Lower than My Practice) to 5 (Much Higher than My Practice).

2.3.3 Semi-Structured Interviews

To complement the quantitative findings, semi-structured interviews were conducted with the selected teachers. The interview protocol consisted of open-ended questions designed to explore teachers' reasoning, classroom practices, and contextual challenges related to discussion-based instruction.

Example questions included:

- What helps or hinders you in anticipating students' thinking?
- How do you deal with multiple solution strategies among students?
- Describe a recent classroom discussion and how you managed it.

2.4 Validity and Reliability

Content validity was established through expert review. The preliminary version of the scenario-based instrument was submitted to a panel of five specialists in mathematics education to evaluate the relevance, clarity, and representativeness of each scenario in relation to its intended dimension. Based on their feedback, revisions were made to improve wording and conceptual clarity before the final version of the instrument was prepared. Only scenarios that

achieved an agreement rate of at least 90% among the experts were retained in the final version.

To further strengthen content validity, each scenario was systematically mapped onto its corresponding dimension within the integrated theoretical framework adopted in this study. This process ensured consistency between the theoretical constructs and the scenario content, providing additional evidence of the instrument's content validity

Internal consistency was examined using Pearson correlation coefficients between items and their corresponding dimensions.

Reliability was assessed using Cronbach's alpha coefficients based on a pilot sample of 30 mathematics teachers. Table 2 presents the reliability coefficients for the study dimensions and the overall instrument.

Table 2. Reliability Coefficients of the Scenario-Based Instrument

Dimension	Number of Indicators	Cronbach's Alpha
Anticipating Student Thinking	3	.88
Exploring the Mathematical Task	2	.86
Monitoring and Questioning	2	.89
Selecting Student Responses	2	.87
Facilitating Peer Interaction	2	.91
Encouraging Explanation and Justification	2	.85
Connecting Ideas and Mathematical Goals	3	.90
Overall Instrument	16	.92

The trustworthiness of the qualitative findings was enhanced through several strategies. First, methodological triangulation was achieved by integrating quantitative survey results with qualitative interview data. Second, member checking was conducted by sharing summaries of the interview interpretations with participants and inviting them to verify the accuracy of the researchers' interpretations. Third, peer debriefing was carried out through discussions with two colleagues experienced in qualitative research, who reviewed the coding process and the interpretation of themes. These procedures helped strengthen the credibility and trustworthiness of the qualitative findings.

2.5 Data Analysis

2.5.1 Quantitative Data Analysis

Quantitative data were analyzed using descriptive statistics (means and standard deviations) to determine the level of implementation of discussion practices.

To examine differences based on gender and teaching experience, independent samples t-tests and ANOVA were conducted.

2.5.2 Qualitative Data Analysis

Qualitative interview data were analyzed using thematic analysis. The analysis proceeded through several stages. First, interview transcripts were read repeatedly to achieve familiarity with the data. Second, initial codes were generated and assigned to meaningful segments of text. Third, related codes were grouped into broader categories and potential themes. Fourth, themes were reviewed and refined to ensure consistency with the interview data and the purposes of the study. Finally, the themes were defined, named, and used to explain and interpret the quantitative findings.

3. Results

3.1 Level of Implementation of Productive Classroom Discussion Practices

To address the first research question, descriptive statistics (means and standard deviations) were calculated to determine the level of middle school mathematics teachers' implementation of productive classroom discussion practices across the seven dimensions of the scenario-based instrument.

The quantitative analysis revealed that the mean scores for the seven discussion scenarios ranged from 3.28 to 4.12, indicating moderate to relatively high levels of implementation.

Table 3. Level of Implementation of Productive Classroom Discussion Practices

Scenario	Mean	SD
Exploring the task	4.12	0.60
Anticipating	3.91	0.65
Monitoring and questioning	3.76	0.72
Selecting student responses	3.58	0.70
Facilitating peer interaction	3.47	0.74
Encouraging explanation	3.40	0.78
Connecting ideas	3.28	0.81

Overall, the findings indicate that teachers demonstrated stronger implementation in planning-related practices, particularly exploring the task and anticipating student responses, whereas lower levels were observed in dialogic practices such as connecting ideas and encouraging explanation.

3.2 Differences Based on Gender and Teaching Experience

To address the second research question, independent-samples t-tests and one-way analyses of variance (ANOVA) were conducted to examine whether teachers' implementation of productive classroom discussion practices differed according to gender and teaching experience. The results, including effect sizes (η^2), are presented in Table 4.

Table 4. Differences in Teachers' Implementation of Productive Classroom Discussion Practices by Gender and Teaching Experience

Variable	Dimension	Test	Statistic	p	η^2	Result
Gender	Overall discussion practices	Independent-samples t-test	0.84	.403	.009	Not significant
Teaching experience	Selecting student responses	One-way ANOVA	3.27	.044	.078	Significant
	Connecting mathematical ideas	One-way ANOVA	3.58	.032	.085	Significant

As shown in Table 4, no statistically significant differences were found in teachers' overall implementation of productive classroom discussion practices according to gender, $t = 0.84$, $p = .403$, $\eta^2 = .009$, indicating a negligible effect. In contrast, statistically significant differences according to teaching experience were found in the dimensions of selecting student responses, $F = 3.27$, $p = .044$, $\eta^2 = .078$, and connecting mathematical ideas, $F = 3.58$, $p = .032$, $\eta^2 = .085$. These findings suggest that teaching experience had a modest but meaningful influence on teachers' implementation of these two discussion practices, whereas gender had no meaningful practical effect.

3.3 Contextual Factors Influencing Discussion Practices

To address the third research question, qualitative interview data were analyzed using thematic analysis to identify the contextual factors that help explain teachers' implementation of productive classroom discussion practices. The identified themes are presented in Table 5.

Table 5. Themes Explaining Teachers' Implementation of Productive Classroom Discussion Practices

Code	Theme	Description
C1	Time pressure	Limited class time restricts extended classroom discussions
C2	School culture	Variation in administrative encouragement for discussion-based instruction
C3	Unclear instructional goals	Lack of clarity regarding the objectives of classroom discussions
C4	Professional training	Professional development improves teachers' instructional responses during discussions

These findings highlight the influence of institutional and contextual factors on teachers' ability to implement productive classroom discussions.

Theme 1: Time Pressure

Four of the six interviewed teachers identified limited instructional time as a major challenge affecting classroom discussions. They explained that curriculum coverage requirements often reduced opportunities for extended

mathematical dialogue.

"Sometimes we want students to discuss different solution strategies, but the lesson time is limited, and we need to complete the curriculum." (Participant 2)

Theme 2: School Culture

The six interviewed teachers expressed differing perceptions of administrative support for discussion-based instruction. Three teachers reported receiving encouragement from school leaders to implement discussion-based instruction, whereas the remaining three perceived a stronger emphasis on curriculum coverage and assessment results.

"Support from school administration makes it easier to allocate time for classroom discussions and student participation." (Participant 5)

Theme 3: Unclear Instructional Goals

Three of the six interviewed teachers indicated that classroom discussions were not always linked to clearly defined learning objectives, which reduced their effectiveness.

"Sometimes discussions occur, but the mathematical purpose behind them is not sufficiently clear." (Participant 4)

Theme 4: Professional Training

Five of the six interviewed teachers emphasized the role of professional development in strengthening their confidence and ability to facilitate productive classroom discussions.

"After attending training workshops on classroom discussions, I became more confident in encouraging students to explain their ideas and respond to their classmates." (Participant 1)

Differences were observed across the six interviewed teachers representing the high (n = 2), moderate (n = 2), and low (n = 2) score ranges on the scenario-based instrument. Teachers from the higher score range tended to describe discussion practices in terms of facilitating student reasoning, explanation, and connections among mathematical ideas. In contrast, participants from the lower score range placed greater emphasis on lesson completion, procedural accuracy, and curriculum coverage. Teachers from the middle score range demonstrated characteristics of both orientations. These differences provide additional insight into the variation observed in the quantitative findings.

3.4 Integration of Quantitative and Qualitative Findings

To provide a comprehensive understanding of teachers' implementation of productive classroom discussion practices, the quantitative and qualitative findings were integrated. Table 6 presents the major points of convergence between the two phases and the resulting interpretations.

Table 6. Integration of Quantitative and Qualitative Findings

Quantitative Finding	Qualitative Explanation	Integrated Interpretation
Exploring the task obtained the highest mean (M = 4.12)	Teachers reported confidence in planning mathematical tasks before instruction	Planning-oriented practices appear more established than interactive discourse practices
Connecting ideas obtained the lowest mean (M = 3.28)	Teachers described difficulties linking students' responses under time pressure	Real-time orchestration of mathematical discourse remains challenging
Experienced teachers scored significantly higher in selecting responses and connecting ideas.	Experienced teachers emphasized interpreting students' thinking during discussions.	Teaching experience appears to support advanced discussion facilitation skills.
No significant gender differences were found.	Participants described similar instructional expectations regardless of gender.	Discussion practices seem more influenced by professional experience than by demographic variables.

4. Discussion

The findings of this study provide important insights into how middle school mathematics teachers implement productive classroom discussion practices within an integrated framework that combines planning-oriented discussion

practices and interactive discourse practices.

The results indicated that teachers demonstrated relatively stronger implementation in planning-related practices, particularly anticipating student thinking and exploring mathematical tasks, compared with dialogic practices such as encouraging explanation, facilitating peer interaction, and connecting ideas. This interpretation was further supported by one participant's reflection on the classroom scenario: "Before presenting the angle task, I first think about which incorrect solution students are most likely to produce, especially confusing supplementary and complementary angles. Anticipating that misconception helps me prepare questions that guide the discussion rather than simply correcting the answer." (Participant 4). This pattern can be interpreted in light of the theoretical distinction between planning practices and interactive discourse practices.

From the perspective of the Five Practices Framework, anticipating student responses and exploring tasks represent preparatory actions that occur before or at the early stages of classroom discussion. These practices require teachers to analyze tasks and predict possible student strategies, which can often be carried out during lesson planning (Stein et al., 2011). In contrast, practices such as connecting ideas and encouraging explanation involve real-time orchestration of student contributions during classroom discourse, requiring teachers to manage multiple ideas simultaneously and guide the discussion toward meaningful mathematical conclusions.

This interpretation is consistent with previous research showing that teachers often find it easier to plan discussions than to manage them dynamically during instruction. For instance, Heyd-Metzuyanim et al. (2019) reported that teachers frequently struggle with coordinating students' responses and maintaining the cognitive demand of tasks during classroom discussions. Similarly, Yılmaz and Yetkin-Özdemir (2021) found that preservice teachers encountered difficulties implementing practices such as sequencing and connecting student responses in authentic classroom settings.

From the perspective of the Interactive Discourse Framework, the lower levels of implementation observed in practices such as facilitating peer interaction and encouraging explanation may reflect challenges in sustaining dialogic interaction among students. According to King et al. (2022), productive mathematical discussions require teachers not only to present questions but also to create opportunities for students to respond to one another's ideas and engage in collaborative reasoning. However, developing such dialogic environments requires advanced facilitation skills and supportive classroom conditions, which may explain the relatively lower implementation levels observed in these dimensions. This challenge was also evident in the qualitative interviews. One participant explained: "Allowing students to compare all three solutions takes much longer than simply presenting the correct answer. The challenge is keeping the discussion focused while students justify why one solution is mathematically stronger than another." (Participant 11).

The findings revealed no statistically significant differences in discussion practices based on gender, suggesting that teachers' ability to facilitate productive classroom discussions is not strongly influenced by demographic characteristics. Instead, these practices appear to be shaped primarily by professional experience and instructional context.

In contrast, statistically significant differences were found based on teaching experience, particularly in practices such as selecting student responses and connecting ideas. These practices require teachers to interpret students' thinking, identify mathematically meaningful contributions, and organize them in ways that support conceptual understanding. Such skills typically develop through accumulated classroom experience and reflective teaching practice. This interpretation was reinforced by an experienced teacher who reflected: "As my teaching experience increased, I no longer began with the correct solution. Instead, I intentionally started with the incorrect one because discussing why it was wrong encouraged students to examine the mathematical relationships more carefully." (Participant 15).

This finding is consistent with previous research highlighting the role of professional experience in developing teachers' discourse facilitation skills. For example, Bağdat and Yanık (2023) found that teachers with greater classroom experience were more capable of creating opportunities for students to explore mathematical ideas and participate in meaningful discussions. Similarly, studies in mathematics education suggest that experienced teachers develop stronger classroom orchestration abilities, enabling them to manage complex classroom interactions more effectively.

The qualitative findings provide further insight into the contextual factors influencing teachers' implementation of discussion practices. Several participants emphasized time constraints, curriculum pressure, and unclear instructional goals as major barriers to facilitating extended classroom discussions. One interviewee commented: "In this lesson, I would like students to discuss all three solutions, but limited class time often forces me to move directly to the correct

solution before students have fully explored the incorrect reasoning." (Participant 2).

These findings align with previous research indicating that institutional and structural conditions play a crucial role in shaping classroom discourse. For example, Mdladla (2017) reported that teachers often rely on procedural instruction when instructional time is limited, leaving little opportunity for open-ended discussion. Similarly, Attard et al. (2018) observed that classroom discourse frequently remains dominated by teacher-controlled interaction patterns in environments where curriculum coverage is prioritized over conceptual exploration.

The qualitative results also highlighted the importance of professional development and institutional support. Teachers who had participated in training programs reported greater confidence in managing classroom discussions and responding to students' ideas. A participant who had attended professional development workshops noted: "Professional development changed how I use incorrect solutions. Instead of correcting them immediately, I now ask students to explain why the reasoning behind a solution is mathematically valid or invalid before asking the class to agree on the most appropriate solution." (Participant 1). This observation supports the argument that developing discussion-based teaching practices requires sustained professional learning opportunities and supportive school cultures.

Taken together, the quantitative and qualitative findings provide a comprehensive understanding of teachers' implementation of productive classroom discussions. While the quantitative data revealed patterns in teachers' implementation levels across different discussion practices, the qualitative data helped explain the contextual factors underlying these patterns.

The convergence of these findings suggests that improving discussion-based instruction requires attention to both teacher competencies and institutional conditions. Teachers need opportunities to develop the pedagogical skills necessary to facilitate interactive discourse, while schools must provide the structural support and professional learning environments that enable such practices to flourish.

Beyond the immediate findings of this study, the results can also be interpreted within the broader transformation occurring in mathematics education. Contemporary reforms increasingly emphasize a shift from procedural, teacher-centered instruction toward dialogic and inquiry-oriented classrooms that support mathematical reasoning and collective knowledge construction. Within this paradigm shift, productive classroom discussion is considered a central pedagogical mechanism for engaging students in mathematical sense-making.

The findings of the present study suggest that while teachers demonstrate reasonable competence in planning discussion-oriented lessons, the enactment of dialogic interaction during instruction remains a significant challenge. This pattern reflects the transitional nature of current instructional practices, where traditional teaching routines coexist with emerging discussion-based approaches. Consequently, supporting teachers in developing both planning competencies and interactive discourse facilitation skills becomes essential for advancing the broader goals of contemporary mathematics education reforms.

The integration of quantitative and qualitative findings suggests that productive classroom discussion practices are shaped by the interaction between teachers' planning competencies and their ability to facilitate real-time classroom discourse. While planning-oriented practices appear relatively well established, dialogic practices remain constrained by contextual factors such as time pressure, school culture, and limited professional development opportunities. These findings indicate that improving discussion-based instruction requires simultaneous attention to both teacher expertise and institutional support.

Overall, the qualitative findings not only corroborated the quantitative results but also provided explanatory insights into why planning-oriented discussion practices were implemented more consistently than interactive discourse practices. The integration of both strands of evidence strengthened the interpretation of the findings and demonstrated the value of employing an explanatory sequential mixed-methods design to understand teachers' implementation of productive classroom discussion practices.

5. Limitations

Several limitations should be acknowledged. First, the study relied on a scenario-based instrument that assessed teachers' instructional judgments rather than actual classroom practices. Second, the study was conducted within a single educational context, which may limit transferability. Third, the qualitative phase involved a relatively small number of participants. Future studies may incorporate classroom observations and larger samples to further validate the findings.

6. Conclusion and Recommendations

This study examined middle school mathematics teachers' implementation of productive classroom discussion practices using a scenario-based assessment instrument developed within an integrated framework that combines the Five Practices Framework and the Interactive Discourse Framework. By adopting an explanatory sequential mixed-methods design, the study provided a comprehensive understanding of teachers' implementation of productive classroom discussions and the contextual factors influencing these practices.

The findings indicated that teachers demonstrated stronger implementation of planning-oriented discussion practices than interactive discourse practices. While teachers showed greater confidence in anticipating student thinking and exploring mathematical tasks, they experienced greater difficulty facilitating peer interaction, encouraging mathematical explanations, and connecting students' ideas during classroom discussions. In addition, teaching experience was associated with differences in selecting student responses and connecting mathematical ideas, whereas no significant differences were found according to gender. The qualitative findings further explained these results by highlighting the influence of time pressure, school culture, instructional goals, and professional development on teachers' instructional decisions during classroom discussions.

This study contributes to the literature by introducing a scenario-based assessment instrument that integrates two complementary theoretical perspectives within a single analytical framework. The findings also demonstrate the value of explanatory sequential mixed methods in explaining not only how productive classroom discussion practices are implemented, but also why variation in these practices occurs across teachers. Together, these contributions provide a more comprehensive perspective for understanding and evaluating productive classroom discussions in mathematics education.

Based on these findings, teacher professional development should extend beyond lesson planning to emphasize the facilitation of real-time mathematical discourse, including interpreting students' thinking, selecting mathematically meaningful responses, and connecting multiple solution strategies. Schools should also provide organizational conditions that support discussion-based instruction through adequate instructional time and sustained professional learning. Furthermore, scenario-based assessment instruments may serve as useful diagnostic tools for supporting teachers' professional growth and evaluating the implementation of productive classroom discussion practices.

Although the study offers valuable insights, it was conducted within a single educational context and employed a scenario-based assessment instrument together with a relatively small qualitative sample. Future research could validate the proposed instrument across different educational contexts, investigate the impact of professional development programs on teachers' discussion practices, and examine how productive classroom discussions influence students' mathematical reasoning, engagement, and learning outcomes.

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Author contributions

Bandar Marzoog Al-Mutairi was solely responsible for the study conception and design, instrument development, data collection, data analysis, interpretation of the findings, and drafting and revising the manuscript. The author read and approved the final manuscript.

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Data sharing statement

No additional data are available.