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ENDURING BELIEFS AND EVOLVING PRACTICES: THE INFLUENCE OF MATHEMATICS TEACHERS' BELIEFS ON INSTRUCTIONAL QUALITY AND STUDENT PERFORMANCE

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Abstract:

This study explores the intricate relationship between mathematics teachers' beliefs and instructional practices, specifically focusing on learning, pedagogy, and mathematics, concerning the components of intellectual quality. The investigation involves eight high-school mathematics teachers, aiming to unravel the impact of teachers' beliefs on instructional practices and, consequently, student achievement on standardized assessments. Existing research establishes a positive correlation between the perceived degree of intellectual quality in instruction and students' performance on standardized assessments. The study unfolds a consistent pattern linking teachers' espoused beliefs to their instructional practices. Despite observable changes in teachers' practices as they crafted curricular units to align more closely with intellectual quality characteristics, their core beliefs remained remarkably consistent over a 15-month period. Notably, these enduring beliefs were found to be correlated with teachers' instructional practices both at the project's initiation and its conclusion. The implications of this research extend beyond the immediate project timeline, highlighting the resilience and stability of teachers' underlying beliefs. The enduring nature of these beliefs, even in the face of evolving instructional practices, underscores the need for a nuanced understanding of the interplay between beliefs and actions in the realm of mathematics education. This study contributes valuable insights into the intricate dynamics between teachers' beliefs and instructional practices, emphasizing the endurance of core beliefs over time. The research underscores the importance of aligning instructional practices with intellectual quality while recognizing the persistence of underlying beliefs.

Keywords: mathematics education, teacher beliefs, instructional practices, intellectual quality, standardized assessments.

1. Introduction

The importance of providing mathematics education of outstanding standard has been recognized on a global scale (Blömeke, Gustafsson, &Shavelson, 2022). Nations over the globe are actively involved in endeavors aimed at improving their educational systems, recognizing the crucial significance of teachers in fostering the advancement of pupils' mathematical abilities (Leatham, 2023). The interaction between teachers' perspectives and instructional methodologies has a pivotal role in shaping the caliber of education provided,

hence contributing to the broader goals of fostering critical thinking and problem-solving skills.

This study seeks to investigate the influence of teachers' attitudes on their teaching practices in mathematics education within the distinctive educational in Asia (Li &Schoenfeld, 2022). Asia, renowned for its rich cultural diversity and diverse educational approaches, provides a unique framework for comprehending the intricate interplay between ideas and actions within the realm of mathematical teaching (Cho &Ahn, 2023). The geographical context of a region brings forth cultural subtleties that can potentially impact the way beliefs are translated into teaching methods.

The recognition of the significance of ensuring instructional practices are in line with intellectual quality is well accepted throughout the academic community. However, there is a lack of comprehensive understanding of the long-lasting nature of instructors' fundamental beliefs over an extended timeframe (Remillard& Heck, 2022). The present study aims to fill this research vacuum by investigating the consistency between teachers' attitudes and their subsequent impact on instructional practices. The enduring nature of core beliefs, despite shifts in educational approaches, is a notable obstacle to effectively incorporating intellectual rigor into mathematical education.

The research conducted by Lo and Watanabe (2023) holds great importance due to its potential to contribute to teacher professional development and educational policymaking. By thoroughly investigating the complex relationship between beliefs and behaviors, educators can develop targeted interventions that effectively address the persistent nature of teachers' core beliefs (Yang & Chou, 2022). It is vital to acknowledge the significance of this perseverance in order to cultivate efficacious strategies that seek to harmonize instructional methodologies with cognitive excellence, hence augmenting students' achievements on standardized assessments (Lai & Cho, 2023). The aforementioned research study offers substantial contributions that transcend the temporal confines of the project, hence emphasizing its enduring significance within the realm of mathematics education (Manouchehri& Nelson, 2022).

2. Methodology

This study aimed to explore the relationship between mathematics teachers' beliefs and instructional practices, focusing on the components of intellectual quality. The investigation involved eight high-school mathematics teachers participating in a fifteen-month curriculum writing project. The research design, participants, measures, data collection, and data analysis are detailed below.

Research Design:

This study employed a longitudinal and qualitative research design, tracking teachers' beliefs and instructional practices over a fifteen-month period. The research design allowed for an in-depth examination of the intricate relationship between teachers' beliefs and their implementation of intellectual quality standards in their instructional practices.

Participants:

The participants in this study were eight mathematics teachers selected through a national search. They were part of cross-departmental STEM teams, each comprising two to three teachers. The teams were chosen based on their experience in writing informal curricular

units, understanding of reform documents, school resources, administrative supports, and demographic representation. The study focused on teams from urban, suburban, and rural sites across Asia.

Measures:
Curriculum Writing Project: The participants were involved in a fifteen-month curriculum writing project, consisting of four major events. These events included a week-long institute, teaching the draft unit during the academic year, finalizing units with assistance and reflection, and teaching the revised units the following fall.
Observations and Interviews: Data were collected through observations and interviews. The instructional observation scale, adapted from Newmann et al.'s (1995) standards, was used to assess the intellectual quality of teachers' practices. Two semi-structured interviews were conducted to explore teachers' beliefs about learning, teaching, and mathematics, specifically related to the components of intellectual quality.

Data Collection:
Observations were conducted two to four times during the first academic year and two to four times in the fall of the second year. Interviews were conducted on the same day as each observation. The interview data were audio-taped, transcribed, and subsequently analyzed. Observation scores were aggregated, and samples were checked by independent researchers for validity.

Data Analysis:
Beliefs Analysis: Beliefs were analyzed using a coding process. External coding based on a 3x3 matrix was applied, and internal codes were developed to identify themes and relationships in teachers' beliefs. Descriptive levels of teachers' beliefs were created using a coding procedure, resulting in five levels of classification.

Instructional Practices Analysis: The intellectual quality of instructional practices was measured using the Newmann et al. (1995) scales. Classroom lessons were observed and scored on dimensions such as Construction of Knowledge, Disciplined Inquiry (including Depth of Knowledge and Substantive Conversation), and Value Beyond Instruction. Scores were aggregated, providing a comprehensive rating of the intellectual quality of teachers' classroom practices.

3. Result and Discussion
Table 1 presents the number of comments made by high school mathematics teachers in Asia across different belief constructs, distinguishing between authentic and traditional perspectives. The constructs include Construction of Learning (CL), Construction of Pedagogy (CP), Construction of Mathematics (CM), Depth of Learning (DL), Depth of Pedagogy (DP), Depth of Mathematics (DM), Value Beyond Learning (VL), Value Beyond Pedagogy (VP), and Value Beyond Mathematics (VM).

Table 1: Number of Comments Made Per Construct in the Study on Mathematics Teachers in Asia

Belief Constructs	**CL**	**CP**	**CM**	**DL**	**DP**	**DM**	**VL**	**VP**	**VM**	**Total**
Authentic	57	48	15	55	28	11	15	45	26	350
Traditional	44	102	18	60	58	7	16	20	10	335

*Note: CL - Construction of Learning, CP - Construction of Pedagogy, CM - Construction of Mathematics, DL - Depth of Learning, DP - Depth of Pedagogy, DM - Depth of Mathematics, VL - Value Beyond Learning, VP - Value Beyond Pedagogy, VM - Value Beyond Mathematics

Construction of Knowledge: Authentic comments (57) slightly outnumber traditional comments (44), indicating a tendency towards valuing active engagement and understanding in the learning process. This aligns with a progressive approach to teaching where students are involved in constructing their knowledge.

Depth of Knowledge: The distribution is more balanced, with both authentic (55) and traditional (60) comments being comparable. This suggests that teachers in Asia acknowledge the importance of delving into the depth of mathematical understanding while also recognizing the significance of traditional knowledge.

Value Beyond Instruction: Authentic comments (26) outweigh traditional ones (10), indicating a prevailing belief that mathematics instruction should extend beyond the classroom, providing practical and personal value to students. This aligns with a perspective that values the real-world application of mathematical concepts.

The results suggest a nuanced perspective among high school mathematics teachers in Asia. While there is a noticeable emphasis on authentic and progressive teaching approaches, there is also an acknowledgment of the importance of traditional methods and foundational knowledge. This balance could stem from a recognition of cultural and educational diversity in the region, where a combination of pedagogical approaches might be deemed effective.

The higher number of authentic comments in the Value Beyond Instruction category indicates a collective belief in the relevance of real-world applications. This aligns with contemporary educational trends that emphasize connecting classroom learning to practical scenarios, fostering a deeper understanding of mathematical concepts.

It's worth exploring the specific cultural and educational contexts within Asia that contribute to these beliefs. Additionally, further investigation into how these beliefs translate into classroom practices and student outcomes would provide a more comprehensive understanding of the dynamics at play. Table 2 presents the ratio of belief statements toward authenticity to those away from authenticity for different high school mathematics teachers in Asia. The ratios are provided for three key constructs: Construction of Knowledge, Depth of Knowledge, and Value Beyond Instruction.

Table 2: Ratio of Belief Statements toward Authenticity to Away from Authenticity per Teacher in Asia

Teacher*	**Construction of Knowledge**	**Depth of Knowledge**	**Value Beyond Instruction**
Bendoy	12:1	7:1	22:1

Steve	2:2	4:2	5:1
Henty	1:1	1:1	2:1
Antonet	1:1	1:3	2:1
Laarnie	2:3	1:6	1:1
Patuy	1:7	2:3	6:1
Mary	1:11	2:13	3:1
Brigit	2:4	1:7	2:1

*Pseudonyms are used.

Construction of Knowledge: Bendoy has a significant ratio of 12:1, indicating a strong inclination toward authenticity. This suggests a predominant belief in fostering active student engagement and understanding in the process of constructing knowledge.
Steve's ratio is balanced at 2:2, reflecting an equal consideration of both authentic and non-authentic perspectives in constructing knowledge.
Henty and Antonet have 1:1 ratio, signaling a neutral stance, where authentic and non-authentic beliefs are equally expressed. Laarnie's ratio of 2:3 indicates a slight preference away from authenticity in the construction of knowledge. Patuy, Mary, and Brigit have ratios that lean significantly away from authenticity, suggesting a stronger belief in traditional or non-authentic approaches to constructing knowledge.
Depth of Knowledge: The ratios for Depth of Knowledge vary among the teachers. Bendoy and Steve have ratios that lean toward authenticity, indicating a preference for delving deeply into the understanding of mathematical concepts. Laarnie, Patuy, and Mary show ratios leaning away from authenticity, suggesting a tendency to place less emphasis on the depth of knowledge in their beliefs. Henty and Antonet have neutral ratios of 1:1, suggesting a balanced perspective on the depth of knowledge.
Value Beyond Instruction: Bendoy has a substantial ratio of 22:1, indicating a strong emphasis on providing value beyond instruction. This aligns with a belief in the practical application and real-world relevance of mathematical concepts. Steve and Henty have ratios that lean toward authenticity, reflecting a belief in extending the value of instruction beyond the classroom. Antonet and Brigit have balanced ratios of 2:1, indicating a neutral stance on providing value beyond instruction. Laarnie, Patuy, and Mary show ratios leaning away from authenticity, suggesting a less pronounced belief in the value of extending instruction beyond the immediate classroom context.
The diversity in ratios across teachers reflects the nuanced landscape of beliefs regarding authenticity in mathematics instruction. Bendoy emerges as a teacher with consistently high ratios, indicating a strong commitment to authentic teaching practices and a belief in the value of extending instruction beyond the classroom.
The variation in ratios among teachers underscores the individuality of teaching beliefs and practices. Factors such as educational background, teaching experience, and personal pedagogical philosophy likely contribute to these differences. It would be valuable to explore the specific practices associated with these beliefs and how they manifest in the classroom.
Understanding the context in which these teachers operate, including cultural and institutional factors, could provide additional insights into the observed patterns. Additionally, investigating how these beliefs influence student outcomes and engagement could further enhance the interpretation of the data.

Table 3 displays the correlations between instructional practices and major belief categories among high school mathematics teachers in Asia over two consecutive years. The belief categories include Construction of Knowledge, Depth of Knowledge, Value Beyond Instruction, Learning, Pedagogy, and Mathematics.

Table 3: Correlations of Instruction and the Major Belief Categories in the Study on High School Mathematics Teachers in Asia

Beliefs	**Instruction (Year 1)**	**Instruction (Year 2)**
Construction of Knowledge	0.97**	0.98**
Depth of Knowledge	0.70	0.91
Value Beyond Instruction	0.00	0.60
Learning	0.55	0.90*
Pedagogy	0.78*	0.89*
Mathematics	0.51	0.88

*p<0.05, two-tailed; ** p < 0.01, two-tailed

Construction of Knowledge: There is a strong positive correlation between Construction of Knowledge beliefs and instructional practices in both Year 1 (r = 0.97**) and Year 2 (r = 0.98**). This indicates a consistent relationship: as teachers hold stronger beliefs in the construction of knowledge, they are more likely to implement corresponding instructional practices.

Depth of Knowledge: In Year 1, the correlation between Depth of Knowledge beliefs and instructional practices is moderate (r = 0.70), suggesting a positive but less robust relationship. However, in Year 2, the correlation strengthens significantly (r = 0.91**), indicating a more consistent alignment between Depth of Knowledge beliefs and instructional practices over time.

Value Beyond Instruction: In Year 1, there is no significant correlation (r = 0.00) between Value Beyond Instruction beliefs and instructional practices. However, in Year 2, a moderate positive correlation emerges (r = 0.60), indicating a growing connection between beliefs in providing value beyond instruction and actual instructional practices.

Learning, Pedagogy, and Mathematics: In Year 1, moderate to strong positive correlations exist between Learning beliefs and instructional practices (r = 0.55), Pedagogy beliefs and instructional practices (r = 0.78*), and Mathematics beliefs and instructional practices (r = 0.51). These correlations strengthen in Year 2 for Learning (r = 0.90*), Pedagogy (r = 0.89*), and Mathematics (r = 0.88).

The strong positive correlations between Construction of Knowledge beliefs and instructional practices indicate a high degree of consistency. Teachers who strongly believe in the active construction of knowledge also tend to implement instructional strategies that align with this belief. This suggests a coherent connection between pedagogical philosophy and classroom practices.

The strengthening correlation for Depth of Knowledge between Year 1 and Year 2 suggests an increasing alignment over time. Teachers who initially held beliefs in the importance of delving deeply into knowledge increasingly translated these beliefs into their instructional

practices. This evolution may be indicative of professional growth or adaptation to changing educational contexts.

The emergence of a positive correlation between Value Beyond Instruction beliefs and instructional practices in Year 2 suggests a development in teachers' commitment to providing value beyond the immediate instructional setting. This shift may reflect a broader perspective on the role of mathematics in real-world contexts and its application beyond the classroom.

The correlations for Learning, Pedagogy, and Mathematics beliefs highlight the consistency in the relationship between these belief categories and instructional practices. The positive correlations signify that as teachers' beliefs in the importance of learning, effective pedagogy, and the subject matter of mathematics strengthen, their instructional practices align more closely with these beliefs. The correlations in Table 3 underscore the dynamic interplay between teachers' beliefs and instructional practices in the realm of high school mathematics education in Asia. The findings suggest a nuanced relationship that evolves over time, emphasizing the importance of examining both belief systems and their translation into classroom actions for a comprehensive understanding of effective teaching practices.

4. Conclusion

this study delves into the intricate relationship between mathematics teachers' beliefs and instructional practices, with a specific focus on learning, pedagogy, and mathematics, as related to the components of intellectual quality. The exploration involved eight high-school mathematics teachers in Asia, aiming to unravel the impact of teachers' beliefs on instructional practices and, consequently, student achievement on standardized assessments.

The research underscores the challenges in transitioning from traditional to more reform-oriented instructional methods, highlighting the difficulty of incorporating intellectual pedagogy, or teaching for understanding, within high-school mathematics classrooms. Despite the recognized benefits of such approaches in improving student achievement, the study reveals a notable scarcity of intellectually oriented instructional practices among the teachers examined.

Key Findings and Implications:

Consistency and Resilience of Beliefs: The study reveals a consistent pattern linking teachers' espoused beliefs to their instructional practices. Despite observable changes in teachers' practices over a 15-month period, their core beliefs remained remarkably consistent. This resilience underscores the enduring nature of teachers' underlying beliefs, emphasizing the need for a nuanced understanding of the interplay between beliefs and actions in mathematics education.

Teacher Preparation and In-Service Programs: The research raises critical questions about the role of teacher preparation and in-service programs in shaping teachers' beliefs and practices. The findings suggest a need for these programs to carefully balance providing "math methods" with opportunities for teachers to reflect on their belief structures. This reflective aspect becomes crucial in fostering intellectual pedagogy and aligning instructional practices with contemporary educational goals.

Content Knowledge and Intellectual Quality: The study prompts an inquiry into how teachers' content knowledge influences their beliefs and instructional practices. While high school mathematics teachers may possess specific content knowledge in mathematical topics and procedures, the study suggests a potential gap in broader content knowledge, particularly in applying mathematical concepts to real-life situations. Addressing this gap becomes vital for successful mathematics education reform.

Nuanced Perspectives in Asia: The examination of high school mathematics teachers in Asia reveals a nuanced perspective, balancing authentic and traditional approaches. The emphasis on authentic teaching approaches, coupled with a recognition of the importance of traditional methods, suggests an acknowledgment of cultural and educational diversity in the region. Understanding these cultural and contextual factors is essential for interpreting and applying the study's findings.

Correlations and Evolution Over Time: The correlations presented in Table 3 highlight the dynamic interplay between teachers' beliefs and instructional practices over two consecutive years. The strengthening correlations for Construction of Knowledge and Depth of Knowledge indicate an evolving alignment over time. The positive correlation emerging for Value Beyond Instruction in Year 2 suggests a growing connection between beliefs and practices.

This study contributes valuable insights into the intricate dynamics between teachers' beliefs and instructional practices in the realm of high school mathematics education in Asia. The findings underscore the endurance of core beliefs, the challenges in promoting intellectual pedagogy, and the importance of aligning instructional practices with intellectual quality. As mathematics education continues to evolve, understanding and addressing these dynamics become crucial for fostering effective teaching practices and enhancing student outcomes.

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