

Methodological Rigor in Mathematics Education Theses

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Abstract

Graduate theses represent a critical stage in the development of research competence in mathematics education; however, limited attention has been given to the methodological characteristics and rigor-related practices reflected in these studies. This study examined the methodological characteristics of 135 theses from the Master of Arts in Mathematics and Master of Arts in Teaching Mathematics programs through a documentary research design employing systematic review procedures and summative content analysis. Specifically, the study analyzed trends in research approaches and designs, research settings, participants, sampling procedures, data collection instruments, data types, and analytical methods. Findings revealed a strong dominance of quantitative, school-based, and student-focused studies, with most theses utilizing convenience sampling, questionnaire-based instruments, and interval-level data analyzed through commonly employed statistical techniques such as means, t-tests, and correlations. In contrast, qualitative and mixed methods approach, diverse participant groups, non-school contexts, methodological triangulation, and advanced analytical procedures were minimally represented. These patterns appear to reflect the professional contexts and methodological preferences commonly encountered by practicing teacher-researchers, as well as the techniques in analysis most frequently highlighted in graduate research guidance. While the findings demonstrate foundational methodological engagement, they also indicate limited diversity in research approaches, participant contexts, and analytical procedures, which may limit methodological rigor and generalizability. The study provides evidence-based insights into prevailing methodological practices in graduate mathematics education research and highlights the need to strengthen methodological training through broader exposure to qualitative and mixed-methods approaches, advanced analytical techniques, improved sampling strategies, and stronger methodological coherence in graduate research programs.

Keywords: Content Analysis, Graduate Theses, Mathematics Education Research, Methodological Characteristics, Research Trends.

Introduction

Methodological rigor is widely recognized as a critical component of quality educational research because it influences the validity, reliability, and applicability of research findings (1, 2). In researches in mathematics education, methodological decisions related to research design, sampling procedures, data collection instruments, and analytical techniques shape the extent to which studies contribute meaningful and generalizable insights to theory and practice (3). As educational issues become increasingly complex, there is growing emphasis on strengthening methodological diversity and analytical depth in graduate research to ensure that research outputs provide credible and contextually relevant evidence (4). Research methodologies not only determine how educational phenomena are examined but also influence the trustworthiness and transferability of conclusions generated from research findings.

Consequently, the quality of methodological choices made by researchers has become an increasingly important concern in educational inquiry and graduate research training. Within mathematics education, methodological rigor is particularly important because the discipline often addresses multifaceted issues involving cognition, pedagogy, classroom interaction, assessment, curriculum, instructional effectiveness, and learner diversity. These areas require research approaches capable of capturing both measurable outcomes and contextual complexities. Studies have shown that methodological diversity enhances the explanatory and interpretive strength of educational research by allowing researchers to investigate problems from multiple perspectives (1). Similarly, the alignment between research questions, design, sampling procedures, instruments, and analytical techniques contributes significantly to the overall rigor and coherence of a

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study (2). Inadequate methodological alignment may weaken the validity of findings and limit the applicability of research outcomes to broader educational settings. Moreover, educational researchers have emphasized that rigorous methodologies are essential for generating evidence that can inform curriculum development, instructional interventions, policy formulation, and classroom decision-making (3).

Previous studies examining educational and mathematics education research have reported a strong dominance of quantitative methodologies, particularly descriptive and correlational designs, alongside limited utilization of qualitative and mixed-methods approaches (5, 6). Existing literature also highlights recurring concerns regarding convenience sampling, restricted participant representation, and heavy reliance on basic statistical analyses (7, 8). Although quantitative approaches remain valuable for examining relationships, trends, and instructional outcomes, excessive dependence on a limited range of methodologies may constrain analytical depth and contextual understanding. Qualitative and mixed-methods approaches, on the other hand, provide opportunities for richer interpretation, triangulation, and contextual analysis that may strengthen educational research findings (4). Recent discussions in educational research likewise emphasize the need for greater methodological pluralism to address increasingly complex educational issues and diverse learner experiences.

Prior investigations of methodological trends have largely focused on published journal articles and broad educational research outputs rather than graduate theses. Graduate theses represent formative scholarly works that reflect institutional research culture, methodological training, and the developing competencies of teacher-researchers. As such, they provide important insights into prevailing research practices within graduate education programs. Despite this significance, limited attention has been devoted to examining how methodological rigor is manifested in graduate-level mathematics education theses. Existing studies have often emphasized descriptive reporting of methodological frequencies without critically evaluating how methodological choices contribute to or constrain rigor, validity, analytical depth, and generalizability of findings (2, 9).

Consequently, methodological issues related to research design diversity, sampling practices, instrument utilization, and analytical approaches remain insufficiently evaluated in graduate mathematics education research.

Graduate theses are also important indicators of research capacity-building within higher education institutions because they demonstrate how graduate students apply methodological knowledge in actual research practice (10). The methodological characteristics reflected in graduate theses may reveal institutional strengths and limitations in research mentoring, curriculum implementation, and methodological training. Moreover, since many graduate students in mathematics education are practicing teachers, their methodological preferences may also reflect the practical realities and constraints encountered in educational settings, such as accessibility of participants, time limitations, institutional requirements, and availability of resources. While these contextual factors may influence methodological choices, they also contribute to the continued dependence on familiar and procedurally accessible research approaches.

Understanding the methodological characteristics of graduate theses is also important because practicing teachers play a significant role in shaping students' research knowledge and practices. As research is integrated into the junior high school and senior high school curricula, teachers who conduct and apply research are likewise expected to guide students in the proper implementation of correct methodology in doing research. Consequently, the methodological orientations and practices demonstrated by graduate students may eventually influence how research is taught and implemented in basic education settings. Examining these methodological patterns may therefore provide a valuable basis for future curricular enhancements and research training initiatives to ensure that appropriate and rigorous methodological practices are strengthened and effectively cascaded to student researchers.

Understanding these methodological patterns is therefore important not only for evaluating the quality of graduate research outputs but also for identifying areas where graduate programs may strengthen methodological instruction, research mentoring, and analytical training.

This study addresses these gaps by examining and evaluating the methodological characteristics of graduate mathematics education theses. Specifically, it contributes to the literature by integrating descriptive and evaluative analyses of research methodologies rather than merely documenting methodological frequencies. The study aims to describe theses in terms of research design, locale, participants, sampling procedures, instruments, data type, and statistical analysis; identify methodological gaps and limitations; and propose evidence-based directions for strengthening methodological rigor in mathematics education research. By providing an empirical evaluation of methodological practices in graduate theses, the study seeks to contribute to ongoing discussions on research quality, graduate research training, and methodological capacity-building in mathematics education.

Methodology

Research Design

The study employed a documentary research design utilizing systematic review procedures and summative content analysis to examine the methodological characteristics of graduate mathematics education theses. The design was appropriate because the study focused on identifying, categorizing, and synthesizing methodological patterns reflected in existing research documents rather than generating new empirical data or testing causal relationships. The analysis incorporated both quantitative descriptive techniques, such as frequencies and percentages, and qualitative interpretive procedures through thematic clustering and synthesis of methodological tendencies.

The systematic review component provided a structured and transparent procedure for the identification, retrieval, organization, and synthesis of the thesis corpus. Consistent with established systematic review protocols, the study followed a structured process involving identification, screening, eligibility checking, and inclusion of relevant documents (11). Unlike meta-analysis, which statistically aggregates quantitative findings, this study focused on qualitative synthesis and descriptive analysis of research characteristics. This distinction aligns with established systematic review frameworks emphasizing that not all systematic reviews

require statistical integration, particularly when dealing with heterogeneous qualitative data sources (12).

To analyze the corpus, content analysis was employed as the primary analytical technique. Content analysis is widely regarded as a systematic and replicable method for compressing large volumes of textual data into meaningful categories (13). Furthermore, this study is conceptually guided by views in mathematics education that call for considering and engaging with multiple approaches in understanding complex educational issues (14). This view supports the consideration of graduate theses not only as individual studies but as representations of methodological approaches. In this study, it facilitated both quantitative description through frequency counts and percentages and qualitative interpretation through thematic clustering.

Specifically, the study adopted a summative content analysis approach, which involves identifying and quantifying specific words or content, followed by interpretation of their contextual meaning (15). This approach was appropriate because the study not only documented the frequency of methodological characteristics across the theses but also interpreted the broader methodological tendencies reflected in graduate mathematics education research. Through this approach, the study generated descriptive summaries using frequencies and percentages while also identifying recurring methodological patterns through thematic clustering and interpretive synthesis (1, 16).

Corpus of the Study

The study was conducted using archived graduate theses from a state university located in Northern Philippines (approximate GPS coordinates 16°27'17.5"N 120°35'24.9"E). The institution serves as the primary source of the thesis corpus analyzed in the study. A total enumeration sampling technique was employed.

In total, 135 theses from the earliest available records in School Year (SY) 1992-1993 up to the SY 2023-2024 were analyzed. The distribution of theses indicates a generally increasing pattern observed in later academic years, with the highest concentration recorded in 2023, as depicted in Figure 1. This surge in thesis production can be attributed to a confluence of structural, policy-

driven, and cohort-related factors. A key influence is the implementation of Commission on Higher Education Memorandum Order (CMO) 15, s. 2019,

which introduced a requirement for graduate students to produce publishable research outputs as a condition for program completion.

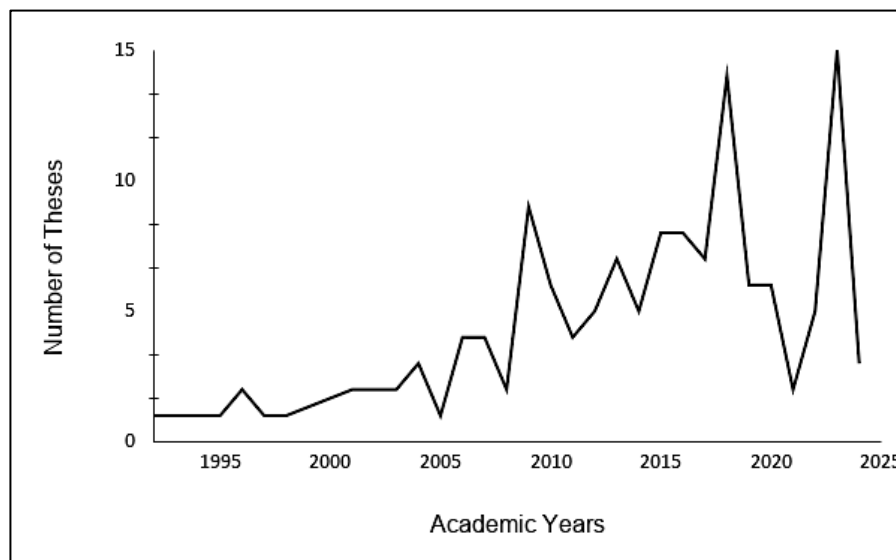


Figure 1: Trend in Graduate Mathematics Education Theses by Academic Year

Notably, this policy shift appears to have created pressure among students enrolled in the previous curriculum. Many of these students expedited the completion of their theses to avoid transitioning into the revised curriculum, which imposes more stringent research dissemination requirements. Such behavior is consistent with findings in higher education research indicating that policy reforms and increased graduation requirements often lead to temporal clustering of completions, as students accelerate progress to meet legacy requirements or avoid additional obligations (17, 18). This phenomenon reflects a rational response to institutional policy changes, where students strategically manage their academic trajectories considering perceived increases in workload, time investment, and performance expectations.

Data Collection and Analysis

A content review matrix was developed to categorize, summarize, and synthesize the theses according to the objectives of the study. The matrix was maintained as a web-based spreadsheet accessible to the research team to facilitate systematic organization and encoding of data. The identification and retrieval of theses followed a manual archival search procedure guided by the official list of graduates obtained from the university registrar's office. This list served as the basis for locating and retrieving all physical thesis copies from the college and departmental

repositories. Since the study employed total enumeration, all these under the Master of Arts in Mathematics and Master of Arts in Teaching Mathematics programs within the identified academic period were included in the analysis. All retrieved theses were accessible and contained the complete sections of the methodology as prescribed in the institutional format for graduate research writing. This ensured consistency in the extraction and analysis of methodological characteristics across the thesis corpus.

The categories included in the content review matrix were primarily derived from the university guidelines on the structure of nontechnical graduate theses. These categories included research approach, research design, locale of the study, participants or population of the study, sampling procedures, data collection instruments, data type, and data analysis methods. By drawing from the institutional structure prescribed for graduate research writing, the matrix captured the methodological characteristics commonly reported in educational research studies within the graduate program. The use of these predefined categories also provided a consistent framework for organizing and synthesizing the methodological information extracted from the theses.

The contents of the theses were carefully reviewed and manually encoded in the content review matrix based on the identified methodological

categories. The study focused on documenting and synthesizing the methodological characteristics reflected in the theses based on their reported methodological sections. The analysis emphasized methodological dimensions commonly associated with research rigor, including research design, sampling procedures, data collection practices, and analytical approaches. While the study examined prevailing methodological patterns and tendencies among graduate student researchers, it did not extend to an evaluative assessment of the alignment between the statement of the problem, research objectives, and methodological procedures. Such evaluative alignment analysis may constitute a separate area of inquiry for future research on methodological quality and coherence in graduate mathematics education research.

Data analysis involved both quantitative and qualitative techniques. The extracted data were organized, encoded, and summarized using Google Sheets as part of the documentary analysis process. Quantitative analysis included the computation of frequencies and percentages to describe the distribution of methodological categories across the thesis corpus. These descriptive statistics provided an overview of patterns and trends in research approaches, designs, participants, sampling procedures, instruments, and analytical methods. Qualitative analysis employed thematic clustering to identify recurring methodological patterns, tendencies,

and preferences observed across the theses. The integration of quantitative descriptive analysis and qualitative thematic synthesis reflects a pragmatic strategy for analyzing documentary datasets with both descriptive and interpretive components (1). To streamline data processing, Artificial Intelligence (AI) text-mining tools were utilized to assist in identifying keywords and patterns within the thesis documents. These tools were used solely to support preliminary organization and coding of extracted information. Final categorization, interpretation, validation, and synthesis of findings were undertaken by the researchers to ensure conceptual validity, contextual relevance, and alignment with the analytical framework of the study.

Results

Research Approaches and Design in Mathematics Theses

A strong predominance of quantitative approaches was observed among the graduate mathematics education theses, indicating that most studies employed methodologies centered on measurable and statistically analyzable educational variables. Of the total theses reviewed, 127 (94.1%) utilized quantitative approaches, 7 (5.2%) employed qualitative approaches, and only 1 (0.7%) integrated both qualitative and quantitative methods, as shown in Figure 2.

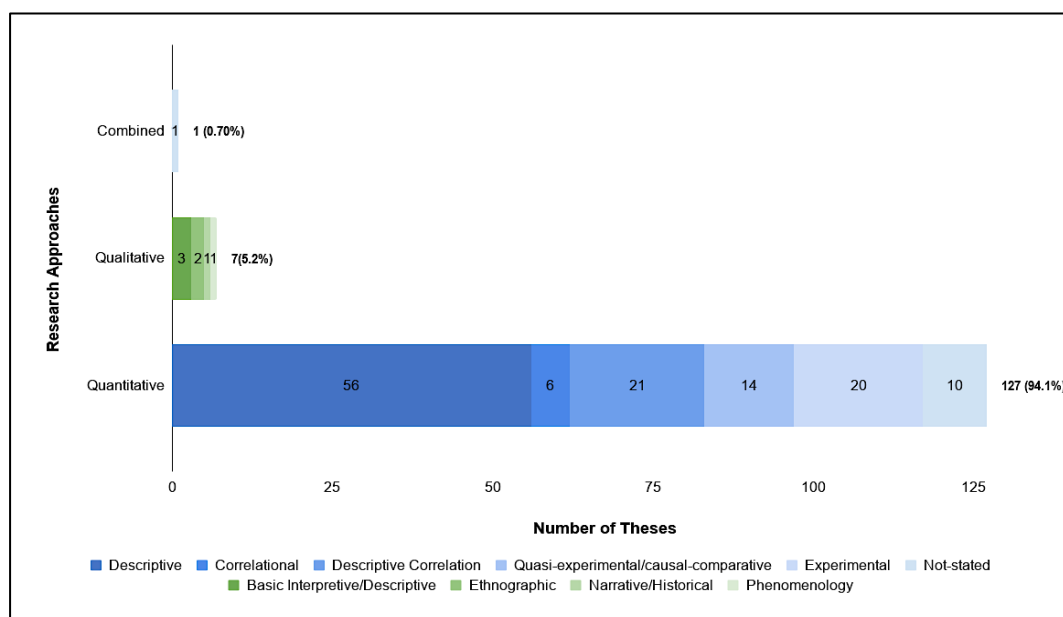


Figure 2: Distribution of Research Designs Across Research Approaches

Among the quantitative studies, descriptive research design recorded the highest frequency with 56 theses, followed by descriptive-correlational design with 21 theses and experimental design with 20 theses. Quasi-experimental or causal-comparative designs accounted for 14 theses, while correlational studies comprised 6 theses. Ten quantitative studies did not explicitly indicate a specific research design.

For the qualitative approach, basic interpretive/descriptive design was the most frequently utilized with 3 theses. Ethnographic studies accounted for 2 theses, while narrative/historical and phenomenological designs were represented by 1 thesis each. The combined approach was represented by a single thesis integrating qualitative and quantitative methodologies with no specific design identified.

Qualitative methodologies were minimally represented (5.2%). Among these, basic interpretive/descriptive designs were most common (3), followed by ethnographic studies (2). Narrative/historical and phenomenological designs each accounted for 1.

Locale of the Studies

The distribution of theses by research location shows a strong concentration in school-based settings. Most studies (82.22%) were conducted at the school level, followed by district-level (14.07%) and division/provincial-level (2.22%) contexts. Only one study each (0.74%) was conducted at the national and international levels, as discussed in Table 1.

Table 1: Distribution of Theses by Study Location

Locale	Frequency	Percentage (%)
School-based	111	82.22
District (Municipal)	19	14.07
Division/Provincial	3	2.22
National	1	0.74
International	1	0.74
Total	135	100.00

Table 2: Distribution of Theses Based on Participants

Participants	Frequency	Percentage (%)
Students	110	81.48
Teachers	7	5.19
Indigenous Group	6	4.44
Farmers	1	0.74
Uniformed Personnel	1	0.74
Students and Teachers	2	1.48
Graduates	3	2.22
Vendor	1	0.74
Subject	4	2.96
Total	135	100.00

Participants of the Studies

Students constituted the primary participants in most studies (81.48%), followed by teachers (5.19%) and indigenous groups (4.44%). Other participant groups included graduates, farmers, vendors, uniformed personnel, and combined student-teacher samples. A small number of studies (2.96%) focused on non-human subjects, such as mathematical models and real-world phenomena, as shown in Table 2.

Sampling Techniques

Sampling practices were predominantly non-probabilistic. Convenience or purposive sampling was used in 70.37% of the theses, followed by simple random sampling (18.52%) and stratified sampling (10.37%). Systematic and cluster sampling were rarely utilized, as discussed in Table 3.

Table 3: Distribution of Theses Based on Sampling Techniques

Sampling Technique	Frequency	Percentage (%)
Purposive/Convenient	95	70.37

Simple random	25	18.52
Stratified	14	10.37
Cluster	1	0.74
Total	135	100.00

Data Collection Instruments

The most used data collection instruments were questionnaires. Adapted questionnaires accounted for 36.30% of the studies, standardized questionnaires for 25.93%, and researcher-made questionnaires for 21.48%. Qualitative instruments such as interviews (3.70%), observations

(3.70%), and document analysis (6.67%) were used infrequently, as shown in Table 4.

Data Types

Most studies utilized interval-level data (80.47%), largely derived from test scores and Likert-scale instruments. Ordinal data accounted for 11.72%, while nominal and ratio data each represented 3.91%, as shown in Table 5.

Table 4: Distribution of Theses by Instrument Used

Instrument	Frequency	Percentage (%)
Questionnaire-standard	35	25.93
Questionnaire-adapted	49	36.30
Questionnaire (researcher-made)	29	21.48
Interview	5	3.70
Field Observation	5	3.70
Documents	9	6.67
Questionnaire – standard and interview	2	1.48
Questionnaire (researcher-made) and Interview	1	0.74
Total	135	100.00

Table 5: Distribution of Theses by Level of data

Level of Data	Frequency	Percentage (%)
Nominal	5	3.91
Ordinal	15	11.72
Interval	103	80.47
Ratio	5	3.91
Total	128	100.00

Table 6: Distribution of Theses by Treatment of the Data Used

Treatment or Analysis of Data	Frequency*
Mean	114
Frequency	54
t-Test	92
F-Test	18
ANOVA	26
Chi-square	17
Pearson	59
Regression	17
Total	397

Note: * Some studies used multiple tools in their analysis of data.

Analytical Techniques

A total of 397 instances of statistical analyses were recorded, as some studies employed multiple techniques. The most frequently used treatment was the mean, followed by the t-test and Pearson correlation. Frequency analysis was also commonly applied. In contrast, more advanced or less frequently used techniques include analysis of

variance (ANOVA), F-tests, chi-square tests, and regression, as depicted in Table 6.

Discussion

Methodological Patterns of Graduate Theses

The findings reveal a highly consistent methodological profile characterized by the dominance of quantitative, school-based, and

student-centered research. This pattern reflects broader trends in mathematics education research, where survey-based and experimental approaches have traditionally been emphasized (19, 20). However, the absence of mixed-methods studies suggests limited engagement with integrative research designs that combine quantitative rigor with qualitative depth. Mixed-methods approaches are increasingly recognized for enhancing validity and providing comprehensive insights into complex educational phenomena (1, 4, 21). This lack of such studies suggests insufficient exposure to the integration of techniques in research training. Since mixed-methods approaches are becoming more popular in educational research, this could be a better way to improve the research culture of the program.

The predominance of quantitative and classroom-based studies reflects prevailing methodological tendencies among practicing teacher-researchers, whose research contexts are often shaped by accessibility of participants, institutional requirements, and procedural familiarity. While such designs are practical in educational settings, the relatively low proportion of experimental and quasi-experimental studies suggests limited engagement with methodologies capable of establishing causal inference (2).

Conversely, findings indicate that a limited number of studies have utilized qualitative methodologies specifically, interpretive/descriptive, ethnographic, phenomenological, and narrative/historical approaches. This underutilization of qualitative methodologies aligns with comprehensive bibliometric studies indicating that mathematics education research remains predominantly influenced by quantitative frameworks (22). This type of mismatch could make it more difficult for programs to develop ideas that consider cultural differences and local situations. For example, ethnomathematics has become increasingly important as a way to study how cultural practices include mathematical notions (23). In the Philippines, comprehensive reviews have recorded an expanding corpus of ethnomathematics research; nonetheless, a significant portion remains descriptive rather than analytical, hence constraining its influence on pedagogy and curriculum development (24).

Contextual and Participant Limitations

The strong concentration of studies in school settings and reliance on student participants reflects the professional context of graduate researchers, many of whom are practicing teachers. This aligns with traditions of practitioner inquiry (25). However, the localized nature of these studies constrains generalizability and limits the applicability of findings across diverse educational contexts.

The limited inclusion of teachers as primary participants represents a missed opportunity to examine instructional practices and pedagogical decision-making, which are critical determinants of student learning (26). Similarly, the minimal representation of diverse participant groups suggests a need for broader engagement with varied educational stakeholders.

It is also evident in the findings that studies involving nonstudent participants were largely associated with those that employed qualitative approaches. The inclusion of indigenous groups, although modest, indicates an emerging interest in contextualized and culturally responsive mathematics education. Expanding such studies may help make mathematics learning more relevant to diverse groups of learners and support inclusive educational practices (27).

Interestingly, a small number of these studies did not involve human participants but instead focused on defined subjects. These included investigations on profit maximization in bread production, mathematical patterns observed in natural and built environments, and the application of mathematical formulas in designing loom bands. Such studies reflect an alternative orientation toward mathematical modeling and real-world applications, where the focus is on analyzing phenomena rather than gathering data from participants.

Overall, the findings suggest that the choice of participants is closely linked to the nature of the research design and the professional context of the researchers. While the dominance of student participants is expected in school-based research, expanding the range of participants and encouraging diverse methodological approaches may further strengthen the scope and contribution of future theses in the program.

Sampling and Generalizability Concerns

The sampling practices show a pattern that is consistent with the earlier findings on the location and participants of the studies. As previously noted, most theses were conducted in school settings and involved primarily student participants. Given this context, the predominance of purposive or convenience sampling reflects the practical realities faced by graduate student researchers, who often rely on readily accessible groups such as their own classes or schools. This alignment between the research setting, participant selection, and sampling technique suggests that methodological choices are largely influenced by feasibility and accessibility rather than by considerations of representativeness.

While this approach is common in educational and classroom-based research, the heavy reliance on nonprobability sampling has implications for the generalizability of findings. Convenience and purposive sampling limit the extent to which results can be extended beyond the immediate study context, as samples may not adequately represent the broader population. This concern is further reinforced by the earlier observation that most studies are localized and institution-centered, thereby constraining external validity. The empirical and methodological literature consistently emphasizes that probability sampling techniques are essential for enhancing representativeness and supporting stronger inferential claims (7,28). This reliance on convenience sampling is consistent with findings in educational research where access constraints shape methodological decisions; however, it raises concerns regarding external validity and transferability (29).

Overall, the findings reinforce the interconnected nature of the methodological choices observed in this study: school-based settings, student participants, and convenience sampling tend to occur together. While these choices are understandable within the context of graduate research, increasing the use of probability sampling techniques, particularly in studies aiming for broader applicability, may improve the credibility and generalizability of future research outputs.

Instrumentation and Data Collection Gaps

The predominance of questionnaire-based instruments reflects a preference for efficient data collection methods suited to large student populations. However, the limited use of qualitative tools such as interviews and observations suggest insufficient attention to the contextual and interactive dimensions of mathematics learning. Methodological triangulation, which integrates multiple data sources, has been widely advocated to improve the validity and depth of educational research (30, 31). Its limited application in the analyzed theses represents a significant gap.

Data and Analytical Depth

The results point to a clear alignment between the types of data collected, the research designs employed, and the statistical techniques applied across the theses. The strong reliance on interval-level data is largely driven by the frequent use of Likert-scale instruments and achievement tests, which are standard in quantitative educational research. This pattern reflects a consistent methodological approach in which quantitative designs, student-based samples, survey instruments, and parametric analyses are closely linked. At the same time, the classification of Likert-scale data as interval remains an area of ongoing methodological discussion. While some researchers consider such data strictly ordinal, others argue that it can reasonably be treated as interval under certain conditions, particularly when multiple items are combined into a scale and sample sizes are sufficiently large. Existing studies suggest that parametric analyses can still yield reliable results even when these assumptions are not perfectly met, provided the data do not significantly violate distributional requirements (32, 33). However, the tendency to apply these techniques without clearly explaining the underlying assumptions suggests that statistical procedures are sometimes used routinely rather than critically.

At a broader level, the findings also indicate a limited range of data types being utilized. The relatively low use of nominal and ratio data, together with the minimal inclusion of qualitative evidence, suggests that many studies draw from a narrow set of data sources. This restricts the ability to fully capture the complexity of mathematics

teaching and learning, which often involves contextual, social, and experiential dimensions. Current perspectives in educational research highlight the importance of combining different forms of data to produce more comprehensive and meaningful interpretations (1, 6). In this light, the observed pattern reflects not only consistency in methodological choices but also a tendency to favor practicality and efficiency over deeper, more context-sensitive analysis.

A similar pattern is evident in the selection of analytical techniques. The frequent use of means, t-tests, and correlation analyses indicates a focus on describing trends, comparing groups, and identifying straightforward relationships among variables. While these methods are appropriate for the types of data collected, their dominance suggests that most studies remain at a basic level of analysis. More advanced techniques, such as regression and multivariate analysis, are used far less often, limiting the ability to explore more complex relationships or account for multiple influencing factors simultaneously (8, 28). These approaches are particularly important in educational research, where variables are often interdependent and influenced by multiple contextual factors. As a result, the analytical depth of many studies remains constrained. Strengthening training in advanced statistical methods, along with encouraging the integration of qualitative or mixed approaches, would allow future research to move beyond surface-level findings and develop more nuanced and robust insights into mathematics education.

Methodological Rigor of Graduate Theses: An Evaluative Perspective

The study's findings were examined in light of recognized standards for scientific rigor in educational research, including validity, reliability, method alignment, and diversity of approaches, in addition to the descriptive patterns discovered. The prevalence of quantitative designs indicates a significant tendency toward postpositivist paradigms, although the appropriateness and depth of methodological execution also have an impact on rigor. Although quantitative approaches are helpful for measuring relationships and effects, an over-reliance on a narrow range of designs, particularly descriptive and correlational, may restrict the explanatory potential of research. The relatively low proportion of experimental and

quasi-experimental studies, which implies little usage of designs that can demonstrate causal inference, is an important component of methodological rigor (2).

Convenience sampling is widely used, which is a significant problem found in this study. Non-probability sampling is frequently used in educational research because of accessibility issues, but it limits the generalizability of results and raises questions about external validity (7). Methodology literature highlights that sample procedures that improve representativeness are necessary for rigorous research, especially when investigations are intended to inform larger educational practice (3). The grouping of convenience-sampled, student-centered, and school-based studies indicates that methodological soundness is frequently subordinated to feasibility considerations.

The findings also reveal a heavy reliance on questionnaire-based instruments, with minimal use of qualitative methods such as interviews, observations, and document analysis. This pattern reflects a limited application of methodological triangulation, which is widely recognized as essential for enhancing the credibility and validity of research findings (30). The absence of mixed-methods designs further underscores this limitation, despite strong recommendations in the literature for integrating quantitative and qualitative approaches to achieve more comprehensive insights (1, 21).

Along data analysis, the dominance of basic statistical techniques such as means, t-tests, and correlations suggests a foundational level of analytical competence but also indicates limited engagement with more advanced methods. The use of multivariate techniques, such as regression and analysis of variance, remains relatively low, constraining the depth of analysis and the ability to model complex relationships among variables (28). Advanced analytical approaches are increasingly emphasized in educational research as they allow for more nuanced and robust interpretations of data.

In summary, these findings point to a pattern of methodological alignment but limited methodological depth and diversity. While the coherence among research design, instruments, and analysis reflects internal consistency, the limited range of approaches constrains the overall rigor of the

studies. This supports previous observations that educational research, particularly at the graduate level, tends to favor practicality over methodological sophistication (29).

Implications for Enhancing Methodological Rigor

The findings highlight the need to broaden the methodological repertoire of graduate researchers. Enhancing rigor requires greater integration of mixed-methods approaches, which combine statistical generalizability with contextual depth (1). Improved sampling strategies, particularly the increased use of probability sampling, can strengthen representativeness and external validity.

Moreover, increasing the application of qualitative methods can yield deeper insights into teaching and learning processes, while training in advanced statistical techniques can improve analytical accuracy. These guidelines correspond with recommendations in mathematics education research to diversify methodologies and enhance the alignment of research approaches with intricate educational phenomena (20, 34).

Conclusion

Analysis of graduate theses shows a consistent and very focused methodological profile, with quantitative, school-based, and student-centered studies being the most common. These studies typically utilize convenience sampling, questionnaire-based instruments, and fundamental statistical methods, including means, t-tests, and correlations. These patterns show that they are consistent with each other and reflect the real-world problems that teacher-researchers face, but they also show that there isn't much methodological diversity.

From an evaluative standpoint, the findings indicate that while the theses dominantly demonstrate coherence among research design, data type, and analytical methods, various aspects of methodological rigor necessitate enhancement. The extensive dependence on non-probability sampling limits generalizability, and the minimal application of qualitative and mixed-methods approaches diminishes the ability to encapsulate the complexity and contextual aspects of mathematics teaching and learning. In the same way, the limited use of advanced statistical methods also reflects the methodological

preferences and analytical tools most emphasized in graduate research training, resulting in greater reliance on familiar and procedurally accessible techniques.

These results directly address the study's aim of pinpointing methodological deficiencies. The analysis identifies significant limitations, such as the restricted variety of research designs, inadequate methodological triangulation, and insufficient interaction with diverse participant groups and research contexts. These limitations indicate that graduate research, although pertinent to current classroom practices, may not fully achieve its potential to provide broader and more substantial insights to the discipline.

In response, the study suggests ways to make graduate-level mathematics education research more methodologically sound. These encompass the enhancement of mixed-methods designs, the fortification of sampling strategies to elevate representativeness, the augmentation of qualitative approach integration, and the provision of advanced training in data analysis. Together, these efforts can help create a research culture that is more methodologically diverse, analytically rigorous, and responsive to the context.

The findings of the study suggest several implications for graduate research instruction and curriculum enhancement in mathematics education. Given the dominance of quantitative and convenience-sampling approaches, graduate programs may strengthen methodological rigor by incorporating more intensive training on probability sampling techniques, qualitative inquiry, and mixed-methods research designs. Research courses and thesis mentoring programs may likewise include structured workshops on advanced statistical procedures, qualitative data analysis, triangulation strategies, and methodological alignment between research problems, objectives, and analytical procedures.

The limited diversity of research participants and settings further suggests the need to encourage graduate students to explore broader educational contexts beyond classroom-based investigations. Institutions may also strengthen research mentoring systems by providing clearer methodological guidance, exemplars of diverse research designs, and enhanced monitoring of methodological coherence during thesis development. Moreover, since graduate theses frequently serve

as reference materials for succeeding student researchers within graduate programs, it is important to expose students to varied methodological approaches and more rigorous research practices in addressing educational problems. Strengthening methodological training may therefore help cultivate broader perspectives in research design selection, analytical procedures, and inquiry processes among future researchers. Since many graduate students are practicing teachers who also guide student research in basic education, improving methodological training at the graduate level may likewise contribute to strengthening research practices that are subsequently cascaded to junior and senior high school learners. Future research may further examine the alignment between statements of the problem, research objectives, and methodological procedures to provide deeper evaluation of methodological coherence and rigor in graduate mathematics education research.

Abbreviations

AI: Artificial Intelligence, ANOVA: Analysis of Variance, CMO: Commission on Higher Education Memorandum Order, MA: Master of Arts, MAT: Master of Arts in Teaching.

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Author Contributions

Julie A Buasen: Conceptualization, Data Gathering, Writing - Original Draft, Review and Editing, Visualization, Formal Analysis, Methodology, Supervision, Nick W Sibaen: Conceptualization, Review and Editing, Validation, Resources, Monica S Alimondo: Conceptualization, Review and Editing, Validation, Resources.

Conflict of Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data Availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Declaration of Artificial Intelligence (AI) Assistance

The authors used assistive artificial intelligence (AI) tools in a limited and supportive capacity during the preparation of this manuscript. Specifically, AI-assisted technologies were utilized for organizing data, initial coding, and improving language clarity, organization, and coherence of the manuscript. All outputs generated through AI tools were carefully reviewed, validated, and substantially revised by the author to ensure accuracy, originality, and alignment with the study's objectives.

The authors retain full responsibility for the content of this manuscript, including the integrity of the data, the accuracy of the analysis, and the validity of the conclusions. No AI tool was used to generate research data, replace analytical judgment, or make autonomous decisions regarding the study's findings.

Ethics Approval

This study did not involve human participants or direct data collection from individuals. The research utilized existing graduate theses that were publicly accessible or institutionally authorized for academic use. All materials were used solely for academic purposes, and ethical standards were observed by ensuring confidentiality, proper data handling, and appropriate attribution of sources.

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