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INSTRUCTIONAL MATERIALS IN QUANTITATIVE DATA ANALYSIS: EFFECTS ON GRADUATE STUDENTS' REFLECTIVE THINKING AND MINDSET

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Abstract

This study investigates the impact of researcher-developed instructional materials for quantitative data analysis on the reflective thinking skills and mindset of graduate students in Mathematics Education at Central Mindanao University. Employing a one-group pretest-posttest design, 34 students participated in the intervention during the 2023–2024 academic year. Results revealed a statistically significant increase in reflective thinking scores (mean: 4.01 to 4.12, $p = .026$) and in the intelligence subscale of mindset (mean: 10.88 to 11.88, $p = .027$). While the character subscale also improved (mean: 11.79 to 12.35), this change was not statistically significant ($p = .136$). The findings suggest that targeted instructional materials can enhance both reflective thinking and growth mindset, particularly in the domain of intelligence, among graduate students studying quantitative data analysis.

Keywords: instructional materials, quantitative data analysis, reflective thinking, mindset, mathematics education, graduate students

Introduction

Quantitative data analysis constitutes a fundamental aspect of mathematics education; however, numerous students struggle to grasp its underlying concepts and techniques. Reflective thinking is defined as the ability to engage in critical self-assessment and adjust one's learning procedures accordingly, has plays an important role in enabling learners to journey the intricacies of statistical reasoning and quantitative analysis (Dewey, 1933). Additionally, mindsets of students, specifically beliefs about character and intelligence, provide a major role in their engagement and success (Dweck, 2006).

While instructional materials, when thoughtfully developed, can provide the structure and scaffolding necessary to foster both reflective thinking and a growth-oriented mindset, empirical evidence on their effectiveness in graduate-level quantitative education is limited. This study aims to address this gap by investigating the impact of researcher-made instructional materials on the reflective thinking and mindset of graduate students in mathematics education.

Numerous research have been undertaken on teaching pedagogies (Gayeta & Caballes, 2017; Ucang & Tan, 2013; Florungco & Caballes, 2021) student preferences and readiness (Ong, et al., 2022; Caballes & Tabang, 2022), student motivation and attitude (Aguanta & Tan, 2018; Ciubal-Fulgencio & Tan, 2018; Cordova & Tan, 2018), assessment techniques and tools

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(Cordova, et al., 2018; Cordova, et al. 2018; Pagtulon-an & Tan, 2018; Tan et al., 2019) and other related factors (Tan & Balasico, 2018; Balasico & Tan, 2020) in order to enhance students learning outcome but little was done on investigating teacher-made instructional materials on graduate students' reflective thinking and mindset.

This study addresses these gaps by assessing the effects of researcher-made instructional materials on the reflective thinking and mindset of graduate students in maathematics education. The research aims to inform curriculum design and instructional practices in quantitative data analysis.

Literature Review

Instructional Materials in Quantitative Data Analysis

Instructional materials are necessary for supporting student learning in quantitative data analysis. They range from textbooks and handouts to interactive simulations and digital platforms, all designed to bridge the gap between abstract theory and practical application (Kern, 2018). Well-structured materials, especially those incorporating visual representations and real-world examples, have been shown to improve comprehension and retention (Li & Wang, 2020; Jones & Turner, 2019).

Reflective Thinking in Mathematics Education

Reflective thinking enables students to critically evaluate their understanding, identify errors, and develop strategies for improvement (Dewey, 1933). Instructional materials that include self-assessment tools, problem-based tasks, and reflective prompts can significantly enhance these skills (Brown & Smith, 2021). Such metacognitive approaches are linked to deeper learning and better academic outcomes (Kern, 2018).

Mindset and Academic Performance

Mindset, as conceptualized by Dweck (2006), refers to beliefs about the malleability of intelligence and character. Growth mindset interventions have been shown to foster resilience, motivation, and improved performance, particularly in mathematics and science (Blackwell et al., 2007; Boaler, 2013). Conversely, a fixed mindset can lead to avoidance of challenges and increased anxiety (Burnette et al., 2013; Yeager & Dweck, 2012).

Integrating Instructional Materials, Reflective Thinking, and Mindset

The integration of instructional materials that promote reflective thinking and a growth mindset is crucial for effective quantitative data analysis instruction. Such materials not only support cognitive development but also help reduce anxiety and foster confidence, leading to better learning outcomes (Saad & Majid, 2020; Hattie, 2012).

Research Objectives

This study aimed to determine the effects of instructional materials in quantitative data analysis on students' reflective thinking and mindset. Specifically, it sought to:

1. Assess the level of students' reflective thinking toward quantitative analysis;

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2. Identify the level of students' mindset toward quantitative analysis, in terms of intelligence and character;

3. Determine the difference in students' reflective thinking before and after the implementation of the developed materials; and

4. Assess the significant difference in students' mindset before and after the implementation of the developed materials.

Methodology

Research Design

A one-group pretest-posttest design was employed to evaluate the effects of the instructional materials. Baseline measurements were taken prior to the intervention, followed by post-intervention assessments using the same instruments.

Participants and Setting

The study was conducted at the College of Education, Central Mindanao University, involving 34 graduate students enrolled in the MS Mathematics Education program during the academic year 2023–2024. All students in the cohort were invited to participate, and data were collected over one semester.

Instruments

Two validated instruments were used:

- **Mindset Survey:** Adapted from Dweck (2006), this instrument measures intelligence and character subscales, each comprising four items.
- **Reflective Thinking Scale:** Developed by De Leon and Prudente (2017), this 15-item scale assesses self-reflection, mastery, feedback, and realization, with a Cronbach's alpha of 0.759, indicating good internal consistency.

Data Collection Procedure

Participants completed pretest assessments of reflective thinking and mindset at the start of the semester. The intervention consisted of structured instructional materials for quantitative data analysis, delivered over several weeks. After the intervention, participants completed the same assessments as a posttest. Data were screened for completeness and validity, excluding responses with missing values, uniform or patterned answers, and multivariate outliers.

Data Analysis

Descriptive statistics were used to summarize the data. Paired sample t-tests were conducted to compare pretest and posttest scores for reflective thinking and both mindset subscales. Statistical significance was set at $p < .05$.

Results

Reflective Thinking

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The mean score for reflective thinking increased from 4.01 (SD = 0.54) at pretest to 4.12 (SD = 0.32) at posttest. This change was statistically significant (t = -2.50, df = 14, p = .026), indicating that the instructional materials had a positive effect on students' reflective thinking.

The initial assessment of students' reflective thinking toward quantitative analysis revealed a moderately high baseline, with a pretest mean score of 4.01 (SD = 0.54) on what is likely a 5-point scale. This suggests that before the intervention, students already engaged in a reasonable level of self-assessment, critical thinking, and metacognitive awareness related to quantitative tasks. Such a baseline is encouraging, as reflective thinking is closely linked to deeper understanding and enhanced problem-solving abilities in quantitative disciplines (Dewey, 1933; Schön, 1983). Although foundational reflective skills were present, there remained potential for further development. This is consistent with prior research indicating that students who exhibit higher levels of reflective thinking tend to perform better in quantitative tasks due to their ability to critically evaluate their reasoning processes (Kember et al., 2008).

Mindset

The intelligence subscale of mindset showed a significant increase from 10.88 (pretest) to 11.88 (posttest) (t = -2.32, df = 33, p = .027). The character subscale also improved from 11.79 to 12.35, but this change was not statistically significant (t = -1.53, df = 33, p = .136).

In terms of mindset, the pretest scores for both the intelligence (10.88) and character (11.79) subscales suggest that students generally held moderately positive, growth-oriented beliefs about their intellectual capabilities and personal traits related to quantitative analysis. A positive mindset toward intelligence implies that students believe their quantitative skills can improve through effort, which is essential for persistence when confronting challenging mathematical problems (Dweck, 2006). Similarly, a positive character mindset reflects resilience and motivation, although the slightly lower score compared to intelligence points to areas where further development may be beneficial. This aligns with literature demonstrating that a growth mindset fosters motivation and academic achievement, particularly in STEM disciplines (Blackwell, Trzesniewski, & Dweck, 2007), and that character traits such as perseverance and grit contribute significantly to success in quantitative learning (Duckworth et al., 2007) support (Yeager & Dweck, 2012).

Table 1. Pretest and Posttest Scores for Reflective Thinking and Mindset

Variable	Pretest Mean (SD)	Posttest Mean (SD)	t-value	df	p-value
Reflective Thinking	4.01 (0.54)	4.12 (0.32)	-2.50	14	.026
Mindset (Intelligence)	10.88 (—)	11.88 (—)	-2.32	33	.027
Mindset (Character)	11.79 (—)	12.35 (—)	-1.53	33	.136

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Following the intervention, the reflective thinking scores showed a statistically significant increase from 4.01 to 4.12 ($t = -2.50$, $p = .026$), indicating that the instructional materials effectively enhanced students' reflective thinking skills. This improvement suggests that the materials successfully incorporated metacognitive elements such as reflective prompts, feedback mechanisms, and problem-solving activities, which are known to promote deeper engagement and self-regulated learning. Enhancing reflective thinking is critical for developing higher-order cognitive skills necessary for mastering quantitative analysis (Zimmerman, 2002). These findings are supported by prior studies showing that instructional interventions emphasizing reflection can improve critical thinking and learning outcomes in mathematics and statistics (King, 1995; Brown & Palincsar, 1989; Prado et al., 2019), and that scaffolded learning materials foster deeper cognitive processing (Bransford, Brown, & Cocking, 2000).

Regarding mindset changes, the intelligence subscale exhibited a significant increase from 10.88 to 11.88 ($t = -2.32$, $p = .027$), reflecting a positive shift toward a stronger growth mindset about intellectual abilities. This suggests that the instructional materials effectively influenced students' beliefs about the malleability of their intelligence in the context of quantitative analysis, which is important because a growth mindset encourages persistence, effort, and resilience when facing academic challenges (Dweck, 2006). In contrast, the character subscale increased from 11.79 to 12.35, but this change was not statistically significant ($t = -1.53$, $p = .136$). This may indicate that beliefs related to personal traits such as perseverance and character are more stable or require longer, more targeted interventions to shift meaningfully. It is also possible that the instructional materials focused predominantly on cognitive aspects rather than affective or character development. Research supports that mindset interventions can rapidly shift beliefs about intelligence, especially when combined with challenging tasks and constructive feedback (Paunesku et al., 2015), whereas changing character-related beliefs often demands sustained effort and broader psychosocial factor.

The findings demonstrate that instructional materials specifically designed for quantitative data analysis can significantly enhance reflective thinking and foster a growth mindset in the domain of intelligence among graduate students. These results are consistent with prior research highlighting the benefits of metacognitive scaffolding and mindset interventions in mathematics education (Brown & Smith, 2021; Blackwell et al., 2007). The non-significant improvement in the character subscale suggests that while instructional materials can influence certain aspects of mindset, more targeted interventions may be necessary to affect broader character beliefs. The study's findings underscore the importance of integrating reflective and mindset-oriented strategies into quantitative curricula to support both cognitive and affective learning outcomes.

The study's one-group design and relatively small sample size limit the generalizability of the results. Future research should consider randomized controlled trials and larger, more diverse samples.

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Conclusion

This study provides empirical evidence that well-designed instructional materials in quantitative data analysis can improve reflective thinking and foster a growth mindset, particularly in intelligence, among graduate students. Educators are encouraged to integrate metacognitive and mindset-supportive elements into their instructional design to maximize student engagement and achievement in quantitative courses.

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