



Systematic Review on the Efficacy of Desmos Integration in Mathematics Education: Unveiling Impacts on Learning Outcomes and Pedagogical Strategies

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Article Info

ISSN (online): 3049-1215

Volume: 02

Issue: 04

July – August 2025

Received: 04-05-2025

Accepted: 03-06-2025

Published: 02-07-2025

Page No: 104-115

Abstract

This study investigated the efficacy of integrating Desmos in mathematics education. It examined the characteristics of selected journal articles, including journal publication, geographical locations, study design, participant profiles, sample focus, and coverage. The study also explored the effectiveness of Desmos integration in enhancing student learning outcomes, shaping attitudes, and improving overall academic achievement. Furthermore, it considered its pedagogical implications in terms of teaching approaches, technology integration strategies, and facilitation of learning. A systematic review served as the primary research methodology, utilizing Harzing's Publish or Perish, Zotero, and the PRISMA 2020 protocol to systematically identify, evaluate, and screen relevant journal articles. A total of eight studies were included, each offering unique features and insights. The findings indicated that Desmos is both flexible and adaptable in improving instructional practices, supporting the development of effective technology integration plans, and promoting deeper mathematical understanding. Positive outcomes were observed in terms of conceptual learning, student engagement, and academic performance. Despite challenges such as the lack of formal training, Desmos still presents significant potential to advance mathematics education. In light of these findings, the study recommends implementing formal professional development programs to equip teachers with the necessary skills to effectively integrate Desmos. Additionally, more diverse and globally representative studies are needed to ensure broader applicability across educational contexts. The inclusion of more qualitative research is also encouraged to provide a richer understanding of the challenges and nuances of Desmos integration. Teachers are urged to collaborate and share best practices to maximize the effective use of digital tools like Desmos in mathematics classrooms.

DOI: <https://doi.org/10.54660/IJFEI.2025.2.4.104-115>

Keywords: Desmos Integration, Learning Outcomes, Mathematics Education, Pedagogical Strategies, Systematic Review

1. Introduction

Over the years, technology has become an integral component of educational reform, shaping contemporary teaching methodologies and enhancing instructional delivery (Mediana, 2023) ^[15]. In mathematics education, the incorporation of digital tools has gained considerable traction, with Desmos emerging as a widely adopted platform. As an open-source application, Desmos offers more than traditional graphing utilities; it provides interactive features that foster meaningful engagement and deeper comprehension of mathematical concepts. Nevertheless, the pedagogical value of integrating Desmos warrants rigorous academic inquiry (Explore Math with Desmos, 2016). This systematic review seeks to critically evaluate the effectiveness of Desmos integration within mathematics instruction.

The analysis is framed by two core dimensions: its impact on student learning outcomes and its influence on instructional practices.

The first dimension interrogates the extent to which Desmos enhances learners' academic performance, particularly in relation to problem-solving, critical thinking, and conceptual understanding. Central to this investigation is the question: What measurable effects does Desmos integration have on student achievement in mathematics?

The second dimension examines pedagogical shifts prompted by Desmos use in the classroom. It addresses the question: In what ways does the use of Desmos influence mathematics teachers' instructional approaches and strategies? This includes a review of how educators adapt their methods to incorporate Desmos and the implications for classroom dynamics and student engagement.

The significance of this review lies in its potential to consolidate fragmented findings and offer a comprehensive understanding of Desmos as a technological intervention. While prior studies report favorable outcomes, the absence of a synthesized body of evidence limits broader generalization. This review aims to fill that gap, offering insights relevant to educators, curriculum developers, and policymakers seeking to harness technology in pursuit of improved mathematics education.

1.1 Research Questions

This study explored the efficacy of integrating Desmos in mathematics education and unveiled its impact on learning outcomes and pedagogical strategies. Specifically, it answered the following research questions:

1. What characteristics do the studies that were included in the systematic review have in terms of:
 - Journal publication characteristics
 - Geographical characteristics
 - Study design
 - Study participants or sample focus
 - Study coverage
2. How does the integration of Desmos affect pedagogical strategies in mathematics classrooms in terms of:
 - Teaching approaches
 - Technology integration scheme
 - Facilitating learning
3. What is the impact of integrating Desmos in mathematics instruction on student learning outcomes, attitude, and overall achievement?

1.2 Literature Review

The literature review conducted in this study served as a critical foundation for examining the efficacy of integrating Desmos into mathematics education. It provided a structured analysis of the conceptual and methodological frameworks guiding the inquiry, particularly emphasizing the systematic review process as a rigorous and evidence-based approach to synthesizing research. Systematic reviews, characterized by their transparency, reproducibility, and methodological precision, are widely regarded as the gold standard in educational research synthesis.

To support this methodological foundation, the review engaged with established tools and protocols, including Harzing's Publish or Perish for citation analysis, Zotero for

literature management, and the PRISMA 2020 guidelines for ensuring transparency in the identification, screening, and selection of relevant studies. These tools facilitated the organization and critical evaluation of existing literature, ensuring the review's alignment with scholarly standards of rigor and replicability.

The review also examined current literature on the integration of Desmos within mathematics instruction, mapping out existing findings related to student learning outcomes, engagement, and pedagogical transformations. This exploration illuminated both the potentials and limitations observed in prior studies, providing a contextual backdrop for the present inquiry.

Overall, the literature review not only established the theoretical and methodological framework of the study but also positioned it within a broader academic discourse. It laid the groundwork for a systematic, critical, and nuanced analysis of how Desmos influences mathematics teaching practices and student achievement, thereby contributing meaningfully to the evolving conversation on technology integration in education.

1.2.1 Systematic Review and Conceptual Framework

Systematic reviews and meta-analyses have long been regarded as the "gold standard" in research synthesis (Clarke & Stewart, 1994)^[6]. These approaches are characterized by their explicit, systematic, and repeatable procedures, making them valuable across diverse types of studies (Tetzlaff, Tricco, & Moher, 2010)^[27]. Despite frequent conflation, systematic reviews differ significantly from traditional literature reviews, although both aim to summarize existing research on a specific topic.

Lyn (2013)^[13] defined a systematic review as a rigorous synthesis of primary research guided by a focused question, which involves identifying, selecting, evaluating, and appraising high-quality studies relevant to that inquiry. In contrast, literature reviews rely on informal or subjective methods to collect and interpret findings, often lacking the methodological structure that defines systematic reviews. These two types of reviews also differ in their goals, structure, authorial demands, timelines, and evidentiary standards.

The framework for conducting this study's systematic review drew heavily from the step-by-step guidelines proposed by the University of Maryland, adapted from *A Guide to Conducting Systematic Reviews* by the Cornell University Library (2023). This framework shown in Figure 1 outlines key stages: identifying the research question, defining inclusion and exclusion criteria, locating and selecting studies, extracting data, assessing risk of bias, synthesizing findings, and evaluating the quality of evidence—often visualized using the PRISMA Flow Diagram. The Cochrane Consumers and Communication review process further clarified the sequence, beginning with issue identification and culminating in synthesis and conclusion.

Central to the present study is the adoption of this systematic review framework to evaluate the integration of Desmos in mathematics instruction. Recognizing the methodological distinctions between systematic and literature reviews, the researcher intentionally chose a systematic approach to ensure transparency, replicability, and methodological rigor. The process, grounded in the guidance from both the University of Maryland and Cornell University, ensured a structured progression from formulating the research

question to synthesizing reliable conclusions.

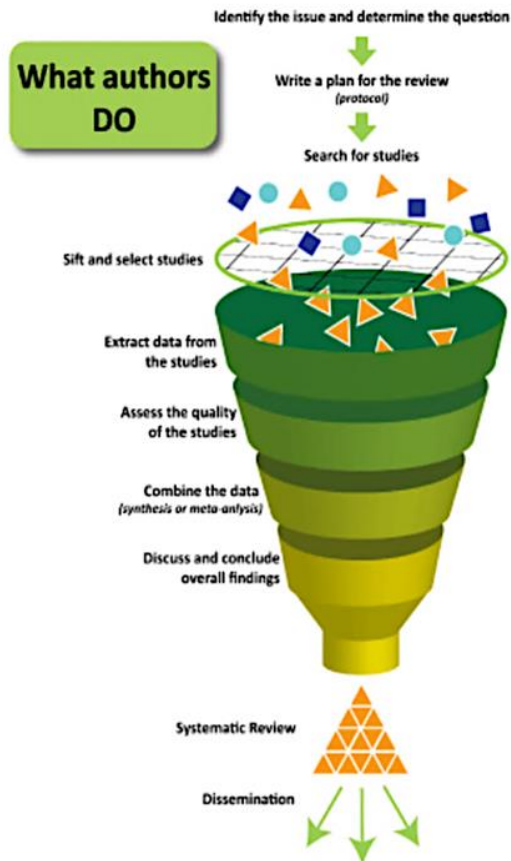


Fig 1: What Authors Do

By aligning with Clarke and Stewart's (1994)^[6] assertion of systematic reviews as the gold standard, this study adhered to high standards of methodological excellence. The aim was to produce a comprehensive and credible synthesis of pedagogical strategies and learning outcomes associated with Desmos integration in mathematics education. This commitment not only enhances the trustworthiness of the findings but also contributes meaningfully to the broader discourse on technology-enhanced learning, offering evidence-based insights for educators, researchers, and policymakers alike.

1.2.2 Harzing Publish and Perish, Zotero, and PRISMA 2020

Harzing's Publish or Perish is a citation analysis tool developed to search and rank academic publications based on their citation metrics. Drawing from multiple databases, it provides critical indicators such as total citations, h-index, and the number of scholarly outputs, thus offering a quantitative overview of research performance (Will-Harzing, 2016)^[30]. In this study, Publish or Perish was utilized to systematically identify and analyze scholarly articles relevant to Desmos integration in mathematics education.

Complementing this, Zotero is a widely adopted reference management software designed to facilitate the organization and citation of bibliographic materials. It enables researchers to collect, categorize, and annotate sources efficiently. Notably, its functionality supports the creation of structured literature databases, annotated bibliographies, and note-taking per citation, making it indispensable for managing

research workflows and ensuring academic integrity (Emilio, n.d.).

In addition to citation and reference management tools, this study also incorporated the PRISMA 2020 framework, a widely endorsed reporting guideline for systematic reviews. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) enhances the transparency and reproducibility of systematic reviews by guiding researchers in clearly reporting their objectives, methodologies, inclusion criteria, and findings. It ensures that readers can critically appraise the quality, relevance, and reliability of the review (DistillerSR Inc., 2023)^[23].

While originally tailored for systematic reviews evaluating the effectiveness of health interventions, PRISMA 2020 has broader applicability. Its checklist items are relevant across various domains, including education and the social sciences, especially in studies examining prevalence, prognosis, etiology, and intervention effectiveness. It also accommodates reviews with or without meta-synthesis and can be adapted for mixed-methods research designs. For systematic reviews that integrate both qualitative and quantitative evidence, the use of PRISMA 2020 is recommended in conjunction with complementary qualitative synthesis reporting standards (The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews, 2021).

Together, Harzing's Publish or Perish, Zotero, and the PRISMA 2020 framework provided the methodological foundation for this study, ensuring rigor, transparency, and comprehensive reporting throughout the systematic review process.

1.2.3 ICT Integration in Mathematics Education

The body of literature presented below underscores the centrality of information and communication technologies (ICTs) in contemporary society, particularly within the educational domain and, more specifically, mathematics instruction. The longstanding concern among mathematics educators regarding the integration of ICT into classroom instruction reflects a sustained commitment to enhancing pedagogical effectiveness. Within this context, the integration of Desmos—a dynamic graphing calculator and interactive mathematical platform—emerges as a critical focal point for evaluating the pedagogical value of digital tools in mathematics education.

Das (2019)^[7] defines ICT as a broad category encompassing diverse tools and systems designed for the storage, retrieval, transmission, and management of information. As a foundational element of modern society, ICT plays a transformative role in educational practices. In mathematics, it extends beyond traditional teaching tools to include databases, spreadsheets, graphing software, and graphical calculators. Desmos exemplifies this evolution by offering students an interactive environment for computation, graphing, and problem-solving, thereby supporting the development of conceptual understanding and mathematical reasoning.

Further grounding this framework, UNESCO (2002) characterizes Information Technology (IT) as a scientific, technological, and engineering field, emphasizing its intersection with social, economic, and cultural contexts. Prytherch (2000)^[22] adds that ICTs function as networks that enable new forms of learning and training through the dissemination of digital content, while Blurton (1999)^[3]

defines ICT as a “diverse set of technological tools and resources used to create, store, and disseminate information.” These definitions collectively highlight the multifaceted potential of ICTs to enhance instructional practices, particularly in subjects requiring analytical and abstract thinking such as mathematics.

Historically, mathematics educators have been at the forefront of advocating for the thoughtful integration of ICT into instructional practices. According to Becta (2003) ^[1], ICT in mathematics education has been operationalized through various applications, including spreadsheets, mathematical software, graphical calculators, and portable digital tools. These resources not only facilitate access to information but also encourage collaborative problem-solving and the application of mathematical thinking in real-world contexts. ICT thus serves as a mediating tool through which learners engage with mathematical content more deeply.

One of the most significant contributions of ICT lies in its capacity to support higher-order thinking. Students who engage with ICT tools are often required to synthesize, interpret, and manipulate information to construct meaning and solve complex problems. Das (2019) ^[7] emphasizes that through processes such as estimating, analyzing, and integrating ideas, students develop a deeper understanding of mathematical concepts and are better equipped to generate innovative solutions. ICT becomes most effective when it supports conceptual understanding, promotes analytical reasoning, and fosters critical thinking.

In practical terms, ICT enables students to perform complex computations, generate graphs, and conduct analyses using devices such as calculators, graph plotters, or dynamic geometry software. For example, students may employ computer algebra systems or spreadsheets to explore algebraic functions or perform statistical analyses. Desmos, as a contemporary graphing platform, offers capabilities that extend these functionalities within a user-friendly, web-based interface. It supports dynamic visualization, fosters interactive exploration, and allows for the immediate manipulation of mathematical models—thereby enriching both teaching and learning.

Despite its potential, effective integration of ICT—particularly Desmos—requires that students acquire the necessary digital competencies. This highlights the need for targeted instructional strategies that not only incorporate Desmos into lesson design but also develop students’ proficiency in its use. Without adequate technical skills, the educational value of such tools may remain untapped.

In sum, the literature consistently affirms the relevance and transformative potential of ICT in mathematics education. Desmos, as a pedagogically rich and technologically advanced platform, aligns with broader educational goals of fostering deeper mathematical understanding, promoting learner autonomy, and enhancing instructional innovation. Its integration represents not merely a technological enhancement but a pedagogical shift toward more interactive, student-centered learning environments.

2. Methodology

This study employed the systematic review framework outlined by the University of Maryland, which draws upon the guide *A Guide to Conducting Systematic Reviews: Steps in a Systematic Review* by the Cornell University Library (2023). The adopted protocol includes key steps such as

defining the research question, establishing inclusion and exclusion criteria, conducting a comprehensive literature search, selecting studies based on pre-established standards, extracting relevant data, assessing risk of bias, presenting the synthesized findings, and evaluating the overall quality of evidence. To facilitate an efficient and methodologically sound review process, this study utilized tools such as Harzing’s Publish or Perish and Zotero for citation tracking, source organization, and reference management. Moreover, the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were followed to ensure transparent reporting of the literature search, screening process, inclusion criteria, and justifications for excluding studies. Collectively, these tools and frameworks provided a rigorous methodological foundation for conducting a credible and replicable systematic review.

2.1 Study Eligibility

The inclusion criteria for eligible literature in this systematic review were carefully pre-defined to ensure consistency and rigor in the selection process. These criteria encompassed publication type, date, language, study design, educational level, outcomes measured, and full-text availability. Only peer-reviewed journal articles published between 2013 and 2023, and indexed in Google Scholar, were included to maintain relevance and scholarly credibility. To ensure consistency in interpretation and analysis, only literature published in English was considered.

Eligible studies were limited to those employing experimental, quasi-experimental, or observational research designs that specifically examined the integration of Desmos in mathematics education in relation to learning outcomes or pedagogical strategies. Furthermore, the review included studies conducted at the primary, secondary, or tertiary levels of education. Only sources with accessible full-text versions and those that reported empirical data—quantitative, qualitative, or mixed—on either student learning outcomes or instructional practices were considered.

Conversely, several exclusion criteria were applied to eliminate non-relevant or low-quality sources. These included: (a) literature not indexed in Google Scholar or published in non-peer-reviewed outlets; (b) studies published prior to 2013; (c) articles without available full texts; (d) publications in languages other than English; (e) studies lacking a clearly defined methodology or research design; and (f) sources that did not report data on the impact of Desmos integration on learning outcomes or pedagogical strategies. These criteria collectively ensured that only methodologically sound and contextually relevant studies were included in the final review.

2.2 Study Identification

Peer-reviewed literature published between 2013 and 2023 was systematically retrieved from the Google Scholar database using the Harzing Publish or Perish software. This tool is widely recognized for its ability to search academic citations and generate a range of bibliometric indicators, including the number of publications, total citations, and the h-index (Will-Harzing, 2016) ^[30]. By leveraging multiple data sources, Publish or Perish enables researchers to identify high-impact literature efficiently.

The literature search was guided by a set of primary keywords, including Desmos, Desmos Software, Desmos Application, Desmos for Mathematics Education, Desmos

for Mathematics Instruction, and Integrating Desmos in Mathematics Teaching. The software's advanced search algorithm allows for the extraction of up to 1,000 records per search term, which are then ranked according to citation count (Tarma Software Research Ltd., 2016) [23].

Existing studies emphasize the importance of citation metrics in identifying high-quality scholarly work. Tenopir *et al.* (2015) [24] and Wang and Soergel (1998) [29] observed that researchers tend to focus their reading on a relatively small subset of available literature, often prioritizing highly cited works due to their perceived quality and relevance.

Supporting this notion, Teplitskiy *et al.* (2022) argued that papers with higher citation counts tend to receive more substantive engagement from readers and exert greater influence on subsequent research than citation numbers alone might suggest.

Given the time constraints of the current study and informed by these insights, the researcher opted to limit the retrieval process to the top 50 most cited records for each keyword. This approach yielded a total of 300 publication records, ensuring both relevance and quality while maintaining manageability within the study's timeframe.

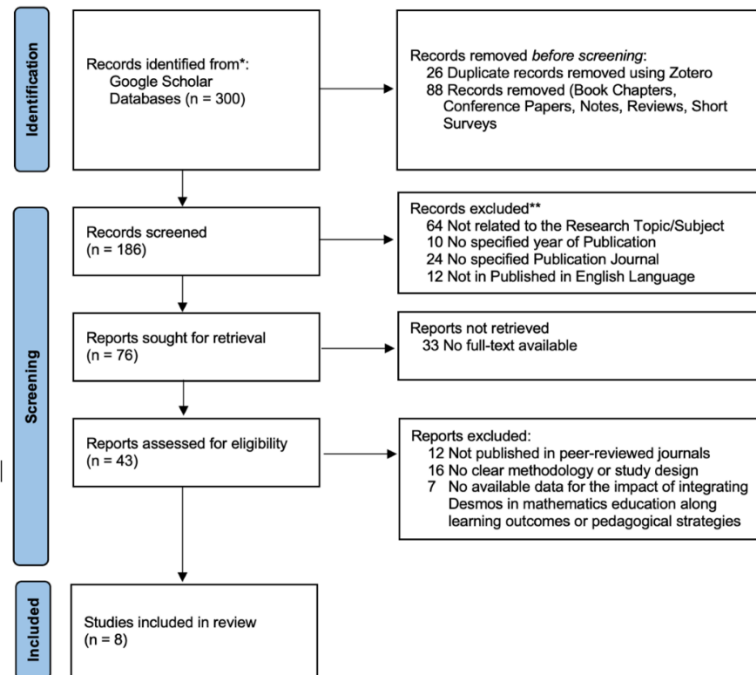


Fig 2: PRISMA 2020 Diagram

2.3 Study Selection

Based on the predetermined inclusion and exclusion criteria, the researcher assessed the 300 publication records retrieved through Harzing Publish or Perish. These records were evaluated in terms of publication type, date, language, study design, educational level addressed, outcome measures, and full-text availability. Following the initial identification of relevant records, the PRISMA 2020 framework was utilized to guide the systematic screening and evaluation process.

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) is widely recognized as a standard framework for reporting systematic reviews. It enables reviewers to transparently describe the objectives of their review, the methods employed, and the findings generated. Through systematic documentation, PRISMA allows readers to assess the quality of the review and the relevance of its conclusions within their specific contexts. As emphasized by DistillerSR Inc. (2023) [18], PRISMA has become an essential component in ensuring the methodological rigor and objectivity of systematic reviews.

As illustrated in Figure 2 (PRISMA 2020 Flow Diagram), the initial pool of 300 publications identified through Harzing Publish or Perish was first screened to remove non-research materials such as duplicate entries, book chapters, literature reviews, conference papers, and notes. This initial screening yielded 186 records eligible for further assessment. From

these 186 records, an additional subset was excluded for the following reasons: 64 were deemed unrelated to the study's focus, 10 did not report a publication year, 24 lacked journal information, and 12 were not published in English. This reduced the dataset to 76 potentially relevant studies, of which 33 were excluded due to unavailability of the full-text article.

The remaining 43 full-text articles were then assessed for eligibility. Of these, 35 were excluded for reasons including absence of peer-review, unclear or missing methodology or study design, and lack of reported data on the impact of Desmos integration in mathematics education, particularly with regard to learning outcomes or pedagogical strategies. Ultimately, only 8 studies *met all* criteria and were included in the final synthesis of this systematic review. This aligns with the approach taken by Mediana, Funa, and Dio (2025) [16], who emphasized the importance of strict inclusion criteria and methodological rigor in their meta-analysis on inquiry-based learning in science and mathematics.

2.4 Data Coding and Extraction

Data coding and extraction were conducted by the researchers based on a pre-established data collection scheme and a structured extraction matrix form. The following key information was gathered from each study: title, author(s), study objectives, country of origin, year of publication,

participant details, study design, journal of publication, and major findings and conclusions. The included studies were categorized primarily according to study characteristics (e.g., country, year, participants, study design, and journal source), study design and methodology (e.g., duration, theoretical framework, research approach, data collection and analysis methods), and findings and conclusions (LibGuide, 2023; Mediana, Funa, & Dio, 2025) ^[16].

Furthermore, all extracted data from the included studies were utilized in the synthesis and interpretation of the outcomes. To ensure consistency and clarity in the review process, data were organized and categorized using tables and tabulation forms. These tables served as tools for systematically compiling study characteristics, methodological approaches, and key findings across all selected research articles, thereby enhancing the reliability of the data extraction process and facilitating comparative analysis.

2.5 Data Synthesis

Since the studies included in this review are heterogeneous—partly due to variations in research methods and study designs—conducting a meta-analysis was deemed inappropriate. Although statistical analysis of achievement data may be feasible, the central research question guiding this review does not primarily focus on quantifiable outcomes (Petticrew & Roberts, 2008) ^[20]. Therefore, the researcher opted to use a meta-narrative review as the method for data synthesis. According to LibGuide (2023), a meta-narrative summary is typically employed when a meta-analysis is not viable. While it provides a descriptive account of the review results, it can also take a more interpretive stance in synthesizing diverse findings.

Moreover, meta-narrative review is a relatively new and evolving methodology for conducting qualitative and mixed-method systematic reviews. It is particularly useful in revealing the contrasting and complementary ways researchers have explored a complex or multidisciplinary topic. Through this lens, a meta-narrative review aims to bring coherence to diverse perspectives by tracing how different research traditions have approached the same or closely related questions (Wong *et al.*, 2013) ^[31].

3. Results and Discussion

This section presents the results and discussion derived from the comprehensive analysis of eight (8) selected studies that explored the efficacy of Desmos integration in mathematics education, specifically in relation to learning outcomes and pedagogical strategies. Data coding and extraction were conducted systematically using a pre-established matrix, ensuring consistency and reliability across studies. Given the heterogeneity of the selected studies in terms of research design and methodology, a meta-narrative review—or narrative summary—was employed to analyze and interpret the findings. This approach allowed for a more nuanced understanding of how Desmos has been utilized and its impact across diverse educational settings and research contexts.

3.1 Study Characteristics

The eight (8) journal articles included in this systematic review were examined based on five key dimensions: journal publication characteristics, geographical characteristics, study design characteristics, study participants or sample

focus, and study coverage. First, in terms of journal publication characteristics, the included studies were published in peer-reviewed and open-access journals indexed in reputable academic databases such as Google Scholar and Scopus. All selected articles were published within the last ten years, specifically between 2013 and 2023, thereby meeting the study's inclusion criteria for publication recency and relevance. These journals primarily focused on mathematics education, educational technology, and STEM instruction, ensuring alignment with the thematic scope of the present review.

Regarding the geographical characteristics, the studies were conducted in diverse educational settings across several countries, reflecting a range of cultural and institutional contexts in which Desmos has been integrated into mathematics teaching. This geographical diversity adds depth to the analysis, highlighting how Desmos is being utilized across global learning environments and showcasing its adaptability to different curricula and pedagogical approaches.

In terms of study design characteristics, the articles employed a variety of methodological approaches, including experimental, quasi-experimental, and qualitative designs. Data collection methods ranged from pre- and post-tests, classroom observations, and surveys to interviews and case studies. This methodological heterogeneity reflects the multifaceted nature of educational research and the flexibility of Desmos as a technological tool in both quantitative and qualitative inquiries. Analytical techniques used in these studies included statistical analysis, thematic coding, and comparative assessment, allowing for a robust examination of Desmos' impact on learning outcomes and teaching strategies.

With regard to study participants or sample focus, most studies involved secondary or high school students as primary participants, although several also engaged pre-service teachers and tertiary-level students. The sampling methods varied, with purposive, convenience, and random sampling being the most commonly employed. These choices in sample selection provide insights into how Desmos functions across different learner groups and levels of mathematical proficiency.

Finally, the study coverage of the included articles addressed a range of learning objectives and mathematics content areas. Common topics explored through Desmos integration included algebra, graphing functions, geometry, and mathematical modeling. Some studies focused on improving conceptual understanding and problem-solving abilities, while others aimed to enhance student engagement, motivation, and teacher pedagogical practices. Collectively, these studies demonstrate the pedagogical potential of Desmos in enriching mathematics instruction, supporting active learning, and fostering deeper conceptual understanding.

3.1.1 Journal Publication Characteristics

The eight ($n = 8$) journal articles included in this review were published across seven (7) distinct academic journals, namely the International Journal of Science and Research (IJSR), Eurasia Journal of Mathematics, Science and Technology Education, Ascendens Asia Journal of Multidisciplinary Research, International Conference on Islamic Education, Jurnal Cendekia: Jurnal Pendidikan Matematika, International Journal of Mathematical Education in Science and

Technology, and the European Journal of Science and Mathematics Education. Among these seven journals, one primarily focuses on the dissemination of scientific knowledge and general research; three journals center on mathematics, science, and technology education; one is devoted to multidisciplinary research; another is a compilation of conference proceedings; and one focuses specifically on mathematics education, including instruction, curriculum development, learning environments, educational technology, and teacher training.

All of the identified journals and conference proceedings are peer-reviewed and open-access, ensuring the credibility and accessibility of the included studies. Additionally, all articles were published in English and were indexed in Google Scholar. Seven (7) of the studies were also available on ResearchGate, three (3) were indexed in SCOPUS, one (1) in Web of Science, one (1) in CrossRef, one (1) in ScienceGate, one (1) in GARUDA, and one (1) in the Directory of Open Access Journals (DOAJ). In terms of publication year, one article was published in 2016, two in 2019, three in 2022, and two in 2023. These publication details highlight the academic legitimacy, recentness, and accessibility of the reviewed literature, all of which align with the inclusion criteria established for this systematic review.

5.1.2 Geographical Characteristics

Among the eight ($n = 8$) included studies, three were conducted in the Philippines, two in Indonesia, one in Sweden, one in Portugal, and one in Canada. While numerous studies on Desmos integration in mathematics education have been conducted across Asia, the Americas, Africa, and Europe, a substantial number were excluded from this review due to the predetermined eligibility criteria. Specifically, studies not published in English-language and peer-reviewed journals, as well as those employing qualitative approaches that focused solely on perceptions, were excluded. This reflects a deliberate emphasis on scientific and quantitative research designs that provide more objective and measurable insights into the efficacy of Desmos in enhancing mathematics instruction and learning outcomes.

The geographical distribution of the included studies reveals a noticeable concentration in Southeast Asia, with five (62.5%) of the eight studies originating from the Philippines and Indonesia. This regional focus underscores the growing interest and adoption of Desmos in mathematics classrooms within this educational context. Conversely, the presence of studies from Sweden and Portugal represents the European region, while a single study from Canada provides representation from North America. This limited geographic dispersion suggests a potential regional bias in the current body of literature concerning Desmos integration. While the emphasis on Southeast Asian contexts offers valuable insights into localized practices and outcomes, it also raises questions about the generalizability and applicability of the findings to broader, more diverse educational systems.

The exclusion of studies from other continents and the emphasis on specific methodological criteria reflect the review's intentional prioritization of empirical rigor. By focusing on English-language, peer-reviewed, and quantitatively driven research, the review aims to provide a robust synthesis of evidence-based findings. However, this approach may inadvertently overlook valuable qualitative perspectives and culturally embedded practices, which could otherwise enrich the understanding of Desmos' global impact

on mathematics education.

3.1.3 Study Design

The reviewed studies employed a range of research designs, with experimental methods emerging as the most frequently used. Four of the eight journal articles adopted experimental approaches: three utilized quasi-experimental designs involving control and experimental groups, while one applied a pre-experimental design featuring a one-group pre-test and post-test structure. Beyond experimental methods, one study employed a quantitative design, another followed a Research and Development (R&D) framework using Sugiyono's (2013) ADDIE model, while another adopted a case study approach that was exploratory, observational, and non-interventional in nature. One additional study combined direct observation and documental analysis techniques, including assessment tasks, computerized student performance data from the Desmos platform, field notes, and interviews.

The quasi-experimental studies focused on comparing academic performance, engagement, and behavioral outcomes between students taught through traditional methods and those exposed to Desmos-enhanced instruction. This approach aimed to establish the causal effects of Desmos integration on mathematics learning. In contrast, the other studies utilized varied methodologies that reflect the complex and multifaceted nature of the research topic. These included investigations of instructional development, exploratory case analysis, and in-depth observational techniques, which allowed for a broader understanding of how Desmos influences both teaching strategies and student experiences. The use of case study and documental analysis designs supported a richer, context-specific exploration of Desmos in classroom settings, offering insights into pedagogical approaches and the nuanced advantages and limitations of the tool. These qualitative perspectives complemented the quantitative findings, contributing to a more balanced understanding of the effectiveness and practical implications of Desmos integration in mathematics education.

This methodological diversity underscores a thoughtful effort to approach the research problem from multiple angles. While the prevalence of experimental designs reflects a desire for empirical rigor, the inclusion of qualitative and mixed-method strategies highlights the value of capturing both measurable outcomes and the lived experiences of learners and educators. Such a comprehensive approach enhances the reliability and relevance of the findings across varied instructional contexts.

3.1.4 Study Participants or Sample Focus

The journal articles included in this review employed a diverse range of sample populations, reflecting varied approaches to participant selection. One study involved two sections of Grade IX students selected through simple random sampling, while another drew ninety-eight (98) learners from a Swedish upper secondary school using the same technique. Similarly, sixty (60) Grade XI students were randomly selected in a separate secondary school. Other studies employed purposive sampling: Grade X students from a Philippine secondary school, fifty-one (51) Indonesian Grade X students from Mathematics, Natural Science, and Social Science streams, six (6) Grade VIII student representatives in one study, and twenty-nine (29) Grade IX students from Cape Verde, Portugal. In Canada, four (4) high

school mathematics teachers were purposively chosen and observed while integrating Desmos into their classroom instruction.

This variation in sample characteristics—spanning different grade levels, countries, and sampling strategies—enhances the external validity of the findings and provides a broader understanding of how Desmos functions across diverse educational settings. Despite the geographic and methodological differences, all studies were conducted within secondary school contexts, often in lessons involving advanced mathematical concepts. This shared emphasis suggests that Desmos is being actively explored in the context of teaching more complex mathematical ideas, where visual representation and interactivity can significantly enhance conceptual understanding.

The consistent focus on secondary-level instruction highlights Desmos's potential to support learning in cognitively demanding mathematical domains. Taken together, the diversity of sample populations and the uniform context of secondary education offer a nuanced and comprehensive view of Desmos's pedagogical value and the challenges associated with its integration into mathematics instruction.

3.1.5 Study Coverage

Diverse in scope and intent, the journal articles analyzed in this review approached the integration of Desmos in mathematics education from various perspectives. Several studies were designed to determine the platform's impact on students' learning outcomes, such as mathematical achievement, conceptual understanding, and attitudes toward the subject. For instance, one investigation explored the use of Desmos as a conversational strategic intervention to enhance students' performance in mathematics. Others evaluated how the platform influenced students' comprehension of functions, conceptual knowledge, and engagement with mathematical content.

Beyond student performance, the reviewed studies addressed broader instructional goals. These included developing digital instructional materials like electronic worksheets for linear function problems, facilitating lessons on rational functions, and supporting the teaching of geometric solids. A number of studies also extended their inquiry to the instructional side—examining teachers' strategies in using Desmos, the challenges they faced, and how these experiences contributed to the development of pedagogical content knowledge and instructional craft.

This breadth of study coverage illustrates that Desmos is not merely a digital enhancement to traditional instruction but a multifaceted tool capable of shaping both teaching practices and student learning experiences. The inclusion of research on instructional strategies and technological integration signals a shift toward more dynamic and learner-centered pedagogies in mathematics education.

Taken together, the studies emphasize the broader educational implications of Desmos use—highlighting its role not only in academic achievement but also in shaping attitudes, facilitating conceptual clarity, and enriching instructional design. This affirms Desmos as a powerful ally in both teaching and learning mathematics in today's digital classrooms.

3.2 Pedagogical Strategies

The integration of digital tools, particularly the networked

graphing application Desmos, has become a significant development in contemporary mathematics instruction. As educators work to incorporate this technology into their teaching practices, a deeper understanding of the pedagogical strategies involved becomes increasingly important. The synthesis presented below offers a narrative summary of the effectiveness of Desmos integration in mathematics education, with emphasis on teaching approaches, technology integration schemes, and methods for facilitating student learning.

In addition, the collective insights from these studies contribute to a comprehensive understanding of the pedagogical context in which Desmos is implemented. These findings provide meaningful guidance on how educators can utilize the platform to enhance students' attitudes toward mathematics, strengthen conceptual understanding, and support the development of essential mathematical skills within a dynamic and technology-enhanced learning environment.

3.2.1 Teaching Approaches

A review of the numerous journal articles on the integration of Desmos in mathematics education reveals diverse insights, with each study offering unique perspectives on the challenges encountered and strategies employed in its classroom application. Chorney (2022)^[5] highlights the need for educators to independently navigate and incorporate Desmos into instruction, given the absence of formal training. Her study emphasizes Desmos as an advanced graphing tool that extends beyond the capabilities of traditional calculators by allowing networked, interactive tasks. The emphasis on teachers' access to frameworks such as Ruthven's Structuring Features of Classroom Practice (SFCP), along with their innovative use of Desmos, illustrates the development of specialized instructional knowledge or "craft knowledge." This kind of knowledge emerges from hands-on experience, showcasing educators' capacity to design and adapt technological tools to meet specific learning objectives.

Other studies, including those by Machado *et al.* (2023)^[14] and Karindra and Ekawati (2022),^[18] explore both the strengths and limitations of Desmos within didactic contexts. While their findings acknowledge Desmos's ability to promote interactive learning, they also point to technical challenges, such as the need for familiarity with new programming languages and difficulties in classroom implementation. These limitations highlight the importance of aligning the platform with instructional goals and ensuring that digital tools are not used merely for visual appeal but are integrated with clear pedagogical intent. Moreover, the necessity for further testing and validation of digital materials, including interactive worksheets and task modules, reflects the ongoing need for refinement in technology-enhanced instruction.

In support of Desmos's positive impact on learning, Biladina *et al.* (2022)^[2] and Galopo (2019)^[11] emphasize its effectiveness in teaching logical functions and functional materials. These studies report improved student performance and deeper comprehension, suggesting that Desmos acts as a cognitive aid that facilitates abstract reasoning and strengthens problem-solving skills. Similarly, the studies conducted by Chechan, Ampadu, and Pears (2023)^[4] and Prepuse (2019)^[21] provide evidence that Desmos positively influences students' conceptual understanding and attitudes toward mathematics. The

observed gains in student motivation and function-analysis abilities suggest that technology, when paired with thoughtful pedagogy, can create engaging and meaningful learning environments.

Further expanding the scope of application, Mercado and Tandog (2023) integrate Desmos with MALMATH in their development of Conversational Strategic Intervention Material (CSIM). Their findings demonstrate significant gains in student achievement, particularly among those exposed to this blended instructional approach. This study affirms that Desmos, when thoughtfully incorporated into intervention programs, can support differentiated instruction and address learning gaps effectively.

Taken together, these studies demonstrate that Desmos is a versatile tool capable of enriching pedagogical strategies and fostering a more effective and engaging mathematics learning environment. The collective evidence suggests that Desmos not only enhances academic performance but also contributes to the development of conceptual understanding, positive student attitudes, and dynamic classroom practices. However, the success of its integration depends heavily on the teacher's pedagogical orientation, digital proficiency, and access to supportive resources. Therefore, the implications for policy and practice include the need for targeted professional development, the creation of curriculum-aligned digital content, and the provision of technological infrastructure. These measures are essential to ensure that Desmos is integrated consistently and equitably across different educational settings, thereby maximizing its potential as a transformative tool in mathematics education.

3.2.2 Technology Integration Scheme

The studies included in this review shed light on the diverse technological integration strategies employed in mathematics instruction and provide valuable insights into how educators navigate challenges and leverage the affordances of Desmos. Chorney (2022)^[5] introduces Ruthven's Structuring Features of Classroom Practice (SFCP) framework, which serves as a useful lens for evaluating classroom practices involving digital technologies. This framework emphasizes teacher actions as situated within authentic teaching contexts and highlights the development of "craft knowledge" — a set of context-dependent instructional decisions grounded in classroom experience. The findings reveal that each educator in the study employed unique strategies when utilizing Desmos, demonstrating the platform's adaptability and the diverse ways it can be implemented across instructional settings.

In a similar vein, Machado *et al.* (2023)^[14] and Karindra and Ekawati (2022)^[18] explored the pedagogical intentions underpinning Desmos integration. Their findings highlight the necessity of balancing the platform's benefits and constraints, emphasizing that an effective technology integration plan must be intentional and aligned with instructional goals. For example, they noted the challenges related to learning new programming commands and the lack of built-in data export functionalities, which complicate assessment and tracking of student progress. These findings suggest that successful integration depends not only on access to the tool itself but also on the technical preparedness of educators and the availability of supporting digital infrastructure.

Moreover, studies conducted by Biladina *et al.* (2022)^[2], Galopo (2019)^[11], and Prepuse (2019)^[21] demonstrated how

Desmos could be strategically integrated to deepen conceptual understanding and enhance students' problem-solving skills. These studies reported favorable outcomes in student learning, reinforcing Desmos's potential as a key component in a well-designed technological integration framework. Similarly, the work of Mercado and Tandog (2023) and Chechan, Ampadu, and Pears (2023)^[4] underscores Desmos's positive impact on students' mathematical comprehension and performance. Notably, Mercado and Tandog's integration of Desmos with MALMATH into the development of Conversational Strategic Intervention Material (CSIM) led to significantly higher student achievement, thereby highlighting the value of multi-platform integration supported by sound pedagogical design.

Collectively, these studies illustrate that technology integration strategies involving Desmos are evolving and context-sensitive. Teachers actively design innovative lessons that account for both the strengths and limitations of the platform, indicating a dynamic and responsive approach to educational technology. The findings underscore the importance of having clear instructional objectives, pedagogical flexibility, and a comprehensive integration strategy in order to maximize Desmos's impact on mathematics education. Furthermore, they point to the need for continued professional development and institutional support to equip teachers with the skills and confidence necessary to use Desmos effectively. Ultimately, strategic integration of Desmos has the potential to transform the mathematics classroom into a more interactive, conceptual, and student-centered learning environment.

3.2.3 Facilitating Learning

The study conducted by Chorney (2022)^[5] demonstrates how educators creatively integrate Desmos into their instructional practices, even in the absence of formal professional training. Utilizing Ruthven's Structuring Features of Classroom Practice (SFCP) framework, the research captures the immediacy and adaptive nature of teachers' decision-making in technologically mediated instruction. The framework foregrounds material constraints and emphasizes the role of craft knowledge in navigating transitions between traditional and digital instructional environments. Teachers' adaptations vary based on their experience and familiarity with Desmos, highlighting the tool's flexibility and its capacity to enrich classroom engagement with mathematical concepts.

Building on this foundation, Machado *et al.* (2023)^[14] and Karindra and Ekawati (2022) examine the educational goals underpinning Desmos integration. While acknowledging its limitations—such as the requirement to learn new programming commands and challenges related to data management—these studies affirm Desmos's utility in facilitating both formative and summative assessments. Its ability to support interactive, real-time feedback and enable distance learning environments positions Desmos as a powerful pedagogical resource. These findings underscore the importance of intentional planning in integrating Desmos, where the focus lies not merely on using technology, but on designing meaningful learning experiences aligned with instructional objectives.

Furthermore, the combined findings of Biladina *et al.* (2022)^[2], Galopo (2019)^[11], Prepuse (2019)^[21], Chechan, Ampadu, and Pears (2023)^[4], and Mercado and Tandog (2023) provide robust evidence of Desmos's role in enhancing student

learning outcomes. These studies report improvements in mathematical performance, conceptual understanding, and student attitudes toward mathematics. When strategically implemented, Desmos proves effective in supporting instruction on rational functions, conceptual knowledge development, and formative assessment practices. Qualitative data from several studies further suggest that Desmos contributes positively to students' overall comprehension and problem-solving skills, indicating its value as both a cognitive and affective learning tool.

Overall, these journal articles reinforce the view that Desmos is more than a supplemental digital tool; it functions as a transformative element in the mathematics classroom. Its potential lies in enabling student-centered, interactive learning experiences that are grounded in pedagogical intention and strategic integration. The findings collectively imply that effective use of Desmos requires more than technical familiarity—it calls for deliberate instructional design that considers learners' needs, curricular goals, and the broader educational context. As such, Desmos not only facilitates mathematical understanding but also exemplifies how technology, when meaningfully embedded, can elevate the quality of mathematics education.

3.3 Learning Outcomes, Attitudes, and Overall Achievement

The synthesized findings from the studies reviewed underscore the multifaceted impact of Desmos integration on student learning outcomes, particularly in enhancing mathematical knowledge, skill acquisition, attitudes toward the subject, and overall learning experiences. Chorney's (2022) [5] study reveals the challenges teachers face in incorporating connected graphing tools, such as Desmos, especially in the absence of formal training. The emergence of original instructional strategies in response to these challenges illustrates the development of teacher craft knowledge. Through Ruthven's Structuring Features of Classroom Practice (SFCP) framework, Chorney captures the immediacy and responsiveness of teachers adapting their methods to leverage Desmos effectively. The contrast between less experienced educators like Ava and more experienced ones like David further highlights the platform's learning curve and the role of professional experience in facilitating technology integration.

Machado *et al.* (2023) [14] and Karindra and Ekawati (2022) [18] emphasize Desmos's educational utility, especially in formative and summative assessments. These studies recognize Desmos not only as a digital enhancement but also as a strategic tool for delivering real-time feedback, conducting evaluations, and supporting remote learning environments. Their findings suggest that while technological tools offer considerable pedagogical affordances, maximizing their effectiveness requires thoughtful planning and awareness of potential limitations, such as technical complexity and data export constraints.

The studies conducted by Biladina *et al.* (2022) [2] and Galopo (2019) [11] further substantiate Desmos's instructional value. Their quantitative analyses reveal statistically significant improvements in students' understanding of rational functions after engaging with Desmos-based activities. These results validate Desmos as an effective instructional aid that supports conceptual development through dynamic and interactive visualizations, particularly in topics that are often abstract and difficult to master through traditional methods.

Meanwhile, Prepuse (2019) [4] and Chechan, Ampadu, and Pears (2023) [4] focus on students' attitudes and conceptual comprehension. Their findings reveal positive shifts in learners' perceptions of mathematics and notable gains in their understanding of function concepts. The qualitative data collected in these studies reinforce the notion that Desmos fosters deeper engagement, enhances visualization of complex ideas, and supports the development of critical thinking skills.

Finally, the work of Mercado and Tandog (2023) demonstrates the benefits of integrating Desmos with complementary digital tools, such as MALMATH, within the framework of a Conversational Strategic Intervention Material (CSIM). The combined use of these platforms resulted in significant improvements in student achievement, suggesting that Desmos can function as part of a synergistic digital learning ecosystem. This finding reinforces the importance of intentional and strategic integration of educational technologies to address learning gaps, sustain engagement, and enhance outcomes.

In summary, the body of literature reviewed points to Desmos as more than just a graphing application. It emerges as a pedagogical catalyst capable of transforming mathematics instruction when applied thoughtfully. The collective evidence supports its role in enriching conceptual understanding, promoting positive student attitudes, and improving academic achievement. These implications signal the need for continuous professional development for educators, focused not just on tool usage but on designing meaningful, student-centered learning experiences grounded in both pedagogical intention and digital innovation.

4. Conclusions and Recommendations

The systematic review of eight studies on the integration of Desmos in mathematics education highlights its effectiveness in enhancing teaching approaches, student engagement, and academic performance. Despite challenges such as the lack of formal training and certain technical limitations, Desmos has consistently demonstrated its value as a flexible and interactive tool, particularly in secondary education. It has been shown to support the development of conceptual understanding, problem-solving abilities, and positive attitudes toward mathematics. The studies also emphasize the role of teacher creativity and strategic implementation in maximizing the platform's impact on learning outcomes.

In light of these findings, several recommendations are proposed. First, formal training programs should be developed to equip teachers with both the technical and pedagogical skills needed to integrate Desmos effectively. Second, further research should be conducted in more diverse educational and cultural settings to broaden the applicability of current findings. Third, qualitative and mixed-method studies are encouraged to provide deeper insights into the experiences of both educators and learners. Fourth, educators are encouraged to establish collaborative communities where they can share strategies and support one another in navigating Desmos integration. Lastly, policymakers should support well-designed technology integration plans that align with curriculum goals and address infrastructure needs. These combined efforts will help realize the full potential of Desmos in transforming mathematics education.

5. Acknowledgement

The researcher wishes to express his heartfelt gratitude to all

those who, in one way or another, contributed to the successful completion of this systematic review. Special thanks are extended to Dr. Ryan V. Dio, his professor, for his invaluable guidance, support, and constructive feedback throughout the conduct of this study. The researcher is also deeply thankful to his loved ones for their unwavering moral and emotional support, which served as a source of strength and motivation. Above all, the researcher offers his deepest thanks to the Almighty God for His boundless grace, wisdom, and guidance, without which this research endeavor would not have been possible.

6. References

1. BECTA. What the research says about interactive whiteboards [Internet]. 2003 [cited 2024 Jan 1]. Available from: http://becta.org.uk/corporate/publications/documents/Research7_Whiteboards.pdf
2. Biladina SG, Sholikhah A, Pramesti SLD, Andriani S. The effectiveness of using Desmos graph calculator application in functional materials. In: Proceeding International Conference on Islam and Education (ICONIE) [Internet]. 2022 Aug;2(1). Available from: <https://proceeding.uingusdur.ac.id/index.php/iconie/article/view/666>
3. Blurton C. New directions of ICT-use in education. Paris: UNESCO; 1999.
4. Chechan B, Ampadu E, Pears A. Effect of using Desmos on high school students' understanding and learning of functions. *Eurasia J Math Sci Technol Educ*. 2023;19(10):em2331. <https://doi.org/10.29333/ejmste/13540>
5. Chorney S. Classroom practice and craft knowledge in teaching mathematics using Desmos: Challenges and strategies. *Int J Math Educ Sci Technol*. 2021;53(12):3203-27. <https://doi.org/10.1080/0020739X.2021.1931974>
6. Clarke MJ, Stewart LA. Systematic reviews: Obtaining data from randomised controlled trials: How much do we need for reliable and informative meta-analyses? *BMJ*. 1994;309(6960):1007-10. Available from: <https://www.bmj.com/content/309/6960/1007>
7. Das K. Role of ICT for better mathematics teaching [Internet]. 2019 Sep [cited 2024 Jan 1]. Available from: <https://files.eric.ed.gov/fulltext/EJ1245150.pdf>
8. DistillerSR Inc. PRISMA 2009 versus 2020 - DistillerSR [Internet]. 2023 Jul 17 [cited 2024 Jan 1]. Available from: <https://rb.gy/3eeygm>
9. Emilio. Using Zotero to create literature reviews [Internet]. Appropedia: The sustainability wiki [cited 2024 Jan 1]. Available from: https://www.appropedia.org/Using_Zotero_to_create_literature_reviews
10. Explore math with Desmos [Internet]. Smore; 2016 Jun 18 [cited 2024 Jan 1]. Available from: <https://www.smore.com/atwk9-desmos-for-beginners>
11. Galopo N. The use of Desmos graphic calculator in teaching rational functions. *Ascendens Asia J Multidiscip Res Abstr*. 2019;3(2N). Available from: <https://ojs.aaresearchindex.com/index.php/AAJMRA/article/view/11098>
12. IFIS. Good review practice: A researcher guide to systematic review methodology in the sciences of food and health: 5. Data extraction [Internet]. 2023 Sep 18 [cited 2024 Jan 1]. Available from: https://ifis.libguides.com/systematic_reviews/data-extraction
13. Lynn K. Difference between a systematic review and a literature review [Internet]. 2013 [cited 2024 Jan 1]. Available from: <https://doi.org/10.6084/m9.figshare.766364>
14. Machado D, Bastos N, Hall A, Pais S. Volume of geometric solids on the Desmos platform—A didactic experience in Cape Verde. *Eur J Sci Math Educ*. 2023;11(3):376-91. Available from: <https://www.scimath.net/download/volume-of-geometric-solids-on-the-desmos-platform-a-didactic-experience-in-cape-verde-12788.pdf>
15. Mediana Jr N. Collegiate program alignments of STEM graduates of Mercedes B. Peralta Senior High School along the Science, Technology, Engineering, Agriculture, and Mathematics (STEAM) domains and allied disciplines: A tracer study [Internet]. *ScienceOpen Preprints*; 2023 [cited 2024 Jan 1]. Available from: <https://doi.org/10.14293/PR2199.000287.v1>
16. Mediana N, Funa A, Dio R. Effectiveness of inquiry-based learning (IbL) on improving students' conceptual understanding in science and mathematics: A meta-analysis. *Int J Educ Math Sci Technol*. 2025;13(2):532-52. <https://doi.org/10.46328/ijemst.4769>
17. Mercado KC, Tandog VSJ. Integrating MALMATH and Desmos in Conversational Strategic Intervention Material (CSIM) to enhance students' achievement in mathematics [Internet]. [cited 2024 Jan 1]. Available from: <https://rb.gy/cpg06>
18. Oktaviane DAK, Ekawati R. Development of electronic students' worksheet linear function-problem based using Desmos application. *J Cendekia J Pendidik Mat*. 2022;6(1):445-58. Available from: <https://j-cup.org/index.php/cendekia/article/view/1153>
19. Page MJ, McKenzie JE, Bossuyt PM, *et al*. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. <https://doi.org/10.1136/bmj.n71>
20. Petticrew M, Roberts H. Systematic reviews in the social sciences: A practical guide. Oxford: John Wiley & Sons; 2008. Available from: <https://rb.gy/qc8fgi>
21. Prepuse CA. The effects of graphing utility Desmos on students' conceptual understanding and attitudes in mathematics. *Ascendens Asia J Multidiscip Res Abstr*. 2019;3(2J). Available from: <https://www.ojs.aaresearchindex.com/index.php/AAJMRA/article/view/9383>
22. Prytherch R. Harrod's librarians' glossary and reference book. 9th ed. Aldershot: Gower Publishing; 2000.
23. Tarma Software Research Ltd. Publish or Perish 4 User's Manual [Internet]. 2016 [cited 2024 Jan 1]. Available from: <https://rb.gy/enqrk4>
24. Tenopir C, King DW, Christian L, Volentine R. Scholarly article seeking, reading, and use: A continuing evolution from print to electronic in the sciences and social sciences. *Learn Publ*. 2015;28(2):93-105. <https://doi.org/10.1087/20150203>
25. Teplitskiy M, Duede E, Menietti M, Lakhani KR. How status of research papers affects the way they are read and cited. *Res Policy*. 2022;51(4):104484. <https://doi.org/10.1016/j.respol.2022.104484>

- 2.104484
26. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews [Internet]. BioMed Central; 2021 Mar 29 [cited 2024 Jan 1]. Available from: <https://systematicreviewsjournal.biomedcentral.com/articles/10.1186/s13643-021-01626-4>
 27. Tricco A, Tetzlaff J, Moher D. The art and science of knowledge synthesis. *J Clin Epidemiol.* 2010;64(1):11-20. <https://doi.org/10.1016/j.jclinepi.2009.11.007>
 28. UNESCO. Information and communication technologies in teacher education: A planning guide. Paris: UNESCO; 2002.
 29. Wang P, Soergel D. A cognitive model of document use during a research project. Study I. Document selection. *J Am Soc Inf Sci.* 1998;49(2):115-33.
 30. Will-Harzing A. Publish or perish [Internet]. Harzing.com; 2016 Feb 6 [cited 2024 Jan 1]. Available from: <https://rb.gy/kawx33>
 31. Wong G, Greenhalgh T, Westhorp G, Buckingham J, Pawson R. RAMESES publication standards: Meta-narrative reviews. *BMC Med.* 2013;11(1):20. <https://doi.org/10.1186/1741-7015-11-20>