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ChatGPT-Assisted Data Analysis in Mathematics Education Research (CADAMER): A Scoping Review in the Post-Modern Scholarly Milieu

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Abstract

This study investigated the role of ChatGPT-assisted data analysis in mathematics education research within the post-modern scholarly milieu using a scoping review approach. This examined how ChatGPT contributes to ethical, reliable, rigorous, and context-sensitive data analysis in mathematics education research. The findings reveal five (5) emergent themes that define ChatGPT's role in this domain: (1) ChatGPT for Quantitative Analysis; (2) ChatGPT for Qualitative Coding; (3) ChatGPT and Research Ethics; (4) ChatGPT in Literature Reviews; and (5) ChatGPT on the Future of Research. Based on the findings, the study extracted the ChatGPT-Assisted Data Analysis in Mathematics Education Research (CADAMER) model, positioning ChatGPT as a versatile research assistant that enhances analytical efficiency while upholding scholarly rigor. Although ChatGPT streamlines data analysis, human oversight and ethical safeguards remain crucial to ensuring accuracy and academic integrity. The integration of ChatGPT with expert validation strengthens the rigor, ethics, and reliability of mathematics education research.

Introduction

The integration of artificial intelligence (AI) in educational research has significantly transformed the landscape of data analysis, particularly in mathematics education. One emerging AI tool is ChatGPT, an advanced language model capable of performing complex analytical tasks, generating insights, and assisting in qualitative and quantitative data interpretation (Hassani & Silva, 2023). While numerous studies have explored the potential of AI in education, there remains a dearth of research specifically addressing its role in data analysis within mathematics education research. Existing literature predominantly focuses on AI-driven teaching strategies, intelligent tutoring systems, and automated assessment tools, leaving a critical gap in understanding how ChatGPT can support researchers in handling mathematical data, structuring research findings, and improving methodological rigor (Frieder et al., 2023). Given the increasing reliance on AI for academic inquiry, a systematic investigation into ChatGPT's application in mathematics education research is both timely and essential.

Despite the potential advantages of AI-assisted analysis, the literature reveals a lack of clarity on how ChatGPT enhances or potentially limits the research process. While AI tools are often praised for their efficiency in text generation and data summarization, concerns persist regarding their accuracy, interpretability, and alignment with

established research methodologies (Oyelude, 2024). In mathematics education research, where precise quantitative and qualitative analyses are crucial, the reliability of ChatGPT-assisted data interpretation remains underexplored. Existing studies on AI in education have yet to comprehensively address its implications for data integrity, potential biases, and ethical considerations in research settings. This scoping review aims to bridge this gap by mapping out the current state of knowledge on ChatGPT-assisted data analysis in mathematics education research.

Another critical issue is the methodological rigor associated with AI-generated analyses (Khlaif et al., 2023). Traditional statistical and qualitative methods require a high level of expertise, yet ChatGPT presents a paradigm shift where researchers may increasingly rely on AI-driven tools for interpretation (Christou, 2023). However, the extent to which ChatGPT-generated analyses align with conventional research standards remains an open question. Some scholars argue that AI-enhanced research may lead to superficial or misleading conclusions if not properly validated, while others emphasize its role in augmenting human cognition and improving accessibility to advanced analytical techniques (Wachinger et al., 2024). This review seeks to clarify these perspectives by synthesizing existing research on ChatGPT's effectiveness, limitations, and methodological implications in mathematics education research.

Furthermore, the intersection of AI and mathematics education research brings forth linguistic and contextual challenges, particularly in multilingual and diverse educational settings (Canonigo, 2024). Mathematics research often involves technical jargon and discipline-specific language that AI models may misinterpret or oversimplify. Additionally, the use of ChatGPT in non-English research contexts remains largely unexplored, raising questions about its adaptability to different linguistic and cultural frameworks. As mathematics education continues to evolve in increasingly diverse environments, it is crucial to examine whether AI-assisted analysis can accommodate various academic discourses and research traditions (Cao et al., 2023). Addressing these gaps will provide a clearer picture of ChatGPT's applicability in mathematics education research.

Ethical concerns further complicate the adoption of AI in academic research. Issues such as data privacy, algorithmic bias, and the potential for AI-generated misinformation pose challenges that need to be carefully considered (Carobene et al., 2023). While AI tools like ChatGPT offer promising avenues for streamlining research processes, they also introduce new risks that may compromise the integrity and reliability of scholarly work. The lack of standardized ethical guidelines for AI-assisted research exacerbates these concerns, leaving researchers uncertain about best practices for utilizing ChatGPT in data analysis (Burger et al., 2023). By mapping existing literature, this scoping review will contribute to the ongoing discourse on responsible AI use in mathematics education research.

As AI becomes increasingly integrated into educational research, this scoping review addresses critical gaps by examining ChatGPT-assisted data analysis in mathematics education research. By synthesizing existing studies, it explores the potentials, challenges, and methodological implications of ChatGPT-assisted analysis, assessing its efficacy and ethical considerations. The findings will provide researchers, educators, and policymakers with insights into the practical and responsible use of ChatGPT in academic inquiry. Ultimately, this study contributes

to the broader discourse on AI's evolving role in post-modern scholarly practices, particularly within mathematics education research.

Objectives

This study explored via scoping review the existing literature on ChatGPT-assisted data analysis in mathematics education research to provide a comprehensive understanding of its applications, benefits, challenges, and ethical considerations. The study further sought to uncover the evolving role of ChatGPT in mathematics education research within the post-modern scholarly milieu.

Specifically, this aspired to answer the given specific objectives:

1. Examine the scope, trends, and methodological approaches in existing literature on ChatGPT-assisted data analysis in mathematics education research;
2. Analyze the opportunities, challenges, and ethical considerations associated with ChatGPT-assisted data analysis in mathematics education research;
3. Identify research gaps and propose future directions for the effective and responsible integration of ChatGPT in mathematics education research within the post-modern scholarly milieu; and
4. Develop a conceptual model based on the findings, outlining best practices and guidelines for leveraging ChatGPT in data analysis for mathematics education research.

Method

This study employs a scoping review approach to systematically examine and synthesize existing research on ChatGPT-assisted data analysis within mathematics education research in the post-modern scholarly milieu. Grounded in the methodological framework established by Arksey and O'Malley (2005), the scoping review serves as a structured yet flexible approach to literature synthesis, ensuring the comprehensive inclusion of relevant studies regardless of their methodological orientations. In contrast to systematic reviews, which operate within narrowly defined research parameters and adhere to rigid methodological constraints, scoping reviews adopt an exploratory, iterative, and adaptive approach. This methodological flexibility allows researchers to refine their focus throughout the review process, facilitating responsiveness to emerging themes and insights within the literature. Furthermore, the scoping review methodology promotes continuous reflection and iterative methodological adjustments, thereby enhancing the depth, coherence, and relevance of the synthesis.

Following Arksey and O'Malley's (2005) five-stage framework, this study meticulously adheres to each phase of the scoping review process, ensuring methodological rigor and coherence in mapping the existing knowledge base on ChatGPT-assisted data analysis in mathematics education research within the post-modern scholarly milieu.

Formulating Research Questions

The initial phase of this study entailed the formulation of core research questions, which served as the foundational framework for the scoping review. To ensure a systematic and structured exploration of ChatGPT-assisted data

analysis in mathematics education research within the post-modern scholarly milieu, three distinct research questions were carefully developed. These questions were designed to define the scope of inquiry, guide the identification and selection of relevant literature, and facilitate a comprehensive synthesis of the existing body of research.

Identifying and Retrieving Relevant Literature

A systematic and comprehensive literature search was conducted across four highly reputable academic databases—Google Scholar, ERIC, Scopus, and Web of Science—recognized for their extensive coverage of peer-reviewed research. This study focused on scholarly articles published between 2020 and 2024 to ensure the inclusion of contemporary advancements and emerging perspectives on ChatGPT-assisted data analysis in mathematics education research within the post-modern scholarly milieu.

To enhance the precision and relevance of the retrieved studies, a keyword-driven search strategy was implemented. Specific search terms, including “ChatGPT-assisted data analysis,” “mathematics education research in the post-modern scholarly milieu,” and “ChatGPT-assisted data analysis in mathematics education research,” were systematically analyzed. These search parameters were strategically designed to identify studies aligned with the research objectives, thereby facilitating a focused and rigorous synthesis of the existing literature.

Selection of Studies Based on Inclusion Criteria

A systematic and rigorous screening process was implemented to assess the relevance and methodological integrity of the retrieved studies. This selection process entailed a thorough evaluation of each article’s abstract, methodology, results, discussion, and conclusion to ensure alignment with the study’s objectives. Only studies that explicitly and substantively examined ChatGPT-assisted data analysis in mathematics education research within the post-modern scholarly milieu were retained for inclusion. Articles failing to meet the predefined inclusion criteria were systematically excluded. This methodologically robust approach ensured the maintenance of high academic rigor, thematic relevance, and conceptual coherence, thereby fortifying the integrity of the synthesized findings.

Data Charting and Organization

Following the selection of relevant studies, a systematic data extraction process was conducted to ensure a structured and rigorous synthesis of findings. This phase aligned with established methodologies in systematic literature reviews, whereby key study attributes—including research design, primary findings, and pedagogical or theoretical implications—were systematically categorized. By organizing extracted data into structured analytical frameworks, this approach enhanced the coherence, comparability, and depth of synthesis, ensuring a methodologically sound and comprehensive review of ChatGPT-assisted data analysis in mathematics education research within the post-modern scholarly milieu.

Data Synthesis, Analysis, and Interpretation

The final stage of the scoping review involved a systematic content analysis to identify recurring themes, emerging patterns, and critical insights across the selected studies. Extracted data were synthesized and systematically summarized to elucidate significant findings, ensuring a comprehensive understanding of ChatGPT-assisted data analysis in mathematics education research within the post-modern scholarly milieu. Additionally, a conceptual framework was developed, grounded in the existing literature, to provide a structured theoretical representation of ChatGPT-assisted data analysis in mathematics education research. This framework serves as a foundational model for future research and pedagogical applications in the field.

The nitty-gritty of the flow of this scoping review is illustrated in Figure 1.

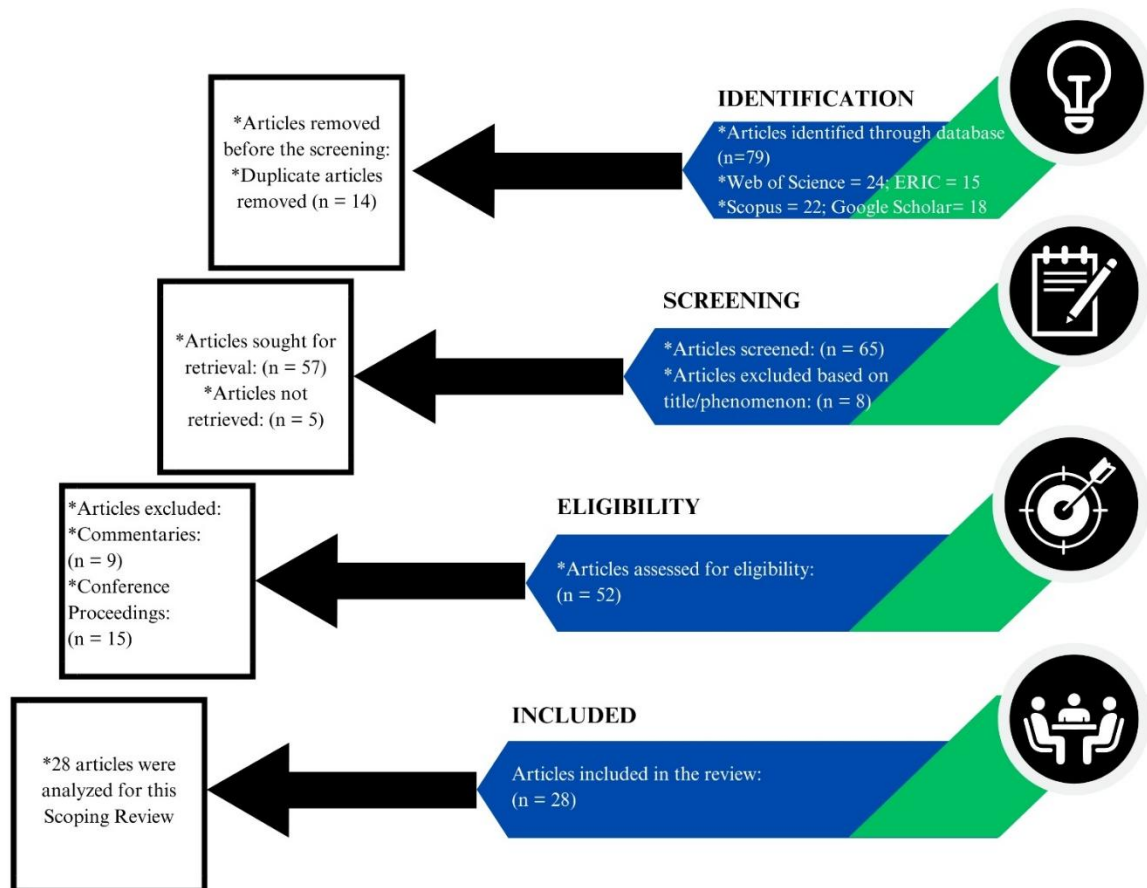


Figure 1. PRISMA Flow Chart of Searching, Selecting, and Abstracting Articles for the Scoping Review

Results and Discussion

Theme 1: ChatGPT for Quantitative Analysis

The integration of ChatGPT in quantitative data analysis within mathematics education research is rapidly gaining traction due to its ability to process large datasets efficiently (Patero, 2023). Traditionally, statistical analysis has required extensive coding knowledge and familiarity with software like SPSS, R, Python, Jamovi, or JASP (Aliyu et al., 2022). However, ChatGPT has significantly reduced this technical barrier by offering automated statistical

explanations, generating code for data manipulation, and suggesting appropriate analytical techniques based on research questions (Huang, Wu, He, & Xiang, 2024). This shift democratizes data analysis, enabling educators and researchers with limited programming expertise to engage in robust statistical investigations.

Moreover, ChatGPT's natural language processing (NLP) capabilities enhance the interpretability of complex statistical outputs (Ahn, 2024). Researchers often struggle with deriving meaningful conclusions from statistical tests such as regression models, ANOVA, or factor analysis (Frossard & Renaud, 2021). ChatGPT can provide simplified, yet academically rigorous explanations of statistical findings, ensuring that the interpretations align with theoretical frameworks in mathematics education (Maurisaca, 2024). This feature is particularly valuable in mixed-methods research, where researchers need to integrate statistical findings with qualitative insights to construct comprehensive narratives.

Despite these advantages, concerns regarding the accuracy and reliability of ChatGPT-generated analyses persist (Shabara, ElEbyary, & Boraie, 2024). Since the model operates probabilistically, there is a risk of misinterpretation or incorrect statistical recommendations. Researchers must critically evaluate ChatGPT's outputs by cross-validating results with conventional statistical software and consulting domain experts. The role of human oversight remains essential to prevent errors and ensure that the data analysis process aligns with best practices in educational research methodology.

Theme 2: ChatGPT for Qualitative Coding

In qualitative mathematics education research, thematic analysis and coding processes are often time-consuming and require meticulous human interpretation (Naeem, Ozuem, Howell, & Ranfagni, 2023). ChatGPT has emerged as a valuable tool for assisting in initial coding, categorizing textual data, and identifying emerging themes from interview transcripts, open-ended survey responses, and classroom observations (Lee et al., 2023). Its ability to summarize large volumes of qualitative data provides researchers with an efficient starting point for further refinement and validation of themes.

One of the key advantages of ChatGPT in qualitative research is its capacity to maintain consistency in coding patterns, reducing researcher bias in theme identification (Theelen, Vreuls, & Rutten, 2024). Traditional manual coding methods are susceptible to subjective variations, especially when multiple coders interpret the same dataset differently (Fujiwara et al., 2020). ChatGPT can standardize initial coding and suggest thematic patterns based on pre-existing educational frameworks, thus enhancing inter-rater reliability (Theelen, Vreuls, & Rutten, 2024).. This automation accelerates the research process, allowing scholars to focus more on interpretation rather than data management.

However, ChatGPT's application in qualitative analysis is not without limitations. While it can assist in thematic identification, it lacks the depth of human intuition required for context-specific interpretations (Morgan, 2023). Mathematics education research often involves nuanced discussions on pedagogical strategies, cognitive processes, and sociocultural influences, which AI-driven coding might oversimplify (Park & Lim, 2023).

Therefore, researchers must critically review and refine AI-generated themes to ensure that qualitative insights remain contextually and theoretically sound.

Theme 3: ChatGPT and Research Ethics

The integration of ChatGPT in mathematics education research raises significant ethical concerns, particularly in data privacy, academic integrity, and the risk of AI bias (Adel, Ahsan, & Davison, 2024). When analyzing student performance data, researchers must ensure compliance with ethical guidelines such as the General Data Protection Regulation (GDPR) and institutional review board (IRB) policies (Parsons, 2020). The use of ChatGPT for data processing introduces challenges related to data security, as researchers must avoid exposing confidential student records to external AI platforms. Academic integrity is another critical issue. The ease of generating statistical interpretations and qualitative themes through ChatGPT may lead some researchers to over-rely on AI-generated content without proper critical evaluation (Kim, 2024). This raises questions about authorship, originality, and the potential dilution of human scholarly contribution. To maintain ethical rigor, researchers should clearly document the extent of AI involvement in their methodology sections and ensure that final interpretations reflect human expertise rather than unverified AI outputs.

Furthermore, AI-generated analyses may reinforce biases present in training data, potentially skewing findings in mathematics education research (Baker & Hawn, 2021). Since ChatGPT's responses are based on probabilistic language modeling, it may inadvertently reflect existing biases in educational datasets, particularly in areas related to gender, socioeconomic status, and learning abilities (Zheng, 2023). Researchers must critically examine whether AI-assisted data analysis aligns with equitable and inclusive research practices, emphasizing the need for transparent and responsible AI usage in educational studies.

Theme 4: ChatGPT in Literature Reviews

Conducting systematic literature reviews (SLRs) in mathematics education research involves extensive data mining, critical synthesis, and thematic categorization of existing studies (Kartika, Warmi, Urayama, Suprihatiningsih, 2024). ChatGPT has demonstrated its utility in assisting researchers with this process by summarizing relevant literature, identifying key theoretical frameworks, and generating structured outlines for review papers (Issa, Faraj, & AbiGhannam, 2024). Its ability to process vast amounts of academic content expedites the literature review phase, allowing researchers to focus on deeper analytical synthesis.

One of the notable advantages of ChatGPT in SLRs is its capacity to map research trends and knowledge gaps efficiently (Alshami et al., 2023). By analyzing patterns in existing studies, it can suggest emerging themes, methodologies, and potential research directions. This is particularly useful for mathematics education researchers who aim to identify underexplored areas, such as the intersection of AI and pedagogy, equity in mathematics learning, or the role of technology in problem-solving strategies (Elifas & Simuja, 2024). ChatGPT's capacity to organize and cluster related studies streamlines the synthesis process, ensuring a more structured and coherent literature review.

Despite these advantages, researchers must be cautious about ChatGPT's limitations in literature reviews. AI-generated summaries may lack critical depth and fail to capture nuanced theoretical arguments (Suppadungsuk et al., 2023). Additionally, ChatGPT's access to paywalled or unpublished academic papers is restricted, which limits its ability to provide comprehensive literature synthesis. Thus, while ChatGPT serves as an efficient research assistant, human intervention remains essential in verifying sources, ensuring proper citation practices, and constructing rigorous academic narratives.

Theme 5: ChatGPT on the Future of Research

As AI continues to evolve, the role of ChatGPT in mathematics education research is expected to expand, offering more advanced data analysis capabilities. Future developments may include enhanced integration with statistical software, real-time data visualization tools, and improved accuracy in qualitative coding (Alexander, Eppler, & Comi, 2020). Such advancements will further streamline research processes, making data analysis more accessible to educators and researchers across different levels of expertise.

One promising avenue is the incorporation of AI-driven adaptive learning analytics, where ChatGPT can analyze student performance patterns and provide personalized feedback for instructional improvement (Mishra, 2024). In mathematics education, this could revolutionize formative assessment practices by offering real-time insights into students' problem-solving strategies, misconceptions, and learning trajectories (Rouben, Carola, Seong-Ho, & Ratimir, 2023). Additionally, AI-enhanced predictive modeling could help educators identify at-risk students and implement targeted interventions to improve learning outcomes. However, challenges remain in ensuring the ethical, reliable, and context-sensitive application of ChatGPT in mathematics education research (Wardat, Tashtoush, Alali, & Jarrah, 2023). Issues related to algorithmic transparency, data validity, and AI bias require ongoing scrutiny to prevent potential distortions in research findings (Daneshjou, Smith, Sun, Rotemberg, & Zou, 2021). As researchers continue to explore ChatGPT's capabilities, a balanced approach—combining AI-assisted analysis with rigorous human oversight—will be essential to uphold the integrity of educational research.

Emergent Model

The integration of ChatGPT in mathematics education research necessitates a comprehensive model that amalgamates its role in quantitative and qualitative analysis, ethical considerations, literature reviews, and its future applications. This model, termed the ChatGPT-Assisted Data Analysis in Mathematics Education Research (CADAMER), positions ChatGPT as a multifaceted research assistant that enhances efficiency while maintaining scholarly rigor. At its core, CADAMER comprises five interconnected dimensions: ChatGPT for Quantitative Analysis, ChatGPT for Qualitative Coding, ChatGPT and Research Ethics, ChatGPT in Literature Reviews, and ChatGPT on the Future of Research. This model underscores the necessity of human oversight in all stages to mitigate AI-generated biases and inaccuracies while leveraging its computational capabilities. Within the CADAMER model, the role of ChatGPT in quantitative analysis is emphasized through its ability to process large datasets, generate statistical scripts, and provide interpretive assistance. Researchers can employ ChatGPT to streamline data preparation and preliminary analysis, reducing the technical barrier associated with statistical

software. Simultaneously, the model integrates qualitative analysis, where ChatGPT functions as an initial thematic coding tool, offering structured patterns that researchers can refine. This dual-functionality approach fosters a mixed-methods research paradigm in mathematics education, ensuring both numerical rigor and contextual depth in educational inquiries. Ethical considerations serve as the regulatory backbone of CADAMER, ensuring responsible AI usage in research. ChatGPT's integration necessitates stringent adherence to data privacy laws, academic integrity, and bias mitigation strategies. Researchers must transparently document AI involvement, cross-validate findings, and critically assess ChatGPT-assisted interpretations. Moreover, the CADAMER model incorporates ChatGPT in literature reviews, where it aids in structuring thematic syntheses and identifying research gaps. However, due to AI's limitations in accessing paywalled sources and interpreting complex theoretical arguments, researchers must supplement AI-assisted literature synthesis with extensive manual verification. The future trajectory of CADAMER envisions ChatGPT's evolving role in mathematics education research, particularly in adaptive learning analytics and predictive modeling. As AI tools become more sophisticated, their potential to offer real-time feedback on student performance and generate data-driven pedagogical strategies will expand. Nevertheless, to uphold research integrity, AI-enhanced methodologies must be balanced with human expertise. By integrating AI-driven efficiency with scholarly rigor, the CADAMER model establishes a robust framework for advancing mathematics education research in an era of artificial intelligence.

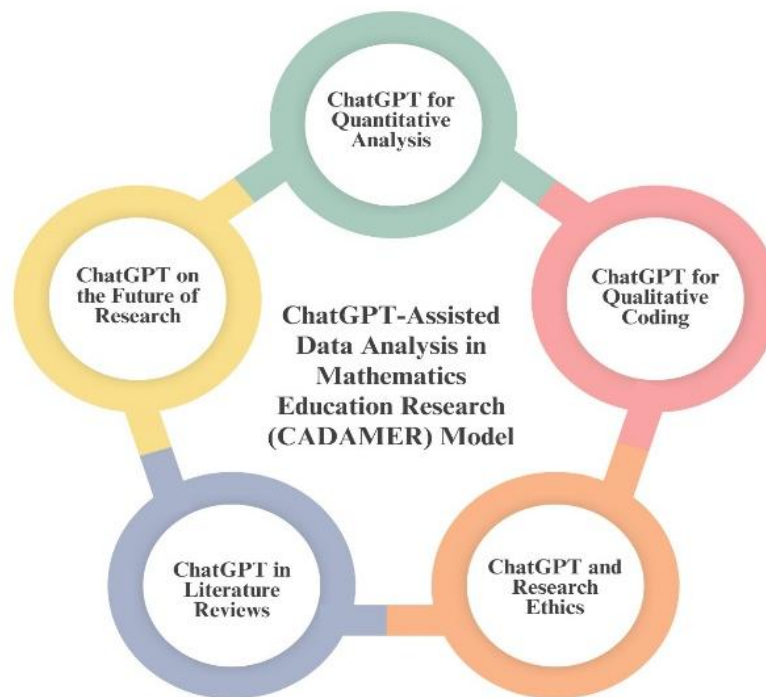


Figure 2. ChatGPT-Assisted Data Analysis in Mathematics Education Research (CADAMER) Model

Conclusion

The integration of ChatGPT in mathematics education research offers transformative possibilities in both quantitative and qualitative data analysis. By reducing the technical barriers associated with statistical software and providing automated interpretations, ChatGPT enhances accessibility and efficiency for researchers with

varying levels of expertise. Moreover, its natural language processing capabilities facilitate the interpretation of complex statistical findings, fostering a deeper understanding of data-driven insights. However, despite its advantages, the reliance on ChatGPT for quantitative analysis necessitates critical evaluation to ensure the accuracy and validity of results, reinforcing the importance of human oversight in research practices.

In qualitative research, ChatGPT streamlines the initial coding process by identifying thematic patterns and reducing researcher bias. This automation allows for greater consistency in data analysis, particularly in studies involving large textual datasets. Nonetheless, AI-driven qualitative coding remains limited in capturing the nuanced interpretations required in mathematics education research, where pedagogical, cognitive, and sociocultural factors play significant roles. Consequently, while ChatGPT serves as a valuable assistive tool, researchers must actively refine and contextualize its outputs to maintain the depth and rigor of qualitative inquiries.

Ethical considerations remain a central concern in the use of ChatGPT for mathematics education research. Issues such as data privacy, academic integrity, and AI bias must be addressed to ensure responsible AI usage. The proposed ChatGPT-Assisted Data Analysis in Mathematics Education Research (CADAMER) model underscores the necessity of balancing AI capabilities with ethical research practices. As AI continues to evolve, future applications in adaptive learning analytics and predictive modeling may further enhance the field, provided that ethical, reliable, and context-sensitive methodologies are upheld.

Recommendations

To maximize the benefits of ChatGPT in quantitative analysis, researchers may employ a hybrid approach that integrates AI-driven assistance with traditional statistical validation. Cross-verifying ChatGPT-assisted analyses with established statistical software (e.g., SPSS, R, Jamovi) and consulting domain experts can mitigate potential inaccuracies. Additionally, training mathematics education researchers on AI-assisted statistical methods will enhance their ability to critically assess AI-generated outputs, ensuring methodological rigor and data reliability in research findings.

For qualitative research, ChatGPT may be used as an initial coding assistant rather than a definitive analytical tool. Researchers may manually refine AI-generated themes, ensuring that contextual and theoretical considerations are adequately addressed. Developing ChatGPT-assisted qualitative analysis protocols, where AI suggestions are systematically reviewed by human coders, can enhance the credibility of thematic findings. Furthermore, interdisciplinary collaboration between AI specialists and educational researchers can lead to the development of tailored AI models that align more closely with the complexities of mathematics education research.

To uphold ethical standards, institutions and research bodies may establish clear guidelines on AI-assisted research methodologies. Researchers need to document the extent of ChatGPT's involvement in their studies, ensuring transparency in data analysis and literature synthesis. Additionally, AI bias mitigation strategies may be

incorporated into research protocols to prevent the reinforcement of existing disparities in mathematics education. By fostering a responsible AI research culture, the academic community can harness the potential of ChatGPT while safeguarding the integrity and inclusivity of educational research.

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