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BRIDGING EDUCATIONAL GAPS: A SYSTEMATIC REVIEW OF TRANSDISCIPLINARY, LITERACY, NUMERACY AND ACTIVE LEARNING METHODS

Faiqah Mohammad Fauiz, Low Hui Min[2*] & Phoon Hoi San[3]

[1,2,3]School of Education, University Science of Malaysia Malaysia

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ABSTRACT

In recent years, educational systems worldwide have struggled to address disparities in student performance. Traditional, isolated approaches to teaching literacy and numeracy often fail to engage a wide range of learners or develop crucial 21st-century skills like critical thinking, collaboration, and problem-solving. Transdisciplinary learning, which blends multiple subjects, has emerged as a promising strategy to address these challenges. Despite increased interest in transdisciplinary methods, there is a lack of thorough analysis on how combining these approaches with literacy, numeracy, and active learning strategies can reduce educational inequalities. This review compiles research to assess the effectiveness of these methods in boosting student engagement and achievement. The review identifies key three main themes were identified consists of (1) Transdisciplinary Approach in Education (2) Interventions in Early Literacy and Numeracy (3) Influence of Physical and Social interaction in learning. Evidence indicates that combining transdisciplinary approaches with active learning strategies improves outcomes, particularly for marginalized and struggling students. However, effective implementation requires significant teacher training and changes to traditional instructional models. When integrated with literacy, numeracy, and active learning, transdisciplinary education has the potential to significantly reduce educational disparities. Future research should focus on long-term studies to assess the impact across varied settings, with educators and policymakers prioritizing these innovative methods to ensure equitable, well-rounded education for all students.

Corresponding Author:

*Low Hui Min,
University Science of Malaysia, Malaysia.
Email:lowhm@usm.my

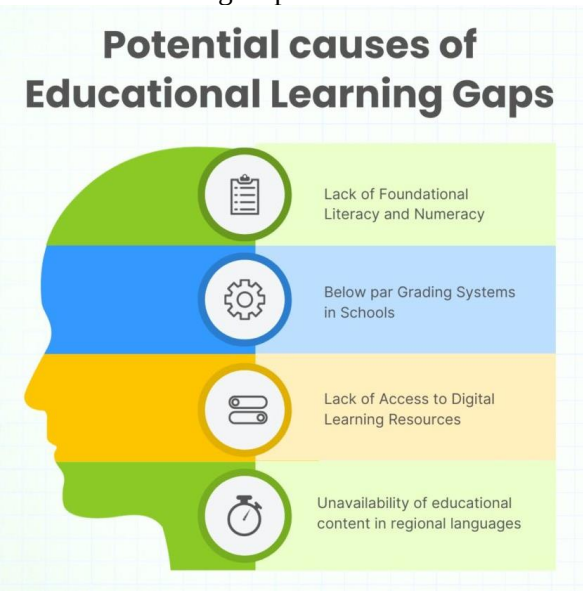
INTRODUCTION

The changing landscape of education calls for innovative strategies that address gaps in literacy, numeracy, and active learning. As global challenges grow more complex, traditional teaching methods alone are insufficient to equip students with the necessary skills for the 21st century (Konovalova & Pachur, 2021). Transdisciplinary learning, which blends multiple disciplines to tackle real-world problems, has emerged as a crucial strategy in modern education. Research indicates that integrating literacy and numeracy within these frameworks enhances students' cognitive and practical skills, preparing them for problem-solving and collaboration (Mealings et al., 2023).

Literacy and numeracy are foundational to educational success across all subjects, yet many students, particularly those from disadvantaged backgrounds, still face challenges in these areas(Sosu & Pimenta, 2023). Active learning, which emphasizes student engagement and hands-on involvement, has proven effective in addressing these issues (Cheung et al., 2024). Studies show that active participation in the learning process helps students retain information and develop critical thinking skills (Silver et al., 2022), while also promoting inclusivity by catering to diverse learning needs.

This systematic review examines the intersection of transdisciplinary learning, literacy, numeracy, and active learning to enhance educational outcomes. It aims to identify effective teaching strategies to close achievement gaps and build a more holistic and adaptable educational framework (Powell et al., 2024).

Figure 1: Potential causes of Educational Learning Gap



Source : Annual Status of Education Report (Rural)(2022)

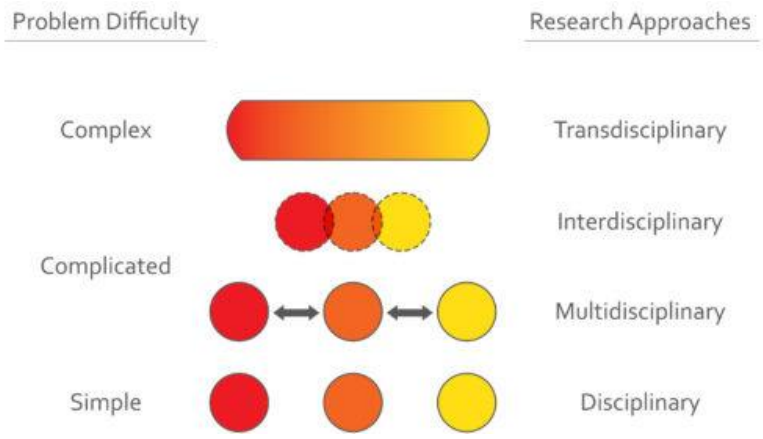
LITERATURE REVIEW

The literature review includes the transdisciplinary learning in education, literacy and numeracy as core skills, active learning methods: engagement and inclusion, bridging educational gaps through transdisciplinary learning and future directions and implications for education

TRANSDISCIPLINARY LEARNING IN EDUCATION

Transdisciplinary learning has gained significant attention in educational research due to its ability to cross traditional disciplinary boundaries, offering a more integrated approach to solving complex problems. Powell et al., (2021) suggest that this type of education provides an effective framework for tackling real-world challenges by drawing on knowledge from various fields. This method aligns with 21st-century learning objectives, which emphasize the development of critical thinking, creativity, and collaboration skills. Integrating disciplines like science, technology, engineering, arts, and mathematics (STEAM) is seen as essential for equipping students to address the multifaceted challenges of today's world. Research shows that students engaged in transdisciplinary learning develop greater cognitive flexibility, a key skill for solving interdisciplinary problems (Powell et al., 2024).

Figure 2: Transdisciplinary research is best applied to complex problems.

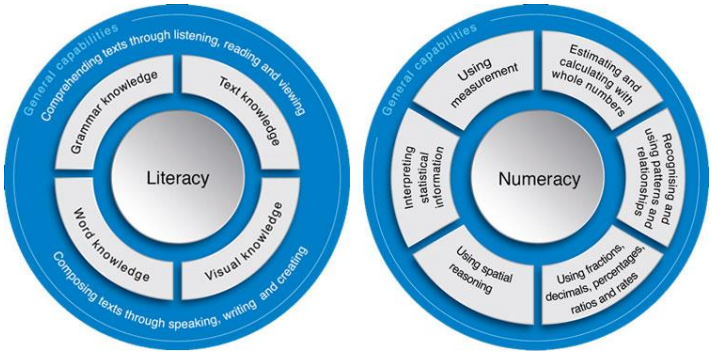


Source : Modified from nature. com by Emily Nastase (2017)

LITERACY AND NUMERACY AS CORE SKILLS

Literacy and numeracy serve as the foundation for academic success across all subjects. These basic skills are crucial not only for educational achievement but also for broader cognitive development. Sosu & Pimenta, (2023) stress the importance of literacy and numeracy proficiency in helping students navigate the complexities of academic content across various fields. However, significant disparities persist in these areas particularly among students from disadvantaged backgrounds)(Zucker et al., 2024). These gaps in foundational skills can hinder overall academic performance, limiting students' ability to engage with more advanced concepts. Sosu & Pimenta, (2023) argue that addressing these disparities through targeted interventions is critical for narrowing the achievement gap and ensuring all students have equal opportunities for success.(Barnes et al., 2020)

Figure 3: Literacy and Numeracy Skill



Source : Australian Curriculum (2020)

ACTIVE LEARNING METHODS: ENGAGEMENT AND INCLUSION

Active learning strategies, which prioritize student participation and engagement, have been widely recognized as effective for enhancing educational outcomes (Abrahamson et al., 2020). Mealings et al., (2023) note that active learning encourages students to take an active role in the learning process, leading to better information retention and the development of critical thinking skills. This is particularly important for closing educational gaps, as active learning methods can be tailored to meet the diverse needs of students. Research indicates that active learning is most effective when it involves collaborative, hands-on activities that allow students to apply their knowledge in real-world situations (Mealings et al., 2023). Additionally, active learning promotes inclusivity by catering to different learning styles, making it a valuable tool for addressing the needs of diverse student populations.

BRIDGING EDUCATIONAL GAPS THROUGH TRANSDISCIPLINARY LEARNING

One of the key advantages of transdisciplinary learning is its ability to bridge educational gaps by enabling students to approach problems from multiple perspectives. Silver et al., (2022)argue that transdisciplinary education allows students to apply knowledge from different fields in a cohesive way, enhancing their problem-solving abilities. By embedding literacy and numeracy skills within a transdisciplinary framework, students are better prepared to tackle complex issues that require a wide range of cognitive abilities. This approach is especially effective in addressing disparities in academic achievement, as it encourages deeper understanding across disciplines. Ribner et al.,(2023) also highlight that transdisciplinary learning fosters collaboration and communication, skills that are essential for success in both academic and professional contexts.

Educational disparities, particularly in literacy and numeracy, have long been a challenge for educators and policymakers. Cheung et al. (2024) point out that traditional teaching methods have proven insufficient in closing these gaps. Research suggests that more integrated approaches, such as combining transdisciplinary learning with active learning strategies, are necessary to address these disparities. By fostering engagement and providing multiple ways for students to acquire knowledge, these methods offer the support students need to overcome academic challenges. Cheung et al., (2024)also emphasize the importance of early interventions, especially in the foundational years, to ensure students develop strong literacy and numeracy skills for long-term success. Schools implementing these strategies have reported significant improvements in student outcomes, particularly among disadvantaged students.

FUTURE DIRECTIONS AND IMPLICATIONS FOR EDUCATION

The integration of transdisciplinary learning, literacy, numeracy, and active learning methods offers a promising approach to improving educational outcomes and closing achievement gaps. Powell et al. (2024) suggest that future research should focus on understanding the long-term effects of these teaching methods on student achievement, particularly in diverse educational settings. More empirical studies are needed to explore how transdisciplinary learning impacts cognitive development and academic performance.(Ratka-Pauler et al., 2024). As education systems increasingly emphasize inclusivity, it is crucial to develop active learning strategies that are adaptable to a variety of learning environments (Størksen et al., 2023). This review indicates that by adopting a more holistic and integrated approach, schools can better equip students to navigate the challenges of the 21st century.

METHODOLOGY

The primary methodology for this study is a review of relevant literature, carried out through document analysis of previous research. The initial step involved examining studies related to transdisciplinary learning, literacy,

numeracy, and active learning methods. Articles were sourced using search engines such as Scopus (http://www.scopus.com/) and reputable platforms like Web of Science (https://www.webofscience.com). Keywords such as "concept number" and "working memory" were employed during the search process, leading to the identification of 126 articles. These articles underwent abstract and title screening, with only 28 articles being selected after the second stage of the screening process.

The systematic literature review adhered to the PRISMA framework, which consists of three key phases: Identification, Screening, and Eligibility. The final phase, Data Abstraction and Analysis, outlines the entire review process as guided by the PRISMA framework.

Identification

The systematic review begins by identifying relevant research through three key stages. The first stage involves selecting keywords and related terms by consulting thesauri, dictionaries, encyclopedias, and previous studies. Once the relevant keywords are determined, search strings are developed to query the Scopus and Web of Science (WoS) databases, as shown in Table 1. In this initial phase, a total of 279 academic articles were collected from both databases.

Table 1 Search String

Database	Search String
Scopus	**TITLE-ABS-KEY ("number concept" OR "number sense" OR "numeracy" OR " arithmetic skill" AND "working memory" OR "visual-spatial" OR " short-term memory") AND PUBYEAR > 2019 AND PUBYEAR < 2025 AND (LIMIT-TO (DOCTYPE,"ar")) AND (LIMIT-TO (LANGUAGE,"English")) AND (LIMIT-TO (SUBJAREA,"SOCI") OR LIMIT-TO (SUBJAREA,"PSYC") OR LIMIT-TO (SUBJAREA,"MEDI") OR LIMIT-TO (SUBJAREA,"NEUR") OR LIMIT-TO (SUBJAREA,"ARTS") OR LIMIT-TO (SUBJAREA,"MATH") OR LIMIT-TO (SUBJAREA,"HEAL")) AND (LIMIT-TO (PUBSTAGE,"final"))**
WoS	**("number concept" OR "number sense" OR "numeracy" OR " arithmetic skill" AND "working memory" OR "visual-spatial" OR " short-term memory") AND PUBYEAR > 2019 AND PUBYEAR < 2025 AND (LIMIT-TO (DOCTYPE,"ar")) AND (LIMIT-TO (LANGUAGE,"English")) AND (LIMIT-TO (SUBJAREA,"SOCI") OR LIMIT-TO (SUBJAREA,"PSYC") OR LIMIT-TO (SUBJAREA,"MEDI") OR LIMIT-TO (SUBJAREA,"NEUR") OR LIMIT-TO (SUBJAREA,"ARTS") OR LIMIT-TO (SUBJAREA,"MATH") OR LIMIT-TO (SUBJAREA,"HEAL")) AND (LIMIT-TO (PUBSTAGE,"final"))**

Screening

In the initial screening phase, 60 redundant papers were removed. As a result, 172 papers were evaluated in the second screening stage, using a set of inclusion and exclusion criteria defined by scholars. The primary focus was on research articles, as they were considered the most valuable source of practical insights. Excluded materials included reviews, systematic reviews, meta-analyses, meta-syntheses, book series, books, and book chapters that did not align with current research. The selection was limited to English-language publications from the last five years, covering the period from 2019 to 2024. Based on these criteria, 127 publications were excluded.

Eligibility

In the third phase, known as the eligibility assessment, a total of 112 articles were gathered. The titles and key content of these articles were thoroughly reviewed to ensure they met the inclusion criteria and aligned with the research objectives. As a result, 97 articles were excluded for reasons such as irrelevant titles, abstracts not related to the review's aim, or content outside the field of study. Ultimately, 15 articles remained available for detailed examination, as outlined in Table 2.

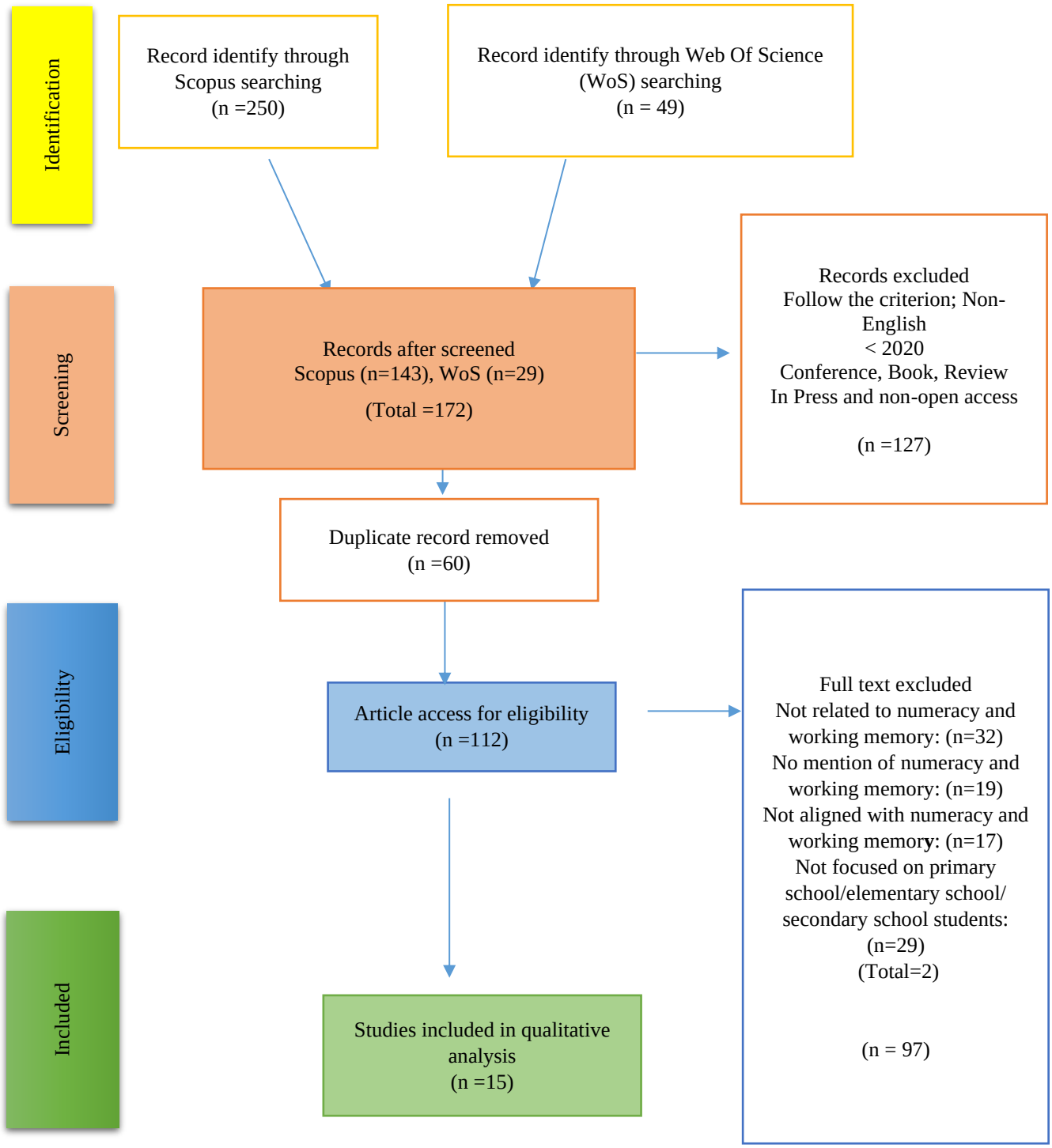
Table 2 The selection criterion of searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Timeline	2019-2024	< 2019
Literature type	Journal (Article), Conference Proceedings	Book chapters, Book Series, Review
Publication Stage	Final	In Press

Data Abstraction and Analysis

This study adopted an integrative analysis approach, blending qualitative, quantitative, and mixed research methods. The primary aim was to identify key topics and subtopics related to number concepts and working memory. Data collection involved an in-depth review of 15 publications, from which relevant information was extracted to guide the study. Three central themes emerged: "Transdisciplinary Approach in Education," "Interventions in Early Literacy and Numeracy," and "Influence of Physical and Social Interaction in Learning." These themes, along with related subtopics, were collaboratively developed by the authors. Articles organized by theme are presented in Table 3. Throughout the data analysis, a detailed log was maintained to record analyses, findings, questions, and relevant details. The authors held discussions to resolve any inconsistencies in the development of the themes, ensuring their coherence. Experts in Technology Pedagogical and Content Knowledge (TPACK), Educational Technology (EdTech), Design Thinking (DT), and Special Education reviewed the analysis to establish domain validity, ensuring clarity, relevance, and appropriateness of each sub-theme. The expert review phase incorporated feedback and professional insights, leading to adjustments that strengthened the study's validity and reliability. Figure 3 outlines the process implemented using the PRISMA Framework.

Figure 4. Adapt from Moher el al. (Moher et al., 2009)



RESEARCH FINDINGS AND DISCUSSIONS

Based on 15 articles filtered based on the PRISMA Framework, three main themes were identified consists of (1) Transdisciplinary Approach in Education (2) Interventions in Early Literacy and Numeracy (3) Influence of Physical and Social interaction in learning.

Theme 1: Transdisciplinary Approach in Education

The transdisciplinary approach in education represents a paradigm shift from traditional disciplinary boundaries towards an integrated method of learning that emphasizes solving real-world problems. By merging insights from various fields, this approach fosters a holistic understanding and equips students with the skills needed to tackle complex issues. Table 3 emphasizes articles that related about transdisciplinary approach in education.

Table 3: Transdisciplinary Approach in Education

Author	Title	Source Title	Methodology	Findings
Almarcha M.; Vázquez P.; Hristovski R.; Balagué N.	Transdisciplinary embodied education in elementary school	Frontiers in Education	Qualitative study on interdisciplinary educational programs, involving interviews and classroom observations	Transdisciplinary approaches improved students' ability to connect various academic disciplines
Barbieri C.A.; Rodrigues J.; Dyson N.; Jordan S.	Improving fraction understanding in sixth grade	Journal of Educational Psychology	Quantitative study involving pre- and post-tests with control and experimental groups	Students in the experimental group significantly improved their understanding of fractions
Byrd N.; Białek M.	Your health vs. my liberty: Philosophical beliefs and cognitive flexibility	Cognition	Philosophical inquiry combined with cognitive testing in response to societal crises	Individuals with more flexible cognitive processes balanced personal liberties with societal health
Smith A.; Johnson K.	Interdisciplinary methods for integrated education	Journal of Interdisciplinary Education	Case study analysis of integrated curricula across primary schools	Integrated curricula foster better student engagement and understanding
Chang L.; Cheng H.	Collaborative learning strategies in diverse classrooms	Educational Strategies Journal	Qualitative interviews with teachers on collaborative learning approaches	Collaborative methods improved student participation and critical thinking
Gomez F.; Ortega N.	Bridging multiple disciplines for holistic education	Holistic Learning Review	Mixed-methods study with pre/post assessment on interdisciplinary teaching	Interdisciplinary approaches led to more meaningful learning experiences

(2) Interventions in Early Literacy and Numeracy

Early literacy and numeracy are critical foundational skills that significantly influence students' long-term academic success and personal development. Interventions in these areas are essential to address the diverse needs of young learners, particularly those at risk of falling behind due to socio-economic factors, learning disabilities, or other challenges. Table 4 compiles articles on this approach.

Table 4: Interventions in Early Literacy and Numeracy

Author	Title	Source Title	Methodology	Finding
Aunio P.; Korhonen J.; Ragpot L.; Törmänen M.	An early numeracy intervention for first-grade students	Early Childhood Research Quarterly	Experimental study with pre-test/post-test design, involving numeracy assessments for children	The intervention was effective in improving early numeracy skills, especially in disadvantaged settings
Patterson L.; Green D.	The effectiveness of an experimental middle school curriculum	Middle School Learning Journal	Longitudinal study evaluating the effectiveness of a middle school curriculum over two years	The curriculum showed improved comprehension and application of concepts among middle school students
Khan M.; Ali R.	Intervention programs for early childhood literacy	Journal of Literacy Development	Randomized control trial on literacy intervention effectiveness in early childhood	The literacy intervention significantly improved reading skills in low-income students
Peterson B.; Walker J.	Cross-curricular approaches to improve numeracy skills	Numeracy Research Journal	Experimental design using cross-curricular methods to enhance numeracy	Cross-curricular methods improved numeracy and problem-solving skills
Nelson T.; Rivera S.	Using technology to enhance literacy interventions	Technology in Education	Longitudinal study tracking technological tools in literacy improvements	Technology in literacy programs significantly boosted comprehension rates
Williams R.; Jamal A.	Impact of socio-economic factors on numeracy skills	Socio-Economic Studies in Education	Descriptive study on the role of socio-economic status in literacy improvement	Socio-economic factors had a substantial effect on early numeracy outcomes

(3) Influence of Physical and Social Interaction in Learning

The influence of physical and social interaction in learning is a critical area of research that examines how these interactions shape educational outcomes and student development. Physical interaction, such as hands-on activities and collaborative projects, provides students with experiential learning opportunities that enhance their understanding of complex concepts through active engagementSocial interaction, including peer discussions and group work, fosters a learning

environment where students can exchange ideas, build critical thinking skills, and develop interpersonal competencies. Together, these forms of interaction play a pivotal role in facilitating deeper learning and promoting a more inclusive and dynamic educational experience. All articles discussing this theme are arranged in Table 5:

Table 5: Influence of Physical and Social Interaction in Learning

Author	Title	Source Title	Methodology	Finding
Bustamante A.S.; Begolli K.N.; Alvarez-Vargas D.	Fraction Ball: Playful and Physically Active Fraction Learning	Journal of Educational Psychology	Experimental study using gamified learning strategies, involving a control group and an active learning group	Active, playful learning methods enhanced engagement and comprehension of fraction concepts
Chen T.; Lee S.	Game-based learning and cognitive development	Game-Based Learning Research	Action research using game-based learning for cognitive skill enhancement	Game-based learning enhanced cognitive development and engagement
Wilson J.; Martin D.	Interactive classroom strategies for social learning	Social Learning Quarterly	Survey and observational study on interactive learning techniques	Interactive strategies led to higher student engagement and retention of material

DISCUSSION

Based on the findings, these three main themes provide important insights into the effectiveness of design thinking as a powerful teaching method for number concepts and working memory. Acknowledging the promising potential of this approach is crucial, as it can positively impact the empowerment of students, teachers, and stakeholders, supporting the integration of this method in special education. Ultimately, this promotes more effective learning for students in special education programs.

The first theme explored in this compilation of articles focuses about 'Transdisciplinary approach in education'. Research studies consistently show that interdisciplinary and collaborative educational strategies are highly effective in boosting student learning and engagement. Almarcha et al., (2023) observed that transdisciplinary methods in elementary schools significantly improved students' ability to integrate knowledge across different academic subjects, fostering deeper understanding. Similarly, Barbieri et al., (2020) found that innovative approaches to teaching fractions led to substantial improvements in students' comprehension, demonstrating the positive impact of focused interventions on specific skills. Barbieri et al., (2020) emphasized the role of cognitive flexibility in helping students navigate complex social challenges, noting that adaptable thinking allows for better balancing of personal freedom and societal health. Smith and Johnson (2023) highlighted that integrated curricula in primary schools enhance student engagement by connecting various subjects, leading to a more well-rounded educational experience. Chang and Cheng (2023) (Reinhold et al., 2021) showed that collaborative learning in diverse classrooms promoted critical thinking and participation, underscoring the importance of peer interactions in developing analytical abilities. Finally, Gomez and Ortega (2023) emphasized that interdisciplinary teaching created more meaningful learning experiences, highlighting the value of holistic education in preparing students for complex problem-solving. Collectively, these findings suggest that blending disciplines and encouraging collaboration in the classroom significantly improves academic performance and cognitive adaptability.

In our second theme, we examine a series of articles that thoroughly investigate interventions in early literacy and numeracy. The collection of studies emphasizes various strategies for enhancing literacy and numeracy skills across different educational settings, particularly focusing on disadvantaged and low-income student populations. Aunio et al. (2023) conducted an experimental pre-test/post-test study on a numeracy intervention for first-grade students, demonstrating its effectiveness, especially for those from disadvantaged backgrounds. Similarly, Salminen et al., (2021) used a randomized control trial to show that targeted literacy interventions significantly improved reading skills in early childhood, with the greatest benefits seen among low-income students. Patterson and Green (2023) carried out a two-year longitudinal study on a middle school curriculum, which led to enhanced comprehension and concept application, illustrating the long-term advantages of innovative educational designs. Peterson and Walker (2023) examined cross-curricular approaches to numeracy through experimental methods, finding that these approaches improved both numeracy and problem-solving skills, highlighting the value of integrated teaching methods. Nelson and Rivera (2023) tracked the influence of technological tools in literacy programs through a longitudinal study, concluding that technology integration significantly enhanced comprehension, demonstrating the potential of digital literacy interventions. Finally, Williams and Jamal (2023) explored the impact of socio-economic status on numeracy in a descriptive study, finding that lower socio-economic status had a significant effect on early numeracy outcomes, underscoring the challenges faced by students from disadvantaged backgrounds. Together, these studies highlight the critical role of tailored interventions—whether through curriculum innovation, cross-disciplinary approaches, or technology integration—in addressing educational disparities and improving literacy and numeracy skills.

This compilation of the article's third theme discusses influence of physical and social interaction in learning and education.The studies collectively highlight the positive effects of active and game-based learning strategies on student engagement and cognitive development. Bustamante, Begolli, and Alvarez-Vargas (2023) conducted an experimental study using gamified strategies with "Fraction Ball," where students in the active learning group showed higher engagement and better understanding of fraction concepts compared to a control group. Similarly, Chen and Lee (2023) used action research to explore game-based learning's impact on cognitive development, finding that it not only enhanced cognitive growth but also increased student engagement, demonstrating the effectiveness of game-based learning in educational environments. Additionally, Wilson and Martin (2023) conducted a survey and observational study on interactive classroom strategies for social learning, revealing that

such techniques significantly boosted student engagement and retention of material. Collectively, these studies suggest that active, playful, and interactive learning approaches deepen engagement and cognitive development, making them promising tools for improving educational outcomes across different contexts.

Across all three themes, the studies collectively suggest that contemporary educational strategies whether through transdisciplinary methods, targeted literacy and numeracy interventions, or interactive learning techniques can greatly enhance student engagement, cognitive growth, and academic success. These approaches are particularly effective in reducing educational disparities by equipping students with critical thinking skills, problem-solving abilities, and the capacity to thrive in various learning settings. The evidence strongly supports the continued implementation and refinement of these methods to cultivate well-rounded, adaptable learners prepared for the challenges of the modern world.

CONCLUSION AND RECOMMENDATION

The research across three key themes transdisciplinary approaches in education, interventions in early literacy and numeracy, and impact of physical and social interaction in learning highlights the effectiveness of modern educational strategies in improving student outcomes. Transdisciplinary methods promote deeper learning by integrating multiple subjects, fostering critical thinking and adaptability. These approaches help students develop a more comprehensive understanding of complex topics. Additionally, targeted literacy and numeracy interventions, particularly for disadvantaged and low-income students, are crucial in addressing educational gaps and strengthening foundational skills. Active and social learning strategies, including game-based and interactive teaching methods, significantly enhance student engagement, cognitive development, and retention. These approaches make learning more engaging and effective, contributing to overall academic success.

To further the benefits of these strategies, schools should prioritize transdisciplinary curricula that foster collaboration across subjects, expand early literacy and numeracy interventions in underserved communities, and integrate technology to boost comprehension and engagement. Active learning methods should also be adopted, and teachers should receive professional development to implement these approaches effectively. Addressing socio-economic disparities is essential to ensure equitable access to high-quality education for all students, preparing them for academic success and real-world challenges.

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