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Enhancing Pre-service Mathematics Teachers' Ability to Recognize Bias, Discrimination and Inequality in Linguistically Diverse Primary Mathematics Classrooms through Critical Discourse Analysis and Combining Content Trajectory and Language Trajectory

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Abstract

This research aimed to study the effect of an intervention designed to promote the ability to recognize bias, discrimination, and inequality among pre-service mathematics teachers in primary mathematics classrooms with linguistically diverse learners. The intervention integrated critical discourse analysis with a framework combining content and language trajectories. A quasi-experimental one-group pretest-posttest design was used with a sample of 30 third-year university students from a university in the lower northern region of Thailand. Research instruments included a 9-hour learning activity divided into three sessions, a record of participants' ability to recognize bias, and exit tickets. Quantitative data were analyzed using a dependent samples t-test, while qualitative data from the exit tickets were analyzed through content analysis. The results showed a statistically significant increase in the pre-service teachers' scores on the ability to recognize bias from a mean of 5.83 to 10.82 ($p < .001$) after participating in the activities. The intervention successfully developed their skills in observing and analyzing communication patterns that could exclude students, and it helped them identify issues of inequity in textbooks that fail to accommodate linguistically limited learners. Qualitative data from the exit tickets reflected a change in their attitudes and understanding of the teacher's role. These findings highlight the benefits of integrating such activities into teacher education curricula to enhance competencies in educational equity.

Keywords: Discrimination and Inequality, Linguistically Diverse, Critical Discourse Analysis, Language Trajectory

1. Introduction

Limited linguistic ability presents a significant challenge to equitable mathematics education. Language is not only a tool for communication (Vygotsky, 1978) but also a resource for learning mathematical concepts. It shapes how students engage in mathematical discourse and how they construct their identity in the classroom (Moschkovich, 2007). According to UNESCO (*2017*), equity involves valuing every student equally, appreciating their differences, and ensuring equal opportunities in three key areas: access to learning, participation in learning, and achieving high levels of success. Gutiérrez (*2009*) proposed a framework for equity in mathematics classrooms comprising four interconnected dimensions: Access, Achievement, Identity, and Power. The outcomes of an equitable classroom are not limited to knowledge acquisition but also include the development of a strong mathematical identity. Thus, equitable mathematics learning goes beyond content delivery; it is about nurturing students' identities as capable mathematical learners. Students' limited language proficiency affects all four dimensions of equity. Language barriers restrict access to content and hinder participation, which undermines both academic success and students' confidence in engaging with mathematical discourse. This, in turn, affects their academic success and their self-perception as incompetent mathematics learners, leading to a lack of power and confidence in participating in mathematical discourse. Inappropriate responses to these linguistic challenges in mathematics education can perpetuate learning inequities.

Linguistic limitations that affect mathematics learning can stem from various causes, including physical impairments, developmental delays, dyslexia, cultural differences, migration, unfamiliarity with or limited proficiency in the language of instruction, inadequate education during the COVID-*19* pandemic, and a lack of motivation or practice in reading and writing (Tiengyoo, *2021*; Institute for the Promotion of Teaching Science and Technology, *2023*; OECD, *2023*; Equitable Education Research Institute, *2024).* These factors impact mathematics learning to varying degrees. While students with severe physical or learning disabilities should ideally be taught by specialized teachers, many students with linguistic limitations are still integrated into mainstream classrooms (Tiengyoo, *2021*; Saardaium et al., *2025*), and the number of students facing literacy challenges is on the rise. Language issues in mathematics are not exclusive to students with disabilities; a number of mathematics educators believe that all students encounter linguistic challenges in mathematics, and every mathematics teacher has a role in enhancing language development related to the subject (Lager, *2006).* This is because the nature of mathematics involves technical terms, symbols, grammatical structures, and specific linguistic conventions that differ from everyday language. If teachers fail to provide adequate linguistic support, these limitations can hinder students' participation in mathematics learning (Moschkovich, *2002)* and, ultimately, their academic success. This challenge can perpetuate and exacerbate inequities in mathematics education. The current school system still struggles to create equitable opportunities for students with limited language proficiency. For example, ethnic minority students often face difficulties in solving mathematics problems due to a lack of understanding of general vocabulary and linguistic structures in problem statements, leading to misinterpretation, incorrect calculations, and flawed conclusions (Waiyawachamai, *2018).* This reality underscores that current mathematics instruction is not yet responsive to students' diverse linguistic abilities, and there is a growing call to enhance the competence of mathematics teachers to manage language-responsive learning (Tiengyoo, *2021*; Waiyawachamai, *2018).*

Teachers' beliefs and attitudes significantly influence their response to language-related inequities. Sharma and Sharma (*2023)* categorize teachers' perspectives on language in mathematics education from a multilingual viewpoint into four categories: Language as a Problem, Language as a Right, Language as a Resource, and Language as a Source of Meaning. Teachers who view language limitations as an obstacle often adopt the attitude that "if students are not proficient in language, it is difficult for them to understand mathematics well." This perspective can lead to labeling students, neglecting their true potential, and providing them with limited opportunities for development. Conversely, viewing language as a student's human right to use their preferred language can also pose instructional challenges if not managed appropriately. Therefore, a perspective that fosters an equitable classroom and the ability to be responsive to students' linguistic needs is essential for modern mathematics teachers. In response to this, Prediger and Pöhler (*2015)* propose a language-responsive approach to address linguistic inequity in mathematics, which involves multiple levels of language, including everyday academic and technical language. This approach emphasizes adapting teaching materials, language, and communication strategies to students' linguistic abilities, utilizing bilingual materials, enriching academic vocabulary, and connecting mathematical concepts to students' lived experiences. Such support, including the use of macro-scaffolding to foster simultaneous language and mathematical development, helps students achieve a deeper conceptual understanding.

Responding to students' linguistic abilities in the mathematics classroom necessitates teachers' noticing skills—a crucial component for identifying bias and unequal participation dynamics during instruction. These skills are a sub-competency of equity literacy (Gorski, *2017).* Research on this topic in the Thai context is scarce. However, a classroom action research study by Seetang & Nokkaew (*2024)* focused on developing mathematical identity in a classroom with non-literate students. The findings underscored the vital role of teachers in designing activities, supporting diverse forms of conceptual exchange, addressing classroom biases, and connecting students' ideas to build knowledge. Simultaneously, teachers must hold high expectations for all students to participate in presenting their thinking and discussing problem-solving methods, using open-ended questions to stimulate student expression. This approach enables students with limited linguistic abilities to engage and develop a positive mathematical identity.

The persistence of educational inequity due to differences in language proficiency is a systemic challenge that current educational systems in Thailand struggle to address. This rigid system of curricula, textbooks, and assessment practices often

places students with limited language skills at a disadvantage in using academic language. Amidst this inflexibility, teachers are crucial in challenging such learning inequities. However, despite evidence of the importance of language in mathematics education, Thai teacher education curricula rarely address how future teachers can recognize and respond to linguistic inequities. Effectively managing language-based learning in mathematics is a complex and demanding task that requires educators to have both strong mathematical knowledge and a deep understanding of language development. Therefore, all teachers, not just special education teachers, need to understand these complex learning issues and actively work to reduce language-related inequities in their classrooms (Brandt et al., *2023).* Raising awareness of these inequities and equipping teachers with the skills to deliver language-responsive, subject-specific instruction will ultimately increase learning opportunities and improve student success (Smith, *2021).*

In the context of mathematics education, textbooks serve as a primary discourse that shapes content, presentation, and values (Morgan, 2006). They are highly influential in forming students' perspectives, identities, and can subtly embed biases or stereotypes. While math textbooks are often perceived as neutral, the language, illustrations, examples, and contexts within word problems can reflect gender, racial, cultural, or class biases. These biases directly impact students' sense of belonging and their mathematical identity, especially for those from diverse linguistic and cultural backgrounds (O'Keeffe & O'Donoghue, 2015). Although recognizing biases in instructional materials is crucial, current teacher education curricula often lack activities that help pre-service teachers develop the ability to recognize bias, discrimination, and inequality embedded in mathematical discourse and textbooks—a fundamental skill for fostering equitable teaching practices in diverse classrooms (Amoussou & Allagbe, 2018). Therefore, integrating Critical Discourse Analysis (CDA) with a framework that combines content trajectory and language trajectory is a powerful approach to developing these critical skills. CDA is a tool that helps analyze discourse to reveal, expose, and challenge the hidden inequities that may be reproduced in both classroom instruction and textbooks (van Dijk, 2015). This approach aligns with Fairclough's discourse dimensions (1995), which examine the text, discourse practice (how text is produced and consumed), and sociocultural practice (the social context influencing these processes). Furthermore, Prediger & Neugebauer's (2023) four-level framework for combining content and language trajectories is used to analyze textbooks, which are a key medium influencing teacher practices (Valverde et al, 2002). This framework is based on the understanding that learning mathematics is not just about numbers and formulas, but also about using language to access mathematical knowledge. It recognizes that the structure, content, images, and language used in textbooks can present obstacles for students with limited language proficiency.

As a key teacher-training institution in the lower northern region, many pre-service mathematics teachers are placed in schools with students from families speaking local or ethnic languages, such as Northern Thai or Karen, rather than standard Thai. This linguistic diversity can hinder students' access to academic language and the specific symbols of mathematics, affecting their conceptual understanding and equitable classroom participation. However, an analysis of the Bachelor of Education curriculum reveals a lack of learning activities designed to help pre-service teachers critically analyze textbooks or recognize the biases and inequities embedded within the language and discourse of mathematics instruction. Consequently, some trainees are unable to question or reflect on pedagogical practices that may reproduce inequality during their teaching practicum. This situation underscores the critical need to develop learning activities that train pre-service teachers to cultivate a "critical gaze" and the ability to recognize bias by combining a content and language trajectory framework with a critical discourse analysis approach. This will prepare them to become professional mathematics educators capable of providing equitable and language-responsive instruction in diverse classrooms.

This study aims to investigate the effects of enhancing pre-service mathematics teachers' ability to recognize bias, discrimination, and inequity in primary mathematics classrooms with linguistically diverse students. This will be achieved by using Critical Discourse Analysis in conjunction with a framework that combines content trajectory and language trajectory as a tool for fostering critical learning. As part of a larger Design-Based Research (DBR) project, this particular study represents the third phase of a process to design, implement, and evaluate the effectiveness of these activities with a group of pre-service teachers.

Therefore, equity in mathematics education extends beyond mere content access; it encompasses the development of a positive mathematical identity and equitable classroom participation, especially for students with diverse linguistic backgrounds. This group often faces significant challenges in accessing content, engaging in classroom activities, and achieving academic success, as language is not just a tool for communication but a fundamental resource for conceptual understanding in mathematics. Teachers' attitudes towards students' language skills directly impact learning management, potentially reproducing existing inequities. Consequently, raising awareness and enhancing teachers' competence in language-responsive instruction are crucial. This research stems from the observation that current teacher education curricula lack the promotion of pre-service teachers' ability to recognize biases, discrimination, and inequities embedded in mathematical discourse and textbooks. This skill is foundational for preparing them to teach equitably in diverse classrooms. Consequently, this study aims to foster this critical ability in pre-service mathematics teachers by employing Critical Discourse Analysis (CDA) in conjunction with a Content and Language Integrated Framework to prepare them to become effective and professional educators who can capably manage linguistically diverse classrooms.

2. Research Methodology

2.1. Research Methodology

This study adopts a quasi-experimental, one-group pretest–posttest design within a broader Design-Based Research (DBR) framework (Wongpanit, 2021). The primary objective of this phase is to test the developed innovative activities aimed at enhancing the ability of pre-service mathematics teachers to recognize bias, discrimination, and inequity in primary mathematics classrooms with linguistically diverse students. This is achieved through the integration of critical discourse analysis with a framework that combines content trajectory and language trajectory.

2.2. Research Area, Population, and Sample

Research Area: This study's research site comprises a major pre-service teacher training university in Thailand's lower northern region, along with elementary schools located in linguistically diverse contexts. These schools, particularly those in rural and marginalized communities, serve students with varying linguistic backgrounds, such as speakers of regional Thai dialects or ethnic minority languages. This specific selection of research sites is crucial as it reflects the pressing need to equip pre-service mathematics teachers with the necessary skills to professionally navigate the challenges posed by linguistic diversity in real-world mathematics classrooms.

Sample: This study focuses on 30 third-year undergraduate pre-service mathematics teachers from a university in the lower northern region of Thailand. This specific group was selected using purposive sampling due to several key academic reasons. First, these students have already completed courses on instructional design for both primary and secondary levels, providing them with a solid theoretical and practical foundation in lesson planning. Second, as third-year students, they are either preparing for or are currently engaged in their student teaching practicums, a crucial period for shaping their educational philosophies and attitudes. Most importantly, all participants have teaching experience in schools with linguistically diverse contexts, where students use local dialects or ethnic languages. This experience makes them uniquely familiar with the challenges of teaching in classrooms with varying language proficiencies, providing essential insights that are directly aligned with the research's objective of enhancing their ability to recognize bias and inequity in linguistically diverse mathematics classrooms.

2.3. Research Instruments

The study will utilize the following instruments:

1) The activity, developed through a design-based research process, is aimed at enhancing the ability of pre-service mathematics teachers to recognize bias, discrimination, and inequity in linguistically diverse primary mathematics classrooms. This is achieved by using Critical Discourse Analysis in conjunction with a framework that combines content and language trajectories. Activities were designed based on the framework presented in Table 1.

Table 1. A Four-Level Framework of Combining Content Trajectory and Language Trajectory

Level	Conceptual Learning Trajectory to Mathematical Concepts	Language Learning Trajectory for Different Discursive Practices
1	Creating initial meaning for problems and their representation	Strategically using students' everyday resources to discuss initial concepts
2	Developing informal strategies within context and graphic representation	Building vocabulary related to general meanings to describe these meanings
3	Developing more formal procedures, independent of context and representation	Introducing formal terminology in a technical register for reporting procedures
4	Applying mathematical concepts and procedures to more complex problems	Introducing additional reading vocabulary to understand texts in unfamiliar contexts

The activity, which consists of three sessions, each lasting three hours for a total of nine hours, was validated by experts, with an Index of Item-Objective Congruity (IOC) ranging from 0.67 to 1.00. The intervention comprised three sessions, each lasting three hours, totaling nine hours, as detailed in Table 2.

Table 2. Activities to Promote the Ability to Recognize Bias, Discrimination and Inequality through Critical Discourse Analysis in Framework of Combining Content Trajectory and Language Trajectory

Class	Hour	Critical Discourse Analysis (CDA)			Expected Learning Outcomes
		Text	Discursive practices	Sociocultural practices	
	1	Pre-test			

Class	Hour	Critical Discourse Analysis (CDA)			Expected Learning Outcomes
		Text	Discursive practices	Sociocultural practices	
Class 1: Causes and Factors Affecting Disparity in the Mathematics Classroom	2	**Information** - PISA assessment results in mathematics and reading.	- What are the objectives of producing and disseminating PISA assessment results in mathematics and reading? - How should the PISA assessment results in mathematics and reading be consumed and interpreted?	- What are the social and cultural factors related to the production and consumption of PISA assessment results in mathematics and reading?	All students are aware of the causes and factors contributing to inequality in Thai mathematics classrooms.
	3	**Academic information** - Evaluation of Reading, Writing, and Numeracy (LAS) Proficiency Levels	- What are the aims of producing and disseminating the results of the Literacy, Arithmacy, and Savvy (LAS) assessment? - How should the results of the Literacy, Arithmacy, and Savvy (LAS) assessment be consumed and interpreted?	- What are the socio-cultural factors involved in the production and consumption of assessment results for Literacy, Numeracy, and Science (LNS) skills?	All students should be aware of the causes and factors contributing to inequality in Thai mathematics classrooms. Language barriers are one such factor.
Class 2: Language Barriers in Mathematics Learning	1 and 2	**Information** - Recorded mathematics instructional videos published on online media.	- What are the aims of producing and disseminating instructional mathematics videos for online media? - How are instructional mathematics videos from online media consumed and interpreted?	- What are the social and cultural factors related to the production and consumption of mathematics instructional videos published on online media?	All students are aware of the linguistic barriers in the teaching and learning of mathematics in the classroom.
	3	**Information** - The article presents a framework of combining content trajectory and language trajectory	- What is the intended purpose of the production and dissemination of this article? - How is this article consumed and interpreted?	- What are the social and cultural factors related to the production and consumption of this article?	All students are able to analyze textbook activities by framework of combining content trajectory and language trajectory

Class	Hour	Critical Discourse Analysis (CDA)			Expected Learning Outcomes
		Text	Discursive practices	Sociocultural practices	
Class 3: Analysis of Mathematics Textbooks on Fractions	1	**Information** - A comprehension test on fractions published via online media	- What is the intended purpose for the production and dissemination of this fraction comprehension test? - How is this fraction comprehension test to be consumed and interpreted?	- What are the socio-cultural factors involved in the production and consumption of this fractional comprehension test?	All students possess a correct conceptual understanding of fractions.
	2	**Textbooks** - Multiple mathematics textbooks on fractions from various publishers, according to the framework of combining content trajectory and language trajectory.	- What are the objectives of each publishing house in producing and disseminating mathematics textbooks on the topic of fractions? - How are the mathematics textbooks on the topic of fractions from each publishing house consumed and interpreted?	- What are the socio-cultural factors related to the production and consumption of diverse mathematics textbooks on fractions from various publishers?	All students can analyze curricula that do not accommodate students with language limitations.
	3	Post-test			

2) The assessment form used to record the ability of pre-service mathematics teachers to recognize bias, discrimination, and inequity in linguistically diverse primary mathematics classrooms through Critical Discourse Analysis and a combined content and language trajectory framework was also validated by experts, with its IOC values ranging from 0.67 *to* 1.00. The details are as follows.

Table 3. Records of Pre-Service Mathematics Teachers' Ability to Recognize Bias, Discrimination, and Inequality in Diverse Elementary Mathematics Classrooms, Analyzed through Critical Discourse Analysis in Conjunction with a Content and Language-Integrated Framework.

Interaction	Overt Behavior (Action) Indicating Communication that Prevents All Students from Accessing Mathematical Knowledge
Student-Learning Materials	Expected Observation: Identifies complex terminology or long, complicated sentences.
Student-Curriculum	Expected Observation: Observes that problems are only text-based, without images or alternatives.
Student-Student	Expected Observation: Identifies situations where students who cannot read are ignored.
Student-Teacher	Expected Observation: Identifies the use of closed-ended questions and rapid speech.

Table 4. Sample Assessment Criteria for Students' Ability to Recognize Bias, Discrimination, and Inequality in Mathematics Classrooms Through Literacy-Enhancing Activities

Interaction	Behavior displayed (Action): The communication observed does not enable all students to access mathematical knowledge. Analysis of video clips based on the CI theory.
M - Between Students and Learning Media	

Interaction	Behavior displayed (Action): The communication observed does not enable all students to access mathematical knowledge. Analysis of video clips based on the CI theory.
M1 - Errors in the Use of Learning Media	Using representations that confuse or mislead students, which are inappropriate for the context of the learners.
M2 - Lack of Diversity in Learning Media	Using learning media that does not cater to students' reading and writing abilities.
M3 - Tasks That Do Not Promote Thinking, Inquiry, or Conceptual Understanding	Tasks that emphasize memorizing procedural steps rather than encouraging inquiry or the correct conceptual understanding, which can be challenging for students with poor or underdeveloped reading and writing skills.
M4 - Lack of Student Engagement with Learning Media	Learning activities where students, especially those with poor or underdeveloped reading and writing skills, are not actively involved in using the learning media.

The analysis includes the following steps:

Initial Analysis of Responses: All participant responses were read and compared against the scoring rubric to ensure comprehensive coverage of the criteria. It was found that the scoring criteria, which were developed based on expert responses, adequately covered the participant responses.

Scoring Process: Each participant's response was scored individually. The scoring rubric was used to assign a score, with one point awarded for each observation that matched the expert's response.

Statistical Analysis: A dependent samples t-test was employed to compare the pre-test and post-test scores within the same group under the same variable.

3) The Exit Ticket is a short, open-ended questionnaire that takes approximately 5–10 minutes to complete after each of the three sessions. Administered via Microsoft Teams, its purpose is to capture students' reflections, perceptions, and understanding of the topics and activities covered in each session. The responses to the question, "What did you learn from today's activity?" will be used for subsequent qualitative analysis.

2.4. Data Collection

1) The pre-test is a crucial step for measuring students' existing knowledge and skills before an instructional activity begins. It provides baseline data for planning and adjusting the curriculum to effectively meet students' needs. In this study, the pre-test was administered to 30 pre-service mathematics teachers to assess their ability to recognize bias, discrimination, and inequity in the context of mathematics teaching. The resulting scores served as a baseline score for analyzing and comparing developmental progress after the educational intervention. This type of assessment not only helps instructors understand each student's strengths and weaknesses but also serves as a key tool for reflecting on learning outcomes and concretely outlining a path for developing critical social awareness.

2) The intervention activity was designed to enhance the ability to recognize bias through a systematically integrated conceptual framework. Critical Discourse Analysis (CDA) served as the core framework for analyzing and understanding implicit biases in language and media. Simultaneously, a Content and Language Integrated Framework was used to design learning activities that effectively integrated the topic of bias with students' language skills. This approach helped students not only to systematically identify and analyze bias but also to comprehensively develop their language skills for communication and accurate understanding. The activity was structured across three sessions, totaling nine hours, to provide ample time for in-depth learning and continuous practice.

3) The process of collecting data during instruction is vital for assessing learning outcomes and improving the quality of teaching. In this study, the researchers used an Exit Ticket—a tool for collecting both quantitative and qualitative data at specific points during the learning activity. Data was collected at the end of each session (sessions 1, 2, and 3) to gather continuous feedback from all students regarding the content and instruction. The collected data reflects students' levels of understanding, attitudes, and suggestions, which will be used to effectively refine and improve future lesson plans. The use of Microsoft Teams to distribute the online questionnaire facilitated a quick and thorough response process, ensuring that the data was comprehensive and could be analyzed in a timely manner.

4) The post-test is a critical process used to measure changes in students' knowledge, understanding, and skills after they have completed a learning process. In this case, the assessment was administered during the final hour of Session *3*, with the goal of measuring the learning outcomes of the pre-service teachers resulting from their participation in the preceding instructional activities. This quantitative data will help to concretely analyze and evaluate the effectiveness of the learning activities and will serve as a fundamental basis for further curriculum development and improvement.

2.5. Data Analysis

1) Quantitative Analysis: A dependent samples t-test was used to compare the pre- and post-activity scores on the ability to recognize bias, discrimination, and inequity within the same group of pre-service teachers. A Box Plot was also utilized to visualize the data distribution and key statistical values.

2) Qualitative Analysis: Two researchers independently coded the data using Elo & Kyngäs's (2008) content analysis approach. Coding discrepancies were discussed until consensus was reached, ensuring reliability. Categories were then grouped into themes to capture participants' perceptions and experiences.

3. Results

In this research study, the collected data were categorized and the findings presented in accordance with the pre-defined research objectives. The conclusions of this study can be summarized as follows:

The analysis of the pre-service mathematics teachers' scores on their ability to recognize bias, discrimination, and inequality before and after participating in the intervention revealed the following results.

Table 5. The Results of the Analysis Showed the Ability of Pre-Service Mathematics Teachers to Recognize Bias, Discrimination, and Inequality both before and after Participating in a Specific Educational Intervention.

Test	Participants (N)	Mean	SD	Cohen's d.	t	df	p
Pre-test	30	5.83	2.92	1.98	9.25	29	.000
Post-test	30	10.82	2.04				

Note: p<.001 indicates a statistically significant difference at the 0.001 level.

Based on Table 5, the average post-activity score of pre-service mathematics teachers on the ability to recognize bias, discrimination, and inequality (M=10.82, SD=2.04) was 4.99 points higher than the pre-activity score (M=5.83, SD=2.92). A statistically significant difference was found between the pre- and post-activity scores (t=9.25*)*, with a very large effect size (Cohen'sd=1.98).

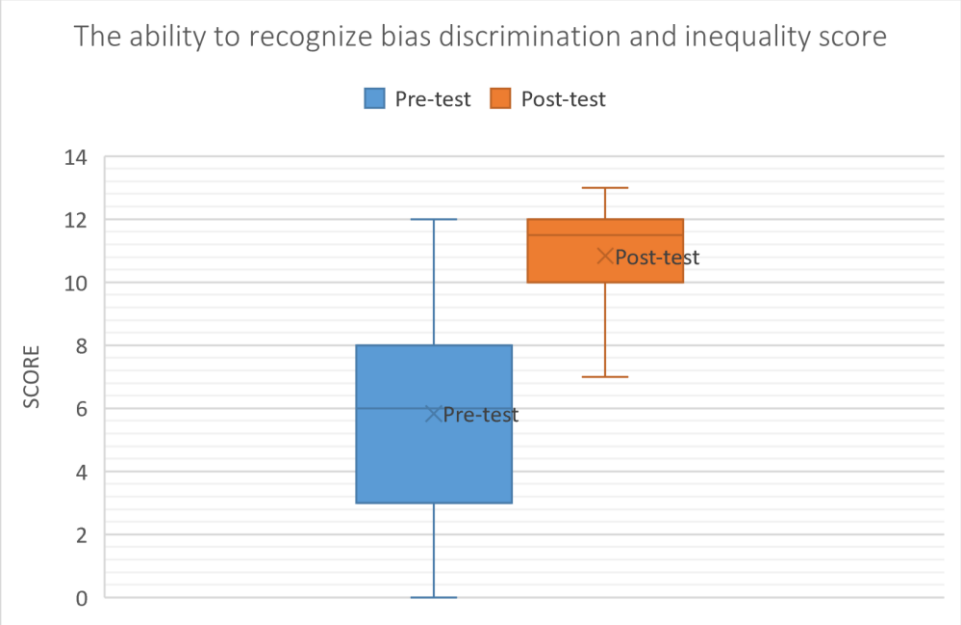

Figure 1. Box Plot

Based on Figure 1, which shows a box plot, the data distribution before participation (the box is wider, meaning Q3-Q1 is larger) indicates a wider spread for the middle *50%* of the data (ranging from approximately *3* to *8).* After participation, the box is narrower (Q3-Q1 is smaller), indicating a narrower spread for the middle 50% of the data (ranging from approximately 10 to 12). Overall, the scores of pre-service mathematics teachers clearly increased. Furthermore, the narrower distribution of scores after the activity suggests an improvement in the consistency of the results.

The analysis of responses to the post-class questionnaire from three sessions, based on the question, "What did you learn from today's activities?", yielded the following results:

Table 6. The Key Issues, Frequency, Percentage (%), and Examples that Appeared in the Students' Answers.

Key Theme	Frequency	Proportion (%)	Sample Student Responses
Session 1: The Disparity in Mathematics Learning Outcomes (30 responses)			
Socioeconomic Disparity and Family Background	21	70%	"Families with low incomes...parents without educational opportunities." "Some families cannot support their children's learning because they have to work from early morning, so their children have no one to help them with tutoring

Key Theme	Frequency	Proportion (%)	Sample Student Responses
			or homework." "Financial problems mean that some children don't even have a calculator or internet access, so they fall behind their peers in lessons."
Lack of Access to Teaching and Learning Resources	18	60%	"Schools in suburban areas lack teachers and have insufficient learning equipment." "Schools in remote areas have few teachers and have to reuse outdated media from many years ago." "Insufficient equipment and learning sources mean children don't get the chance to use real materials and have to imagine them from the blackboard."
Reading and Writing Abilities Affecting Mathematics Learning	16	53%	"Students lack the skills to read, write, and critically analyze problems." "Some have difficulty reading, which makes it hard to understand math problems, even if they are good at calculations." "Some students understand mathematics well when the teacher uses images or explains orally, but they cannot do tests that require interpreting long problems."
Classroom Management and Interaction	12	40%	"One teacher teaches multiple subjects...interactions are not comprehensive." "Teachers have so many students that they cannot care for or answer questions individually, so some children fall out of the learning process." "Sometimes communication between teachers and students is not smooth; children are afraid to ask or answer questions for fear of being criticized or compared."
Understanding of PISA Competency Assessment	9	30%	"Knowing that PISA measures critical thinking skills, not just calculation." "PISA makes us understand that education is about 'competency,' not just memorizing formulas. You have to be able to connect, analyze, and communicate as well." "From the PISA score graphs, we see that Thailand still has problems with reading, calculating, and analysis, creating a large gap between different schools."
Session 2: Language Barriers in Mathematics Learning (30 responses)			
Difficulty of Language and Technical Mathematical Terminology	26	87%	"The formal language used by teachers is confusing for children." "Teachers use language that is too difficult, such as the term 'mixed number,' which students don't understand even though they hear it often." "Words in problems are often complex, making it difficult for students to translate what is required for calculation or analysis."
Lack of Reading Skills and Problem Interpretation	20	67%	"If children cannot read the problem, they cannot continue to think." "Some students don't understand basic words in problems, such as 'how many times more,' so they get the answer wrong even if their calculation is correct." "Children who are weak in reading, despite having good calculation skills, cannot do the tests because they misinterpret the questions."
Ideas for Improving Communication to	18	60%	"Using simple language and more concrete media." "Using examples from real life, such as

Key Theme	Frequency	Proportion (%)	Sample Student Responses
Make it Easier to Understand			'dividing a pizza among friends,' instead of the word 'fraction,' helps children make connections." "Using spoken language more than written language in explanations, such as 'one-half' instead of '1/2,' helps children understand faster."
Awareness of the Impact of Language Barriers Creating Disparity	12	40%	"If teachers don't pay attention to whether children understand the language, it will widen the gap." "If a child cannot read, the problem is meaningless. Therefore, we must start by solving the fundamental reading issue." "Not understanding the language makes children feel bad about math, afraid of answering incorrectly, and eventually causes them to stop asking the teacher questions."
Session 3: Analysis of Mathematics Textbooks (Fractions) (30 responses)			
Using Media and Illustrations to Help Students Understand	22	73%	"Students who cannot read can still learn from the pictures in the textbook." "Textbooks with illustrations allow children who cannot read to still grasp the content, especially images of circles divided into parts that relate to real objects." "Using concrete media like pizza or fruit to explain fractions makes learning more fun and understandable than just theoretical explanations."
Sequential and Step-by-step Content Organization	19	63%	"The textbook arranges content from easy to difficult, which makes it easier to understand." "Some text in the textbook uses specific terminology, such as 'proper fraction' or 'improper fraction,' which children do not yet understand the meaning of and require time to explain." "The language used in the practice problems is long and formal; some children cannot interpret the meaning even if they are familiar with the content."
Explanations That Avoid Excessive Formal Terminology	15	50%	"Explanations should use language that students can generally understand." "Textbook content should gradually progress from 'one-half' and 'one-fourth' to complex fractions, but currently, it seems to skip ahead too quickly." "Some exercises in the early chapters use concepts that should be in later chapters, which confuses children who do not yet have a foundation."
Interaction Among Learners with Content/Teacher/Peers	14	47%	"Discussing with friends helps me see different perspectives." "It is evident that Japanese textbooks have sections that allow students to ask questions, which promotes classroom interaction rather than a one-sided lecture." "The activities in the book that require matching pictures with descriptions encourage children to talk and exchange ideas more in the classroom."

Note: 1 answer can reflect more than 1 important issue, so the proportions total can be more than 100%.

From Table 6, the trends in student responses from the end-of-class questionnaires are as follows:

1) Students demonstrated an awareness of linguistic barriers and structural inequality, reflecting on systemic limitations such as access to media, textbook composition, and learners' socioeconomic status, especially for those who are illiterate or lack linguistic capital. For example, a student noted, "The school lacks teachers. One teacher teaches many subjects. The teachers don't teach their specific major" (Student 26, Session 1). Another student commented, "The teacher speaks too fast; I

can't keep up and so I don't answer" (Student 22, Session 2). A third student added, "The textbook focuses on text with no pictures. It's difficult for illiterate children to understand" (Student 13, Session 3). The students began to understand that inequality is not solely an economic issue but is embedded in the design, content, and use of language.

2) Shifting Perspectives on the Teacher's Role and Classroom Interactions. There is a noticeable shift in perspective regarding the role of teachers and classroom interaction. Many preservice teachers highlighted the importance of clear communication and the necessity of creating a safe space for students to respond freely. For instance, one student noted, "If a child cannot read, they will be unable to understand what the question is asking" (Student No. 22, Session 2). Another student reflected that "Overly formal language confuses children" (Student No. 10, Session 2). Additionally, a third student suggested, "Some children have no foundational knowledge, so teachers should organize activities that use visuals to make concepts easier to understand" (Student No. 1, Session 3). These reflections indicate that students are beginning to critically observe teacher behaviors and the impact of language on students' access to knowledge.

3) Curriculum and Instructional Design for Learner Diversity. The analysis of a mathematics textbook on fractions revealed a need for instructional design that accommodates learner diversity. Several students suggested using images instead of text in word problems to assist learners with language limitations. For example, one student recommended, "Concrete materials should be used before abstract concepts to help children understand" (Student 13, Class 3). Another stated, "Explanations should not use overly specialized vocabulary, as children may not understand" (Student 9, Class 3). A third student suggested, "Content should be sequenced starting with what children are familiar with, such as images or real-life experiences" (Student 7, Class 3). These responses demonstrate the development of observational skills at the curriculum design and media production level, which can create an equitable mathematics classroom where students with language limitations can learn alongside.

4. Discussion

The research findings suggest that activities integrating critical discourse with the combination of content trajectory and language trajectory have high potential for enhancing pre-service mathematics teachers' ability to recognize bias, discrimination, and inequality in linguistically diverse classrooms. This is especially relevant in the context of the mathematics topic of "fractions," which is characterized by highly technical language and is often conveyed using academic language that can pose a barrier for students with varying language proficiency (Prediger & Pöhler, 2015; Vithal et al., 2024).

1) The analysis of pre-service mathematics teachers' ability to recognize bias, discrimination, and inequality showed a statistically significant increase from a mean score of 5.83 to 10.82 after participating in the intervention ($t = 9.254$, $p < .001$). This reflects how critical discourse and the combination of content and language trajectories can significantly transform pre-service teachers' perspectives, particularly in developing "critical noticing," or the in-depth observation of classroom interactions, which is crucial for advancing equity literacy skills. The very high effect size (Cohen's $d = 1.98$) indicates not only a statistically significant difference between pre- and post-intervention scores but also a practically significant one. The activities focused on critical discourse analysis and combining content and language trajectories clearly stimulated a change in the pre-service teachers' thinking. This finding is consistent with Gorski's (2017) concept, which states that equity literacy must be developed through the experience of analyzing and observing the structures of real-world inequities within a learning environment.

2) Based on the responses to the post-class surveys from all three sessions, students demonstrated a development of a critical gaze, as defined by CDA frameworks (Fairclough, 1995, 1989), and a critical perspective toward multidimensional issues of inequality. This critical analysis spanned various levels, from structural and linguistic aspects to instructional materials, particularly textbooks. Furthermore, students were able to connect these concepts with their personal classroom experiences and propose creative solutions for improvement. This mode of learning exemplifies the development of a "teacher as opportunity designer," which is a core tenet of equitable education. It also aligns with Gorski's (2017) concept of "Equity Literacy," which emphasizes that teachers should possess the skills to identify and address the dynamics of inequity in the classroom, viewing themselves not merely as content transmitters but as agents of structural change.

3) In a critical discourse analysis combined with the concept of content trajectory and language trajectory in mathematics textbooks, students can critique the content, images, language, and examples that may pose obstacles for learners with language limitations. For instance, some textbooks employ specific technical terms without providing definitions or visual aids, such as "improper fraction" or "mixed number." Regarding visual semiotics, while images are often seen as supplementary, they play a crucial role in either building or hindering opportunities for students with language limitations. For example, if images depict contexts from major cities, such as showing the division of a pizza, students from rural or remote areas may struggle to visualize the concept. Similarly, if textbooks present non-verbal communication forms like gestures or fraction symbols without any explanation, they may fail to support students who are illiterate or have difficulty with written language, thereby preventing them from engaging in learning. Therefore, textbooks should integrate content and language trajectories that allow all students to learn together. Students from diverse linguistic backgrounds can benefit equally from teaching approaches that consider and respond to this linguistic diversity (Prediger & Neugebauer (2023).

The development of teacher professional knowledge through the three-session activities reinforces Grossman's (2021) concept of "practice-based teacher education," which emphasizes direct experience and deep reflection through hands-on practice. This approach progresses from context analysis to textbook analysis and finally to practical application through post-

lesson video viewing. This process enhances both "noticing skills" and "professional noticing," aligning with the ideas of Sherin & Han (2004) and Jacobs et al. (2010). This involves seeing what a typical teacher might overlook, such as unintended exclusionary interactions and non-inclusive language. The activity design in this research not only develops skills in recognizing bias, discrimination, and inequity but also cultivates an awareness of the influential role of language and textbooks—considered primary media—in teachers' mathematics classroom practices (Valverde et al., 2002). This directly addresses the NCTM (2014) principles, which stipulate that teachers should "design" or "create" equitable learning environments and experiences that enable all students to succeed in mathematics, particularly in alignment with the "Access and Equity" principle and the "Effective Mathematics Teaching Practices."

The findings of this research indicate a shift in the attitudes of preservice teachers, reflecting the formation of a teacher identity as a facilitator of educational justice. This aligns with the proposal by Vithal et al. (2024), which emphasizes that equity research should encompass systemic structures, pedagogical practices, and the development of teacher identity simultaneously. Furthermore, this study highlights a gap in Thailand's teacher education system. Although the system emphasizes quality instruction that responds to students' diverse needs, it lacks systematic and continuous activities for developing equity literacy. According to Gorski's (2017) framework, equity literacy is the ability to clearly and courageously identify, analyze, and respond to injustice at all levels of the education system.

5. Conclusion

This research aims to enhance preservice mathematics teachers' ability to foster educational equity. The researchers define true equity not merely as access to content, but as the development of a positive mathematical identity and equal classroom participation for all students, particularly students with diverse linguistic backgrounds. This group often faces significant barriers to understanding content and engaging in classroom activities, as language is a crucial factor in grasping mathematical concepts. The findings indicate that teachers' attitudes toward students' language skills directly impact instructional practices and can lead to classroom inequities. Therefore, raising awareness and developing teachers' capacity for culturally and linguistically responsive instruction are essential. This study developed an intervention using Critical Discourse Analysis (CDA) in conjunction with a Content and Language Integrated Framework to train preservice teachers to identify and analyze the biases, discrimination, and inequities embedded in mathematical discourse and textbooks. This approach prepares them to become effective and professional educators capable of managing diverse classrooms.

6. Recommendations

6.1. Recommendations for Research Implementation

This activity can be integrated into pre-service teacher education curricula, particularly in courses focused on instructional design and discourse literacy. It is designed to foster pre-service teachers' skills in critical analysis, synthesis, and evaluation of information, which will effectively and sustainably enhance their critical awareness.

This research aims to develop a tool for training pre-service teachers. The knowledge and approaches derived from this study can be applied to enhance teacher training curricula on the topic of "equity pedagogy", particularly in linguistically diverse areas. This will ultimately help teachers manage their instruction more effectively and equitably.

This prototype for analyzing learning materials applies the concept of educational equity to the analysis of mathematics textbooks. The developed evaluation tool enables both educators and researchers to systematically and comprehensively examine learning materials, thereby promoting fair and equitable learning.

6.2. Recommendations for Future Research

The research could be extended into an action research study. The developed activities could be implemented with in-service teachers in authentic school settings to evaluate the flexibility and effectiveness of this pedagogical approach in modifying teaching practices. This would yield valuable empirical data that could inform the development of learning management guidelines, making them more appropriate and responsive to the realities of the classroom.

Long-term studies on teacher training in bias reduction are crucial. These studies should measure pre-service teachers' ability to recognize their own and others' biases and assess the durability of this skill in real-world situations, such as during student teaching or the initial years of their professional careers. This will allow for a more comprehensive evaluation of the training's effectiveness and help in developing sustainable approaches to promote equity in the classroom.

To further examine the practical scalability and efficacy of this model, a professional development program for in-service teachers should be developed and its effectiveness evaluated. This would allow for an assessment of the training package's flexibility in diverse contexts and provide a measure of how effectively the acquired knowledge and skills are applied in actual teaching practice.

References

Amoussou, F., & Allagbe, A. A. (2018). Principles, theories and approaches to critical discourse analysis. *International Journal on Studies in English Language and Literature, 6*(1), 11–18. https://doi.org/10.20431/2347-3134.0601002

Brandt, H., Ehmke, T., Kuhl, P., & Leutner, D. (2023). Pre-service teachers' ability to identify academic language features: The role of language-related opportunities to learn, and professional beliefs about linguistically responsive teaching. *Language Awareness, 33*(1), 70–93. https://doi.org/10.1080/09658416.2023.2194934

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing, 62*(1), 107–115. https://doi.org/10.1111/j.1365-2648.2007.04569.x

Equitable Education Research Institute. (2024, January 1). *Lessons from PISA 2022: What we see in resilient education systems*. https://research.eef.or.th/resilient-education-system/

Fairclough, N. (1989). *Language and power*. Longman.

Fairclough, N. (1995). *Critical discourse analysis: The critical study of language*. Longman.

Fernandes, A., & Kahn, L. H. (2021). Preservice teachers' beliefs in the context of teaching mathematics to English learners in the United States. *Avances de Investigación en Educación Matemática, 19*, 100–116. https://doi.org/10.35763/aiem.v0i19.400

Gorski, P. C. (2017). *Reaching and teaching students in poverty: Strategies for erasing the opportunity gap*. Teachers College Press.

Gutiérrez, R. (2009). Embracing the inherent tensions in teaching mathematics from an equity stance. *Democracy & Education, 18*(3), 9–16.

Grossman, P. (Ed.). (2021). *Teaching core practices in teacher education*. Harvard Education Press.

Herbel-Eisenmann, B. A., Steele, M. D., & Cirillo, M. (2013). (Developing) teacher discourse moves: A framework for professional development. *Mathematics Teacher Educator, 1*(2), 181–199. https://doi.org/10.5951/mathteaceduc.1.2.0181

Hirikokul, C., & Srikoon, S. (2024). A critical discourse analysis of gender ideology regarding alternative gender through Thai textbooks. *Trends of Humanities and Social Sciences Research, 12*(2), 45–60.

Institute for the Promotion of Teaching Science and Technology. (2023). *PISA 2022 assessment results*. https://pisathailand.ipst.ac.th/news-21/

Jacobs, V. R., Lamb, L. L. C., & Philipp, R. A. (2010). Professional noticing of children's mathematical thinking. *Journal for Research in Mathematics Education, 41*(2), 169–202.

Lager, C. A. (2006). Types of mathematics-language reading interactions that unnecessarily hinder algebra learning and assessment. *Reading Psychology, 27*(2–3), 165–204. https://doi.org/10.1080/02702710600642455

Lesh, R., Post, T. R., & Behr, M. (1987). Representations and translations among representations in mathematics learning and problem solving. In C. Janvier (Ed.), *Problems of representations in the teaching and learning of mathematics* (pp. 33–40). Lawrence Erlbaum.

Morgan, C. (2006). What does social semiotics have to offer mathematics education research? *Educational Studies in Mathematics, 61*(1–2), 219–245. https://doi.org/10.1007/s10649-006-5477-x

Moschkovich, J. (2002). A situated and sociocultural perspective on bilingual mathematics learners. *Mathematical Thinking and Learning, 4*(2–3), 189–212. https://doi.org/10.1207/S15327833MTL04023_5

Moschkovich, J. (2007). Using two languages when learning mathematics. *Educational Studies in Mathematics, 64*(2), 121–144. https://doi.org/10.1007/s10649-005-9005-1

Moschkovich, J. (2019). Codeswitching and mathematics learners: How hybrid language practices provide resources for student participation in mathematical practices. In J. Conteh & G. Meier (Eds.), *The multilingual turn in languages education: Opportunities and challenges* (pp. 165–180). Routledge.

National Council of Teachers of Mathematics. (2014). *Principles to actions: Ensuring mathematical success for all*. National Council of Teachers of Mathematics.

OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/40d9e1b5-en

O'Keeffe, L., & O'Donoghue, J. (2015). A role for language analysis in mathematics textbook analysis. *International Journal of Science and Mathematics Education, 13*(3), 605–630. https://doi.org/10.1007/s10763-013-9502-z

Prediger, S., & Neugebauer, P. (2023). Can students with different language backgrounds profit equally from a language-responsive instructional approach for percentages? Differential effectiveness in a field trial. *Mathematical Thinking and Learning, 25*(1), 2–22. https://doi.org/10.1080/10986065.2021.1919817

Prediger, S., & Pöhler, B. (2015). The interplay of micro- and macro-scaffolding: An empirical reconstruction for the case of an intervention on percentages. *ZDM–Mathematics Education, 47*(7), 1179–1194. https://doi.org/10.1007/s11858-015-0723-2

Riccomini, P. J., Smith, G. W., Hughes, E. M., & Fries, K. M. (2015). The language of mathematics: The importance of teaching and learning mathematical vocabulary. *Reading & Writing Quarterly, 31*(3), 235–252. https://doi.org/10.1080/10573569.2015.1030995

Saardaium, A., Mitranun, C., & Sirirak, C. (2025). Diagnosis of learning disabilities in mathematics: Numbers and numerals for students with mathematical difficulties in schools under the Bangkok Primary Educational Service Area Office. *Journal of Local Governance and Innovation, 9*(1), 45–58. https://doi.org/10.14456/jlgisrru.2025.4

Seetang, J., & Nokkaew, A. (2024). Development of grade 4 students' mathematical identities through 5 practices mathematics discussion learning activities in decimals. *Journal of Buddhist Education and Research, 10*(2), 113–125.

Sharma, S., & Sharma, S. (2023). Successful teaching practices for English language learners in multilingual mathematics classrooms: A meta-analysis. *Mathematics Education Research Journal, 35*(4), 821–848. https://doi.org/10.1007/s13394-022-00414-0

Sherin, M. G., & Han, S. Y. (2004). Teacher learning in the context of a video club. *Teaching and Teacher Education, 20*(2), 163–183. https://doi.org/10.1016/j.tate.2003.08.001

Smith, E. (2021). Positioning multilingual learners. *Mathematics Teacher: Learning and Teaching PK–12, 114*(12), 916–924. https://doi.org/10.5951/MTLT.2021.0035

Tiengyoo, K. (2021). Dyslexia and mathematics learning. *Mathematical Journal by the Mathematical Association of Thailand under the Patronage of His Majesty the King, 66*(703), 1–13.

UNESCO. (2017). *A guide for ensuring inclusion and equity in education*. UNESCO.

Van Dijk, T. A. (2015). Critical discourse analysis. In D. Tannen, H. E. Hamilton, & D. Schiffrin (Eds.), *The handbook of discourse analysis* (2nd ed., pp. 466–485). Wiley-Blackwell.

Valverde, G. A., Bianchi, L. J., Wolfe, R. G., Schmidt, W. H., & Houang, R. T. (2002). *According to the book: Using TIMSS to investigate the translation of policy into practice through the world of textbooks*. Springer.

Vithal, R., Brodie, K., & Subbaye, R. (2024). Equity in mathematics education. *ZDM–Mathematics Education, 56*(1), 153–164. https://doi.org/10.1007/s11858-023-01465-5

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Waiyawachamai, P. (2018). Analyzing errors on mathematics word problems made by ethnic primary-school students in Mae Hong Son province. *Journal of Research and Curriculum Development, 8*(1), 110–127.

Wongpanit, S. (2021). *Educational design research* (2nd ed.). Chulalongkorn University Press.