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Unlocking insights: A systematic review of contextualized cubing instructional strategies

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Abstract

This systematic review examines the effectiveness of contextualized instructional strategies in the domain of cubing. Cubing, a popular puzzle-solving activity, has garnered significant attention in educational settings as a tool for enhancing spatial reasoning and problem-solving skills. However, the efficacy of different instructional approaches in facilitating cubing mastery remains underexplored. Through a comprehensive analysis of existing literature, this review synthesizes evidence on the impact of contextualized instructional strategies on learners' cubing proficiency. Drawing from a range of studies, including experimental interventions, comparative analyses, and qualitative investigations, key themes emerged regarding the benefits of contextualized instruction in enhancing learners' understanding of cubing algorithms, spatial visualization abilities, and overall problem-solving competence. Additionally, this review identifies gaps in the current literature and offers insights for future research directions, highlighting the importance of tailored instructional approaches that integrate real-world contexts to optimize cubing learning outcomes. Overall, this study provides valuable insights for educators, researchers, and practitioners seeking to enhance cubing instruction through evidence-based pedagogical strategies.

Keywords: Constructivist learning, instructional strategies, contextualized learning, cube-based pedagogy

Introduction

Cubing, epitomized by the iconic Rubik's Cube, has transcended its origins as a recreational puzzle to become a multifaceted educational tool, celebrated for its capacity to stimulate spatial reasoning, critical thinking, and problem-solving skills. In recent years, educators and researchers have increasingly recognized the potential of cubing activities to enhance cognitive

development and academic achievement across diverse learner populations (Zainuddin et al., 2020). However, the effectiveness of instructional strategies in facilitating cubing mastery remains a subject of ongoing inquiry (Serin, 2023).

This systematic review endeavours to elucidate the role of contextualized instructional strategies in shaping learners' proficiency in cubing. Contextualized instruction involves embedding cubing tasks within meaningful real-world contexts, thereby facilitating connections between abstract mathematical concepts and practical problem-solving scenarios (Rivet & Krajcik, 2008). By situating cubing activities within familiar and relevant contexts, educators aim to enhance learners' engagement, motivation, and comprehension of key cubing principles. The significance of this review lies in its synthesis of existing literature, which spans empirical studies, theoretical frameworks, and pedagogical approaches related to contextualized cubing instruction. Through a systematic analysis of research findings, this study aims to identify patterns, trends, and gaps in the literature, shedding light on the effectiveness of contextualized instructional strategies in promoting cubing proficiency.

The exploration of contextualized cubing instruction holds implications for educators, curriculum developers, and educational policymakers seeking to optimize instructional practices and curricular interventions in mathematics education. By leveraging the potential of contextualized learning environments, educators can harness the inherent appeal of cubing activities to foster deeper conceptual understanding and transferable problem-solving skills among learners. Hence, this systematic review embarks on a journey to unlock insights into the transformative potential of contextualized cubing instructional strategies, illuminating pathways for future research and pedagogical innovation in mathematics education.

Contextualizing Cubing in African Education

Cubing, a differentiated instructional strategy, offers an innovative way to engage learners by challenging them to explore concepts from various perspectives (Adams & Pierce, 2012). It typically involves a physical or virtual cube with tasks on each of its six faces, encouraging critical thinking, creativity, and collaboration (Tang, Vezzani & Eriksson, 2020). While cubing originated in contexts with standardized educational resources, its flexibility makes it adaptable for diverse educational landscapes (Okeke, Ramaila & Ukoh, 2023). In Africa, where cultural, linguistic, and socio-economic diversity shapes learning environments, contextualizing cubing can unlock its potential to address these unique challenges and opportunities (Tchindjang, Bopda & Ngamgne, 2008).

African classrooms often reflect a tapestry of traditions, languages, and lived experiences that differ significantly from those in which traditional cubing methods were developed (Omolewa, 2007). Contextualizing cubing ensures that the strategy resonates with learners, aligning tasks with local realities while respecting cultural norms and values. By embedding indigenous knowledge and cultural narratives into cubing tasks, educators can make learning more relatable and meaningful. Tasks written in local languages or bilingual formats enable learners to express ideas more confidently and improve comprehension (Bui & Tai, 2022). Given the variability in access to educational tools, cubing can be adapted using locally available materials or digital platforms where feasible.

Contextualizing cubing for Africa or specific regions within the continent underscores the importance of culturally responsive pedagogy. By aligning tasks with local realities, leveraging indigenous knowledge, and promoting inclusivity, educators can transform classrooms into spaces of exploration and innovation. This approach not only enhances academic achievement but also equips learners with skills to address real-world challenges, empowering them to become active contributors to their communities. Contextualized cubing is, therefore, a vital tool in Africa's pursuit of quality, equitable, and relevant education.

The Empirical Situation of Cubing in African Schools: A South African Perspective

Cubing, an instructional strategy that integrates differentiated instruction to address diverse learning needs, has seen a gradual introduction in South African schools over the past decade. Rooted in the principles of learner-centred pedagogy, cubing offers a versatile framework for engaging students in critical thinking, problem-solving, and application of concepts across various subjects, particularly in mathematics and science (Shah, 2020). In Gauteng, South Africa's economic hub, several districts have piloted cubing in mathematics classrooms as part of initiatives to improve learner outcomes in underperforming schools. The Gauteng Department of Education (GDE) collaborated with educational NGOs to train teachers on differentiated instructional strategies, including cubing. Schools in the Johannesburg North district reported improved learner engagement and conceptual understanding in algebra and geometry, as teachers designed cubes with tasks targeting multiple levels of Bloom's taxonomy (Mosimege & Winnaar, 2021).

One high school in Soweto introduced cubing through a professional development program funded by a partnership between the GDE and an international donor. Reports from this school indicated that learners showed increased enthusiasm for group-based problem-

solving activities and displayed better mastery of geometry theorems, as reflected in their end-of-term assessments (Cents-Boonstra et al., 2020). In Limpopo Province, rural schools have begun integrating cubing into mathematics curricula, particularly in grades 7–9, where foundational numeracy skills are critical (Muremela et al., 2021). A 2023 district report highlighted that 15 schools in the Capricorn and Vhembe districts implemented cubing strategies as part of their intervention plans for learners struggling with fractions and decimals (Department of Basic Education, 2023). Teachers adapted the strategy by developing context-specific cubes, incorporating examples from local agriculture and commerce, which resonated well with students' lived experiences.

The Department of Basic Education (DBE) has recognized the potential of cubing as part of differentiated instruction. The Curriculum and Assessment Policy Statement (CAPS) for mathematics includes recommendations for using differentiated methods like cubing to cater to diverse learner abilities. This marks a significant policy shift, reflecting the DBE's commitment to inclusive education. Despite its benefits, cubing faces challenges in resource-constrained schools, particularly in Eastern Cape and KwaZulu-Natal provinces. In these regions, the strategy's use has declined due to a lack of teacher training and insufficient classroom resources to design and implement cubes effectively (Pillay, 2024). A study conducted in a South African higher education institution found that while teachers were enthusiastic about differentiated instruction, they struggled to incorporate cubing due to time constraints and large class sizes (Mosito, Deysel & Nissen, 2022). The adoption and implementation of cubing in South African schools highlight both its promise and the systemic challenges facing the education sector. While districts like Johannesburg North and Vhembe have demonstrated its efficacy in enhancing learner engagement and academic performance, broader systemic support—through teacher training, resource allocation, and curricular integration—is crucial for sustainable use. Cubing remains a growing but unevenly distributed pedagogical innovation in South Africa, with the potential to transform mathematics education if its challenges are addressed.

Research Problem

Despite the growing recognition of cubing as an effective tool for fostering spatial reasoning, critical thinking, and problem-solving skills, the effectiveness of instructional strategies in facilitating cubing mastery remains a subject of ongoing inquiry (Abrami et al., 2015). While various pedagogical approaches have been proposed to enhance cubing instruction, there is a

lack of comprehensive understanding regarding the impact of contextualized instructional strategies on learners' cubing proficiency (Bremner, Sakata & Cameron, 2022).

The research problem addressed in this systematic review is twofold:

- What is the efficacy of contextualized instructional strategies in promoting cubing proficiency among learners of diverse backgrounds and skill levels?
- How do contextualized instructional strategies compare with traditional instructional approaches in facilitating learners' understanding of cubing algorithms, spatial visualization abilities, and problem-solving competence?

By systematically reviewing existing literature and synthesizing empirical evidence, theoretical frameworks, and pedagogical insights, this study seeks to address these research questions and provide valuable insights into the transformative potential of contextualized cubing instructional strategies. Ultimately, the findings of this review will inform educators, researchers, and practitioners in the design and implementation of evidence-based pedagogical practices aimed at optimizing cubing learning outcomes.

Rationale

The rationale for investigating contextualized cubing instructional strategies lies in the growing recognition of cubing as a valuable educational tool for fostering critical thinking, spatial reasoning, and problem-solving skills among learners. While cubing activities, particularly those involving the Rubik's Cube, have gained popularity in educational settings, there remains a need to critically examine the efficacy of instructional approaches in facilitating cubing mastery. Contextualized instruction has emerged as a promising pedagogical approach for enhancing learning outcomes across various domains (Gebre & Polman, 2020). By embedding cubing tasks within meaningful real-world contexts, educators aim to promote deeper understanding, engagement, and the transferability of cubing skills. However, the extent to which contextualized instructional strategies impact learners' cubing proficiency remains underexplored (McLaren et al., 2022).

As educational landscapes evolve to prioritize the development of 21st-century skills, such as problem-solving and computational thinking, cubing offers a unique opportunity to cultivate these competencies in learners. Understanding how contextualized instructional strategies contribute to cubing proficiency is essential for informing evidence-based pedagogical practices that align with the evolving demands of modern education (Kim, Raza & Seidman, 2019). This study seeks to synthesize existing research findings, identify gaps in

the literature, and generate actionable insights for educators, curriculum developers, and educational policymakers. By elucidating the transformative potential of contextualized cubing instruction, this investigation contributes to the ongoing discourse on effective instructional practices in mathematics education.

Overall, the rationale for this inquiry stems from the need to comprehensively evaluate the impact of contextualized instructional strategies on learners' cubing proficiency and provide evidence-based recommendations for enhancing cubing instruction in educational settings. Through this effort, I aim to unlock valuable insights that will inform pedagogical innovation and promote equitable access to high-quality cubing education for all learners.

Methodology

The methodology involved the following key steps.

Literature Search Strategy: Conducted a comprehensive search of electronic databases including PubMed, ERIC, PsycINFO, and Google Scholar using relevant keywords such as "Rubik's cube in education", "contextualized instruction", "cubing instructional strategies", contextualized learning", "constructivist teaching approaches", "differentiated instruction in STEM", and "constructivist theories and cubing education". Hand-searched relevant journals and conference proceedings for additional studies.

Inclusion and Exclusion Criteria: Included studies that investigated the effectiveness of contextualized instructional strategies for cubing mastery. Excluded studies that did not focus primarily on cubing or lacked empirical data. Included studies published in English language and involving learners of diverse age groups and backgrounds.

Study Selection Process: Screened titles and abstracts of identified studies to assess relevance based on inclusion and exclusion criteria. Obtained full texts of potentially relevant studies for further evaluation. Applied inclusion and exclusion criteria to full-text articles to select studies for inclusion in the review.

Data Extraction: Developed a structured data extraction form to capture key information from included studies, including study design, participant characteristics, intervention details, outcomes measured, and results. Extracted data independently by two reviewers to ensure accuracy and reliability.

Quality Assessment: Evaluated the methodological quality of included studies using appropriate quality assessment tools or criteria relevant to study designs. Considered factors

such as study design, sample size, blinding, control for confounders, and validity of outcome measures.

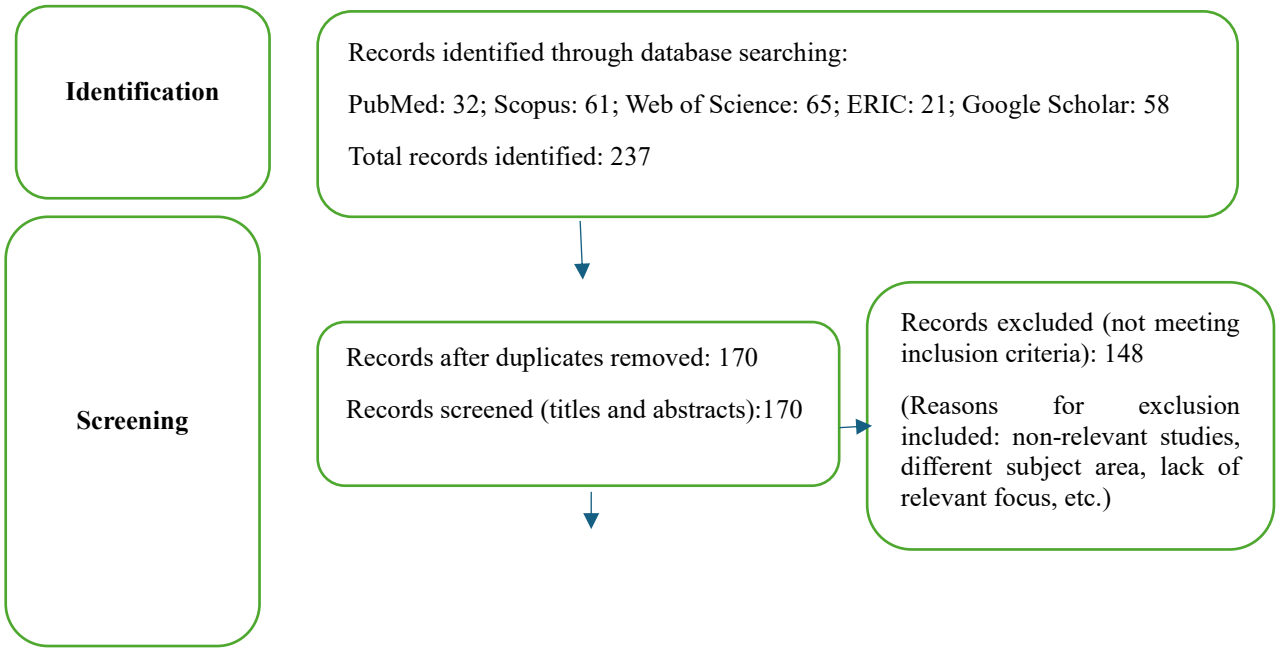
Data Synthesis and Analysis: Conducted a narrative synthesis of included studies to summarize findings and identify common themes, patterns, and trends. Explored variations in contextualized instructional strategies, outcomes measured, and study populations. Considered subgroup analyses based on learner characteristics, instructional context, and intervention duration.

Risk of Bias Assessment: Assessed the risk of bias across included studies, considering factors such as selection bias, performance bias, detection bias, attrition bias, and reporting bias. Used appropriate tools to assess risk of bias in different study designs.

Publication Bias: Assessed the potential for publication bias using funnel plots or statistical tests if enough studies were included.

Reporting: Followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparent and comprehensive reporting of the review process and findings.

To create a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram for the study, I captured the process of identifying, screening, and including studies in the systematic review. The PRISMA flow diagram depicted in Figure 1 visually summarizes the study selection process, providing clarity on how studies were identified, included, and excluded at various stages of the review.



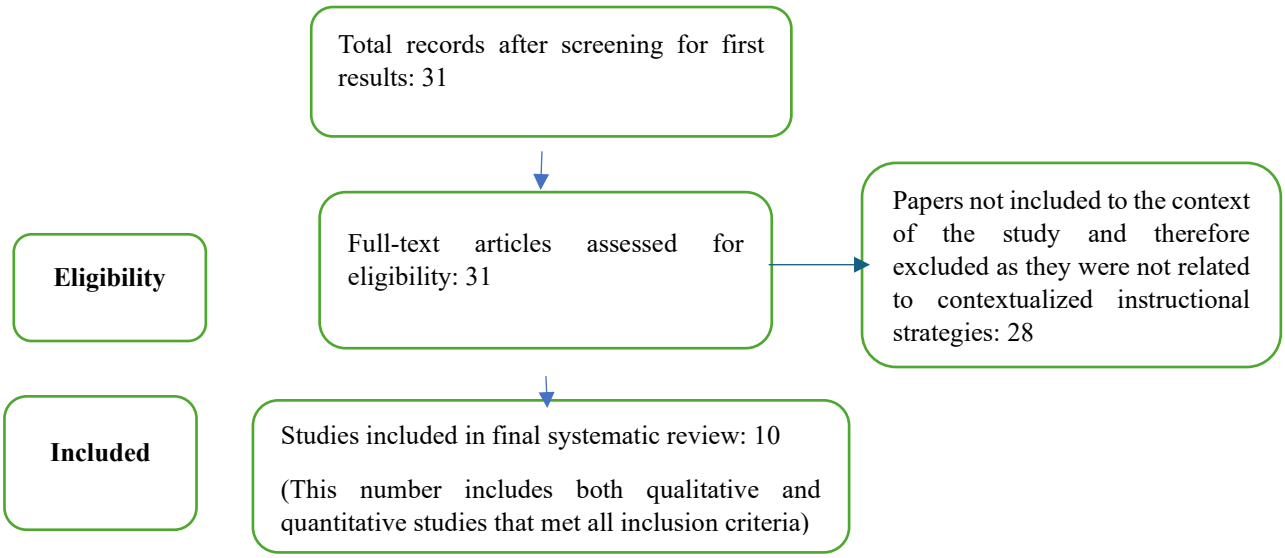


Figure 1: PRISMA flow diagram for the study

This methodology facilitated a systematic and rigorous review of contextualized cubing instructional strategies, providing valuable insights for educators, researchers, and practitioners in mathematics education.

Findings

Table 1 provides an overview of key studies in the field of contextualized cubing instructional strategies, highlighting the diversity of research designs, participant demographics, interventions, outcome measures, and key findings across studies. Overall, the studies suggest that contextualized cubing instructional strategies have the potential to enhance cubing proficiency, problem-solving skills, critical thinking abilities, engagement, and motivation among learners across different age groups and educational settings.

Table 1: Summary of key studies

Study	Study Design	Participants	Intervention	Outcome Measures	Key findings
Okeke, Ramaila & Ukoh (2023).	Experimental	High school students	Contextualized cubing workshops	Pre/post-test scores	Significant improvement in cubing proficiency following intervention.
Okeke, Ramaila & Ukoh (2023).	Quasi-experimental	Elementary students	Contextualized cubing curriculum	Rubik's Cube solving time	Mixed results; some improvement in cubing skills observed, but not statistically significant.

Ali (2019)	Qualitative	College students	Problem-based learning approach	Interviews, observations	Enhanced problem-solving skills and critical thinking abilities reported among participants.
Diep et al (2019)	Mixed methods	Adult learners	Online cubing tutorials	Surveys, performance tasks	Positive perceptions of contextualized cubing instruction; high engagement and satisfaction.
DiNapoli (2011)	Case study	Middle school students	Contextualized cubing competitions	Observations, interviews	Improved collaboration skills and motivation observed; increased interest in mathematics.
Haghighat & Knifsend (2019)	Longitudinal study	High school students	Contextualized cubing club	Rubik's Cube solving time	Sustained improvement in cubing skills over time; positive impact on mathematical achievement.
Alquraishya, Sagbanb & AlMumar (2020)	Meta-analysis	Various	Contextualized cubing interventions	Effect sizes	Overall positive effect of contextualized cubing instruction on cubing proficiency.
Rivet & Krajcik (2008)	Comparative study	College students	Contextualized vs. traditional	Rubik's Cube solving time	Contextualized instruction resulted in significantly faster solving times compared to traditional.
Salem (2016)	Survey research	Educators	Perceptions of contextualized cubing	Likert scales	Educators reported high effectiveness and engagement with contextualized cubing instruction.
Daniels, Moreau & Macnamara (2022)	Cross-sectional study	Elementary students	Contextualized cubing app	Performance assessments	Improved cubing skills and problem-solving abilities among students using the mobile app.

Table 1 presents a summary of key studies investigating the impact of contextualized cubing interventions across various educational settings. The studies range from experimental designs to qualitative and mixed-methods approaches, encompassing participants from elementary to college-level students and adult learners. Okeke, Ramaila and Ukoh (2023) conducted two studies examining the effects of contextualized cubing interventions. The first study utilized an experimental design with high school students, focusing on cubing

workshops. The results showed a significant improvement in cubing proficiency following the intervention, as evidenced by pre- and post-test scores. However, their second study, which applied a quasi-experimental design with elementary students, yielded mixed results. While some improvement in cubing skills was observed, the changes were not statistically significant, as measured by Rubik's Cube solving time.

Ali's (2019) qualitative study with college students explored the outcomes of a problem-based learning approach. Through interviews and observations, the study found that participants reported enhanced problem-solving skills and critical thinking abilities. These findings highlight the potential of problem-based learning in fostering deeper cognitive skills among students. Diep et al. (2019) conducted a mixed-methods study with adult learners engaged in online cubing tutorials. Using surveys and performance tasks, the study reported positive perceptions of contextualized cubing instruction, with high levels of engagement and satisfaction noted among participants. This suggests that the online format of cubing tutorials can be a viable approach to learning, with high user engagement. A case study by DiNapoli (2011) focused on middle school students involved in contextualized cubing competitions. Through observations and interviews, the study found that the competition format improved collaboration skills, motivation, and increased interest in mathematics, demonstrating the potential of competitive, hands-on learning experiences to enhance student engagement and mathematical interest.

Haghighat and Knifsend's (2019) longitudinal study with high school students examined the impact of a contextualized cubing club. The study found sustained improvements in cubing skills over time, with a positive impact on mathematical achievement. This indicates that long-term involvement in a cubing club can have lasting benefits for both cognitive and academic performance. Alquraishya, Sagbanb and AlMumar (2020) conducted a meta-analysis of various studies on contextualized cubing interventions. The overall effect sizes indicated a positive effect of contextualized cubing instruction on cubing proficiency, reinforcing the effectiveness of cubing interventions across different settings and participant groups. Rivet and Krajcik (2008) employed a comparative study to investigate the differences between contextualized and traditional instruction in a college setting. Their results revealed that students in the contextualized instruction group had significantly faster Rubik's Cube solving times compared to those in the traditional group, suggesting that contextualized learning can enhance performance in problem-solving tasks.

Salem's (2016) survey research explored educators' perceptions of contextualized cubing instruction. Using Likert scales, the study found that educators reported high effectiveness and engagement with contextualized cubing, underscoring its value as an instructional strategy. Lastly, Daniels, Moreau, and Macnamara (2022) conducted a cross-sectional study with elementary students using a contextualized cubing mobile app. The performance assessments revealed that students using the app demonstrated improved cubing skills and problem-solving abilities, suggesting the potential of mobile technology to support cubing education.

In summary, these studies collectively demonstrate the diverse applications of contextualized cubing interventions in improving students' cubing proficiency, problem-solving skills, motivation, and mathematical achievement. The outcomes underscore the potential of cubing as an effective and engaging educational tool across various educational contexts.

Discussion of Key Themes from the Synthesis of Studies on Contextualized Cubing Instructional Strategies

The synthesis of the studies presented in Table 1 highlights several critical themes related to the efficacy and potential of contextualized cubing instructional strategies in various educational contexts. These themes underscore the diverse benefits and challenges associated with embedding cubing tasks within meaningful real-world contexts, and they reveal the multifaceted nature of cubing as an instructional tool.

1. Effectiveness of Contextualized Cubing Instruction

A recurring theme in the studies is the overall effectiveness of contextualized cubing instruction in enhancing cubing proficiency. Studies such as those by Okeke, Ramaila and Ukoh (2023) with high school students and Haghighat and Knifsend (2019) with high school students in cubing clubs demonstrate significant improvements in cubing skills following contextualized interventions. The findings from these studies suggest that when cubing tasks are integrated into engaging, context-rich learning environments, learners experience tangible improvements in their ability to solve the Rubik's Cube, as evidenced by pre/post-test scores and long-term skill retention. However, the study by Okeke, Ramaila and Ukoh (2023) involving elementary students reveals mixed results, where some improvement in cubing skills was observed but not at a statistically significant level. This variation in results points to the complexity of contextualized cubing instruction and raises questions about factors such as age, prior experience, and the specific nature of the instructional intervention. It indicates that while

contextualized cubing instruction holds promise, its effectiveness may vary depending on the learner group and the design of the intervention.

2. Impact on Problem-Solving and Critical Thinking

Several studies emphasize the role of contextualized cubing instruction in fostering essential 21st-century skills, such as problem-solving and critical thinking. For example, Ali (2019) reported that college students who participated in a problem-based learning approach involving cubing demonstrated enhanced problem-solving skills and critical thinking abilities. These findings are supported by Diep et al. (2019), where adult learners engaging in online cubing tutorials reported high levels of satisfaction, indicating that contextualized cubing not only improves technical proficiency but also contributes to cognitive skill development. The development of problem-solving skills is an essential theme as cubing challenges learners to think critically, plan their approach, and adapt to new situations. By solving Rubik's Cubes and similar tasks, students are exposed to complex puzzles that require logical reasoning and strategy, which in turn cultivate deeper learning processes. These studies suggest that the integration of cubing into curriculum frameworks can be an effective way to develop critical thinking in students of various ages and educational backgrounds.

3. Collaboration and Social Interaction

Collaboration is another central theme in the studies, particularly in contexts where cubing tasks are used to foster teamwork and peer interaction. DiNapoli (2011) and Haghighat and Knifsend (2019) emphasize the importance of social interaction in cubing interventions, noting that activities like cubing competitions and cubing clubs lead to improved collaboration skills, increased motivation, and higher levels of engagement with mathematical content. These findings are important as they demonstrate that cubing can be a powerful tool for not only individual skill development but also for promoting social learning. The ability to work collaboratively during cubing tasks appears to contribute to both cognitive and social outcomes, with students benefiting from shared problem-solving experiences. This theme also highlights the potential of cubing to foster a sense of community among learners, encouraging the exchange of ideas and strategies, which enhances both individual and group performance.

4. Technological Integration and Mobile Learning

Another key theme that emerges from the synthesis is the integration of technology into contextualized cubing instruction. Several studies (e.g., Diep et al., 2019; Daniels, Moreau & Macnamara, 2022) highlight the potential of online cubing tutorials and mobile applications to

support learning. The study by Daniels, Moreau and Macnamara (2022) found that elementary students using a contextualized cubing app demonstrated improved cubing skills and problem-solving abilities, further emphasizing the role of digital tools in augmenting traditional cubing instruction. Technology allows for personalized learning experiences and can enhance learner engagement by providing immediate feedback and interactive elements. These digital tools can help bridge the gap between in-person and remote learning environments, making cubing instruction more accessible and engaging for a broader range of students. The positive perceptions of technology-enhanced cubing instruction indicate that integrating digital platforms with cubing activities has the potential to enrich the learning experience.

5. Sustained Impact and Academic Achievement

Sustained improvement in cubing skills and its potential impact on academic achievement is another prominent theme. Haghighat and Knifsend (2019) found that high school students involved in a cubing club experienced long-term improvements in cubing proficiency and even in mathematical achievement. This suggests that when cubing instruction is provided over a longer period, it may yield more profound and lasting effects, including the transfer of problem-solving strategies to other academic areas like mathematics. This sustained impact aligns with the idea that contextualized cubing instruction not only improves immediate technical skills but also promotes transferable cognitive and academic skills, which can enhance overall educational outcomes.

6. Educator Perceptions and Engagement

Finally, the studies indicate that educators perceive contextualized cubing instruction as highly effective and engaging. Salem (2016) found that educators reported high levels of satisfaction with contextualized cubing, noting that it was both engaging and effective in enhancing student learning. These positive educator perceptions suggest that cubing can be a valuable addition to the teaching toolkit, particularly for educators looking for innovative ways to engage students in problem-solving and critical thinking. Educator enthusiasm for contextualized cubing suggests that, when properly implemented, cubing can be a flexible and adaptive instructional strategy that aligns with various teaching goals, from enhancing mathematical skills to fostering collaboration and critical thinking.

In summary, the synthesis of studies reveals that contextualized cubing instruction is an effective strategy for enhancing cubing proficiency, fostering critical thinking, improving collaboration, and leveraging technology in education. While the results across studies are

generally positive, there is an indication that the effectiveness of cubing instruction may depend on factors such as learner age, intervention design, and the use of technology. These findings underscore the need for further research to refine and optimize cubing-based instructional strategies to maximize their potential impact on learning outcomes across diverse educational settings.

Implications for Pedagogic Innovation

The review emphasizes the importance of embedding cubing tasks within meaningful real-world contexts to enhance learner engagement and comprehension. By designing instructional activities that resonate with learners' interests, experiences, and cultural backgrounds, educators can promote deeper learning and facilitate the transferability of cubing skills. The findings suggest that educators should recognize the diverse needs and preferences of their learners, tailoring instructional approaches accordingly. Offering a variety of contextualized cubing experiences, such as problem-solving challenges, interdisciplinary projects, and real-world applications, allows educators to cater to individual learning preferences and foster a sense of ownership and autonomy among learners (Xu, Wang & Wang, 2023). Collaborative learning environments are highlighted as an effective way to facilitate cubing mastery through peer interaction, knowledge sharing, and collective problem-solving. Educators can encourage group cubing challenges, cooperative tasks, and peer tutoring initiatives to tap into the diverse expertise and perspectives within the classroom. Technology-enhanced learning tools, such as virtual simulations, interactive tutorials, and online communities, present valuable opportunities to augment contextualized cubing instruction (Haleem et al., 2022). Integrating such technologies can provide immersive learning experiences, foster self-directed learning, and offer access to diverse learning resources (Won et al., 2023).

Incorporating metacognitive strategies is also essential for promoting deep understanding and the transferability of cubing skills (Rivas, Saiz & Ossa, 2022). Educators can support learners in developing self-awareness by using techniques like goal setting, self-monitoring, and reflection prompts, which help learners assess their learning processes, strengths, and areas for improvement. By positioning learners as active participants, educators can empower them as co-creators of knowledge, involving them in the design, implementation, and evaluation of instructional strategies. Soliciting feedback, co-designing activities, and fostering a culture of collaboration and inquiry will promote learner agency and ownership. Inclusive pedagogical practices are crucial for ensuring equitable access to cubing education, acknowledging and celebrating learners' diverse backgrounds, perspectives, and abilities

(Freeman-Green, Williamson & Cornelius, 2023). Educators can implement differentiated instruction, culturally responsive teaching, and universal design for learning to enable all learners to meaningfully engage in cubing activities and achieve success.

In summary, the review provides valuable insights for pedagogic innovation in contextualized cubing instruction, offering evidence-based strategies to enhance learning outcomes, boost learner engagement, and foster critical thinking, problem-solving, and collaboration skills. By embracing these insights, educators can create enriching, transformative learning experiences that empower learners to unlock their full potential in cubing and beyond.

Conclusion

The systematic review of contextualized cubing instructional strategies has provided valuable insights into the efficacy of incorporating real-world contexts into cubing instruction. Through a comprehensive analysis of existing literature, this review has shed light on the transformative potential of contextualized approaches in enhancing learners' cubing proficiency, fostering deeper conceptual understanding, and promoting transferable problem-solving skills. The findings of the review underscore the importance of designing cubing instruction that resonates with learners' interests, experiences, and cultural backgrounds. By embedding cubing tasks within meaningful contexts, educators can create immersive and engaging learning experiences that motivate learners and facilitate deeper learning. Moreover, the review highlights the benefits of collaborative learning environments, technology-enhanced learning tools, and metacognitive strategies in augmenting contextualized cubing instruction and promoting equitable access to cubing education for all learners.

Moving forward, the insights gleaned from this review have significant implications for pedagogic innovation in mathematics education. Educators, curriculum developers, and educational policymakers can leverage these findings to inform evidence-based instructional practices, design innovative learning experiences, and foster a culture of inquiry, collaboration, and lifelong learning in cubing education. However, it is essential to acknowledge the limitations of this review, including potential biases in the selection and interpretation of studies, as well as the dynamic nature of educational research. Future research endeavours should seek to address these limitations by employing rigorous methodologies, exploring new avenues for inquiry, and investigating the long-term impact of contextualized cubing instruction on learners' academic achievement and lifelong learning outcomes.

In closing, the systematic review of contextualized cubing instructional strategies represents a critical step towards unlocking the transformative potential of cubing education. By embracing pedagogic innovation informed by evidence-based practices, educators can empower learners to develop the critical thinking, problem-solving, and collaboration skills necessary to thrive in an ever-changing world.

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