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Exploring The Impact of Self-Regulated Learning on Reducing Students' Mathematics Anxiety

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Abstract

The study of mathematics often presents challenges due to anxiety, which can adversely affect students' understanding and performance. Research on self-regulated learning has received increasing attention as a strategy to address this issue. This article presents a comprehensive literature review to explore the relationship between self-regulated learning and anxiety in mathematics. Using the PRISMA procedure, 28 studies were selected from 2018 to 2024 to explore the relationship between self-regulated learning and math anxiety grouped by level of research, methodology, sample, and instruments used. The review showed that stronger levels of self-regulated learning were associated with lower levels of math anxiety, while lower levels of self-regulated learning were associated with higher math anxiety. These findings provide valuable insights for educators and researchers in developing strategies to increase self-regulated learning and reduce students' math-related anxiety. Understanding these relationships makes it possible to design more targeted interventions to improve teaching practices as well as student learning outcomes in mathematics.

Keywords: self-regulated learning, mathematics anxiety, literature review

INTRODUCTION

Mathematics education shapes students' overall academic success and comprehension across various disciplines. However, a significant number of students experience anxiety when learning mathematics, which negatively affects their ability to understand concepts and approach mathematical tasks with confidence (Khasawneh et al., 2021). This anxiety is recognized as a major barrier to optimal learning outcomes in mathematics education (Ramirez et al., 2018).

Given the detrimental impact of mathematics anxiety, it is crucial to explore strategies that can alleviate this issue and promote better learning outcomes. One such strategy that has garnered increasing attention in educational research is self-regulated learning, a process through which students actively manage their learning by setting goals, monitoring their progress, and adjusting their strategies as needed (Taranto & Buchanan, 2020). Research has shown that students with higher levels of self-regulation tend to demonstrate greater persistence and academic dedication, which can directly influence their success in mathematics (Gabriel et al., 2020).

Despite substantial research into both mathematics anxiety and self-regulated learning, there remains a lack of comprehensive understanding regarding the relationship between these two factors. Understanding how self-regulated learning can mitigate mathematics anxiety is essential for developing more effective educational interventions. Therefore, this study aims to conduct a systematic review of the existing literature to explore this connection in depth. The findings of the study by Karakose et al. (2023) highlight the interconnectedness of classroom management anxiety, academic self-efficacy, and attitudes toward the teaching profession among prospective mathematics teachers. Understanding these relationships can inform the development of targeted interventions to enhance self-regulated learning and reduce anxiety in educational settings, ultimately contributing to improved teaching effectiveness and student outcomes. By identifying the key factors influencing the relationship between self-regulated learning and mathematics anxiety, this review seeks to provide valuable insights for educators and researchers.

Ultimately, a deeper understanding of this relationship will help inform the design of targeted strategies to reduce mathematics anxiety and enhance students' self-regulated learning abilities, thereby improving their overall performance and confidence in mathematics.

METHODS

To explain the relationship between self-regulated learning and mathematics anxiety in mathematics learning, the literature review method was used. This approach involves systematically collecting, reviewing, and analyzing relevant sources related to the research topic. It includes identifying, gathering, assessing, and synthesizing published literature. By applying this method, researchers can gain a comprehensive and in-depth understanding of the existing body of knowledge, which is crucial for framing the research in the broader academic context.

Research Question

Table 1 are the research questions established in this study, adapted from Latifah (2020).

Table 1. Research Question

No	Research Question	Motivation
1	How many journals cover the topics of self-regulated learning and math anxiety, and how are they distributed?	Determining the number and distribution of journals that focus on self-regulated learning and math anxiety.
2	Which research approach is most effective in examining the connection between self-regulated learning and math anxiety	Identifying the most effective research approaches for investigating the relationship between self-regulated learning and math anxiety
3	Who are the ideal participants for obtaining representative data on self-regulated learning and math anxiety?	Determining the most appropriate research participants to gather representative data on self-regulated learning and math anxiety.
4	What are the best instruments for accurately and reliably measuring self-regulated learning and math anxiety?	Finding the most valid and reliable tools for assessing self-regulated learning and math anxiety.
5	What is the most suitable method for analyzing data related to self-regulated learning and math anxiety?	Identifying the most suitable analytical methods for evaluating data related to self-regulated learning and math anxiety.
6	What is the primary aim of this research in understanding the relationship between self-regulated learning and math anxiety?	The main goal of this research is to explore the link between self-regulated learning and math anxiety.
7	What are the significant findings on self-regulated learning and math anxiety, and how can they be understood about existing theories?	Identifying the main findings related to self-regulated learning and math anxiety, and interpreting them in the context of existing theoretical frameworks.

Modified from Latifah (2020)

Research Design

This study employs a content analysis approach (Fauzi & Pradipta, 2018) and examines findings from multiple studies published in national and international journals. The methodology is similar to that used by Fauzi & Pradipta (2018), with some adjustments. Content analysis allows for the systematic examination of data in the form of written documents, facilitating an exploration of themes, patterns, and relationships across different studies. This approach is particularly effective for understanding complex phenomena such as the relationship between self-regulated learning and mathematics anxiety.

Data Sources

The literature review enables researchers to carry out an extensive search of academic databases and reliable sources by utilizing keywords relevant to the study's focus. The search terms include: "Self-regulated learning," "Self-directed learning," "Independent learning," "Learner autonomy," "Self-managed learning," "Self-regulation in education," "Personal learning management," "Cognitive self-regulation," "Student self-regulation," "Self-guided learning," "Self-determined learning," "Self-monitoring," "Self-control in learning," "Learning autonomy," "Active learning strategies," "Self-

planned learning," "Self-regulated academic behavior," "Learning self-management," "Self-motivation in learning," "Self-governed learning," "Student learning strategies," "Metacognitive regulation," "Self-regulation of behavior," "Self-reflective learning," "Strategic learning," "Self-organized learning," "Student-driven learning," "Learning self-regulation strategies," "Math anxiety," "Mathematics anxiety," "Math fear," "Numeracy anxiety," "Math-related stress," "Math phobia," "Fear of math," "Anxiety towards mathematics," "Numerical anxiety," "Quantitative anxiety," "Mathematical apprehension," "Math-related anxiety," "Math performance anxiety," "Test anxiety in math," "Math evaluation stress," "Fear of solving math problems," "Anxiety in math tests," "Math avoidance," "Discomfort with mathematics," "Math learning anxiety," "Mathematical test anxiety," "Fear of arithmetic," "Stress related to math," "Performance anxiety in mathematics," "Math-induced stress," "Panic in math situations," "Worry in mathematical tasks," "High anxiety in math," and "Mathematical stress disorder." Selected articles are carefully reviewed and analyzed based on established criteria**.** In this literature review, the process of selecting literature follows the steps outlined in the PRISMA model (Page et al., 2021);

In the *Identification* phase, relevant literature is gathered from various databases related to the research topic. Next, the *Screening* phase involves filtering the collected literature and removing articles that are irrelevant or do not meet the predetermined inclusion criteria. After screening, *Quality Evaluation* is conducted, where the selected literature is analyzed and evaluated based on the quality of the research methods used; this step ensures that only high-quality studies are included in the review, thereby increasing the reliability of the findings. Finally, in the *Inclusion* phase, the selected literature is incorporated into a data tabulation, summarizing the findings from the included studies. By following these steps, the literature review research can provide a structured, transparent, and reproducible overview of the relationship between self-regulated learning and mathematics anxiety in mathematics learning.

The literature review concentrated on mathematics, specifically exploring self-regulated learning and mathematics anxiety, by utilizing sources published in both national and international journals from 2018 to 2024. Articles falling outside of these parameters were excluded. The review process involved removing duplicate entries, assessing the relevance of titles and abstracts, and verifying the availability of full texts. Data collection involved searching databases such as Google Scholar, Scopus, and PubMed for articles published within the given timeframe. Strict selection criteria were used to ensure relevance, followed by a thorough screening of titles, abstracts, and full-text articles. Irrelevant studies and duplicates were discarded, ensuring that only the most pertinent sources were included.

The data collection process for this systematic review commenced with the identification phase, during which initial data was gathered from three database sources: Google Scholar, Scopus, and other relevant sources. This yielded a total of 178 articles for potential analysis. In the subsequent screening phase, duplicate entries were eliminated, resulting in 93 articles that underwent further filtering based on their titles and abstracts to assess their relevance to the research topic. In the eligibility assessment stage, 37 articles were chosen for a comprehensive review of their full texts. During this

evaluation, 9 articles were excluded due to either the unavailability of full texts or insufficient empirical evidence. Finally, in the inclusion stage, 28 articles that satisfied all eligibility criteria were incorporated into the systematic review. This methodical process ensures that only pertinent articles meeting rigorous standards are considered in the final analysis.

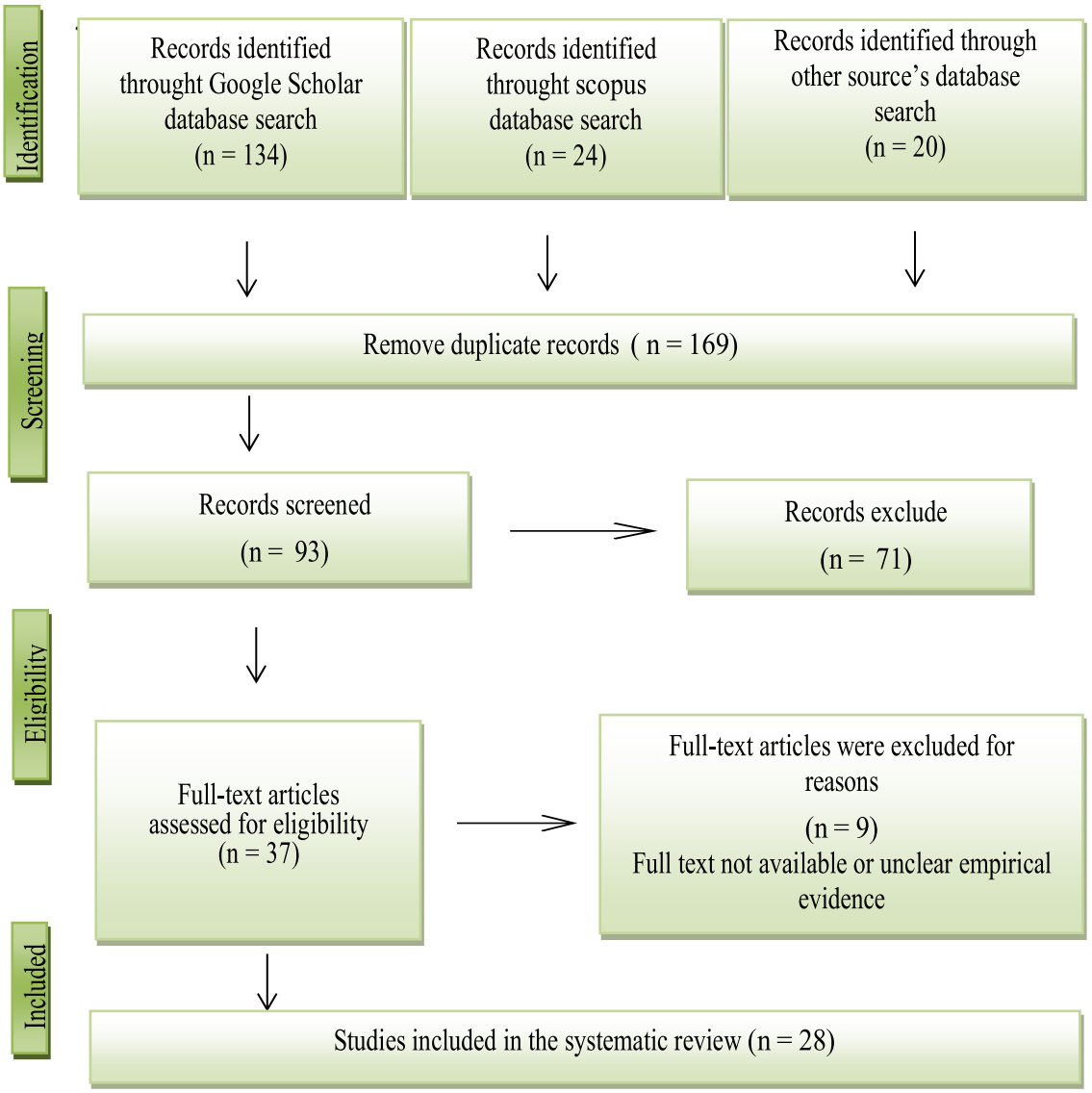

Figure 1. Flow Diagram

Research Instruments

The instruments used in this study were adapted from previous research (see Table 1). Content analysis guidelines are used in this research to examine various observed elements. The study focuses on five main areas: (1) the number of publications per year; (2) types of research; (3) research subjects; (4) data collection instruments; and (5) data analysis methods. Categories for the number of publications per year (aspect 1) were established during the content analysis due to a lack of prior references. In contrast, the categories for aspects (2), (3), (4), and (5) were established

before data collection. This classification system ensures consistency and comparability across different studies, facilitating a robust analysis of trends and patterns. Table 1 shows these categories, which have been adapted and modified from previous research by Fauzi & Pradipta (2018).

Table 2. Research Instruments

Type of Research	A.1-Correlational Research	A.5-Quantitative Research
	A.2-Quasi-experimental	A.6- Survey Research
	A.3-Experimental Research	A.7- Mixed Research
	A.4-Descriptive Research	A.8- Predictive Research
Subject of Research	B.1 Elementary School	B.3 Senior High School
	B.2 Junior High School	B.4 University Students
Data collection instruments	C.1-Questionnaire	C.4-Rating Scale
	C.2-Observation	C.5-Metacognitive
	C.3-Test	
Analysis Method	D.1-Structural Equation Modeling (SEM)	D.6-Chi-Square
	D.2- Correlation	D.7- Pant Analysis
	D.3- Descriptive analysis	D.8- Anova
	D.4-Regression	D.9-MANOVA
	D.5- T-test	D.10-Non-Parametric Statistics

Data Analysis

Each article is categorized based on the pre-defined aspects. Classification relies on information from the abstract, methods, and results sections. Once categorized, the data is synthesized and compared across studies to identify key themes and trends**.** The data is then collected and presented in bar charts to effectively and clearly illustrate the findings (Fauzi & Pradipta, 2018). This visual representation allows for an accessible interpretation of the data, making it easier to draw meaningful conclusions from the analysis.

RESULTS AND DISCUSSION

Distribution of Studied Publications by Year

The number of published articles indicates the frequency of research conducted over a specific period. According to the graph in Figure 1, articles examining self-regulated learning and mathematics anxiety have been present since 2017. While there is no distinct annual publication pattern, Figure 1 shows a notable rise in publications from 2021 onward compared to previous years. Despite a drop in 2022, the overall trend of increasing research on self-regulated learning and mathematics anxiety suggests that the topic remains relevant and in need of further exploration.

Research often addresses common challenges faced by students, such as low self-regulated learning and high levels of mathematics anxiety. Therefore, it is considered a crucial approach to addressing and alleviating these issues. Through research, scholars can identify effective strategies and resources to enhance student confidence and reduce

mathematics anxiety. The increase in publications since 2021 indicates an urgency to continue studying this topic, especially in the context of implementing more effective teaching strategies to reduce mathematics anxiety.

Types of Research

The type and design of the research selected shape the focus of the study. Based on Figure 3, quantitative research is the most frequently employed design among researchers exploring these topics. The quantitative approach offers the benefit of systematically gathering and analyzing measurable and verifiable data. This allows researchers to identify statistical relationships between self-regulated learning and mathematics anxiety.

However, reliance on the quantitative method may leave room for deeper exploration through other approaches. Qualitative designs, such as case studies or phenomenology, could offer deeper insights into students' subjective experiences of mathematics anxiety and how they self-regulate their learning. This is crucial for identifying psychological aspects that are not always measurable by numbers but are highly relevant to addressing students' anxiety

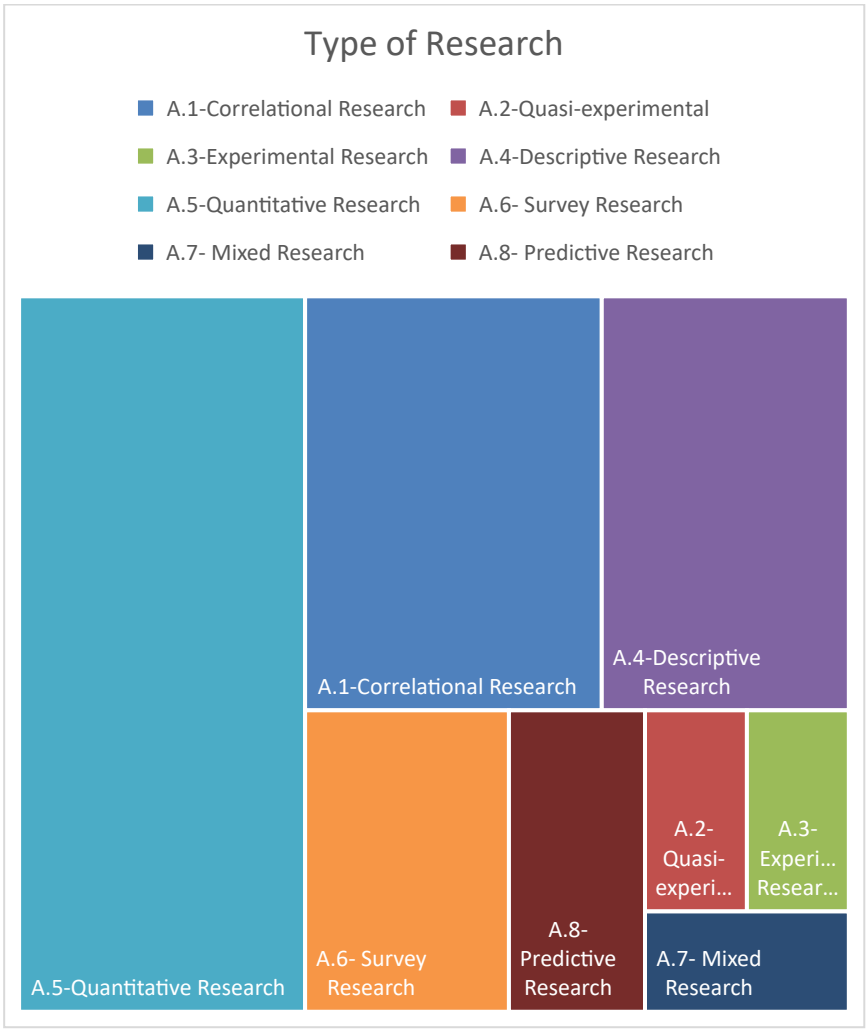

Figure 3. Types of Research Used in Journals

Research Subjects

In research, subjects are necessary for testing hypotheses. As shown in Figure 4, middle school students are the most frequently selected participants. The next most common subjects are students in higher education, followed by high school students.

The selection of subjects from various educational levels shows that mathematics anxiety is not only experienced in basic education but continues into higher education. Focusing on middle school students may reflect the critical transition period from elementary to middle school, which can be a crucial stage for the development of mathematics anxiety. Therefore, future research should consider appropriate interventions for each educational level, with a specific focus on student groups showing higher levels of anxiety.

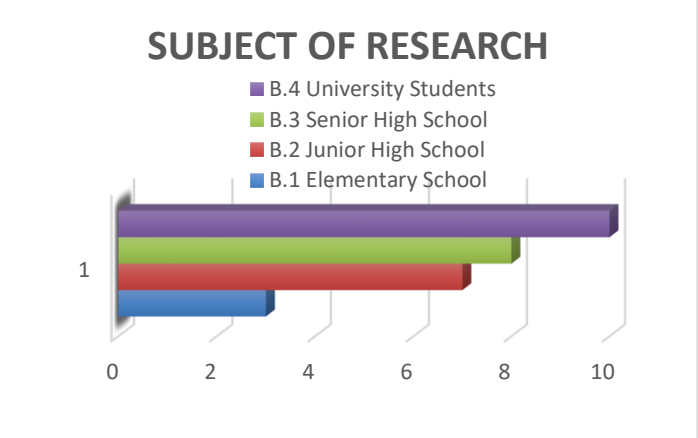

Figure 4. Research Subjects in Journals

Research Instruments

In the research process, researchers require tools to assist in data collection. To assess students' self-regulated learning and mathematics anxiety, various instruments have been developed by previous researchers. According to the data presented in Figure 5, questionnaires are identified as the most commonly utilized tools for gathering relevant research data.

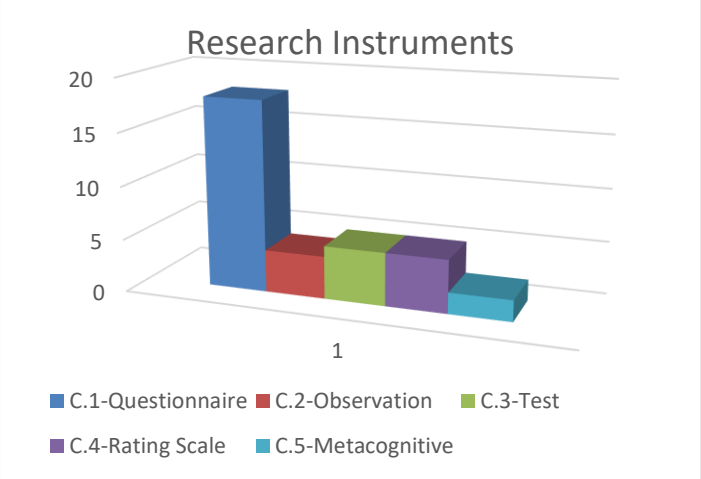

Figure 5. Research Instruments Used in Journals

Questionnaires offer convenience in quickly gathering large amounts of data. However, other tools, such as direct interviews, are also recommended for further research. Interviews provide the advantage of offering a deeper exploration of how students individually experience mathematics anxiety and the strategies they use to overcome it. Interviews can also provide more personal and contextual insights that may not be captured through standard questionnaires.

Analysis Methods

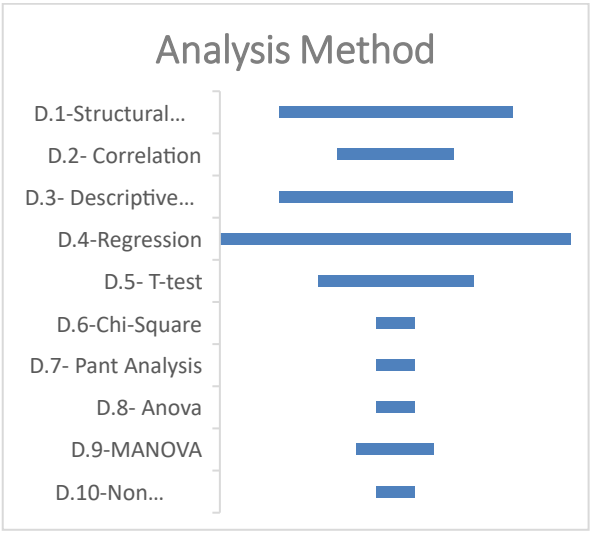

Figure 6. Data Analysis Methods Used in Journals

Regression analysis is the data analysis method most commonly used in peer-reviewed journals. This technique is useful for identifying whether a linear relationship exists between dependent variables (e.g., mathematics anxiety) and independent variables (e.g., self-regulated learning). Regression analysis allows researchers to measure both the strength and the direction of this relationship.

However, it is important to consider other analysis methods that could provide broader insights into the complex relationship between self-regulated learning and mathematics anxiety. For instance, multivariate analyses such as MANOVA or path analysis could help explain the simultaneous influence of multiple variables on mathematics anxiety. These more advanced analysis methods are necessary to understand the intricate dynamics between these variables and to identify potential mediators or moderators affecting the relationship.

RESULTS AND DISCUSSION

Frequency of Publications by Year

The volume of publications on self-regulated learning and math anxiety varied considerably from 2018 to 2024, highlighting the relevance of this topic in academic research. In 2018, there were only 2 publications, (Roick & Ringeisen, 2018) and (Vahidi et al., 2018), but this number increased to 3 in 2019 (Musso et al., 2019; Singh et al., 2019; Thamrin et al., 2018) and 4 in 2020 (Gabriel et al., 2020; Herawati et al., 2021; M. Tashtoush et al., 2022; M. A. Tashtoush et al., 2020). A sharper increase occurred in 2021 with 6 publications indicating greater attention to this issue (Delima & Cahyawati, 2021;

Dirgantoro & Soesanto, 2021; Duru & Okeke, 2021; Hutt et al., 2021; Martićion, 2021; Rayoan & Ludji, 2021). Although there was a decrease to 4 publications in 2022 (Erita et al., 2022; Fajri & Amir, 2022; Ghahremani et al., 2022; Rican et al., 2022(Ghahremani (2022), Erita(2022), interest in this topic peaked in 2023 with 7 (Andres et al., 2023; Atsnan et al., 2018; Balali et al., 2023; Cahyawati et al., 2023; GÜRSEL et al., 2023; Siregar et al., 2023; Wang, 2023). Despite a decrease in the number of publications to 2 in 2024 (Delima et al., 2024; Priharvian et al., 2024), attributed to the study being conducted in early May 2024, these fluctuations suggest that while interest in self-regulated learning and math anxiety has varied, the significance of research in these areas should not be underestimated due to their considerable impact on students learning and well-being (Dowker et al., 2016; Gabriel et al., 2020). If these two issues are overlooked, numerous students will continue to face math anxiety annually, which can adversely affect their academic performance and emotional growth. By recognizing and addressing both concerns, educators can create more effective interventions to assist students, ultimately enhancing their learning experiences and overall well-being.

Types of Research in Publications Studied

The types of research used in studies on anxiety and self-regulated learning vary, with quantitative research being the most common, accounting for 10 publications. Correlational research is also prominent, with 6 publications. Descriptive research follows with 5 publications, while survey research appears in 3 publications. Other types, such as predictive research, are found in 2 publications, and quasi-experimental, experimental, and mixed-methods research are each represented in 1 publication. This indicates that quantitative and correlational approaches are most commonly used to examine the relationship between anxiety and self-regulated learning.

Quantitative research is highly recommended for studying anxiety and self-regulated learning because it allows for objective measurement of variables and robust statistical analysis. The large number of quantitative publications underscores its effectiveness in identifying relationships and patterns between anxiety and self-regulated learning. Additionally, quantitative research provides data that can be generalized to a wider population, facilitating the development of improved educational interventions and policies. Therefore, a quantitative approach is crucial and effective for achieving a deeper understanding of this topic (Dowker et al., 2016).

Research Subjects in Publications Studied

Research on anxiety and self-regulated learning across journals encompasses a range of subjects from various educational stages. University students are the most frequently studied group, with 10 studies, reflecting their advanced educational level where self-regulated learning is essential for academic achievement and managing anxiety is a significant challenge. Studies, such as those by Gabriel et al. (2020), demonstrate a notable relationship between math anxiety and self-regulated learning among college students.

High school students are also prominently featured, with 8 studies addressing their experiences. This highlights the importance of understanding anxiety and self-regulated

learning during this critical transition period to higher education. Rozgonjuk et al. (2020) found that high school students' math anxiety can impact their learning approaches.

Research involving junior high school students appears in 7 studies, underscoring the focus on developing self-regulated learning and anxiety management skills at this stage. For instance, El-Adl and Alkharusi (2020) reported a negative correlation between test anxiety and self-regulated learning abilities among junior high students in Oman. Conversely, primary school students are the least studied group, with only 3 studies. This may be due to their limited ability to understand and apply self-regulated learning concepts, as well as difficulties in accurately measuring anxiety in younger children.

The studies on anxiety and self-regulated learning encompass a wide range of research types, reflecting a diverse array of methodologies that can inform future investigations. The prevalence of quantitative research, along with correlational, descriptive, survey, and other approaches, establishes a solid foundation for exploring the intricate relationships between anxiety and self-regulated learning.

This variety in research methods can be an important consideration for researchers aiming to broaden their studies. By examining different methodologies, they can uncover fresh insights and create innovative interventions to tackle the challenges students face. The existing research not only validates these approaches but also promotes further exploration of less frequently employed methodologies, such as experimental or mixed methods, to achieve a more profound understanding of these essential educational issues.

Research Instruments in Publications Studied.

Research on anxiety and self-regulated learning across journals covers a range of subjects from various educational levels. University students are the most frequently studied group, with 10 studies, likely because they are at a more advanced educational stage where self-regulated learning is crucial for academic success and managing anxiety is a significant challenge. Additionally, university students are often more accessible for research compared to other groups (Gonzalez-DeHass & Alyssa R, 2020; Guo et al., 2015).

High school students are also notably featured, with 8 studies addressing their experiences. This indicates that anxiety and self-regulated learning are critical issues during this transitional phase of higher education. Junior high school students are included in 7 studies, reflecting considerable focus on developing self-regulated learning and managing anxiety at this earlier stage (Kesici & Erdoan, 2009).

Conversely, primary school students are the least studied, with only 3 studies. This may be due to their limited capacity to understand and apply self-regulated learning concepts, as well as difficulties in accurately measuring anxiety in younger children (Hurst & Cordes, 2017).

The wide array of research instruments used in studies on anxiety and self-regulated learning plays a crucial role in advancing the field by offering various tools for future researchers to consider. The collection of instruments, which includes surveys, assessments, and observational methods, reflects the complexity of these topics and illustrates different approaches to measuring and analyzing the relationship between anxiety and self-regulated learning.

This assortment of research tools can act as a valuable resource for other researchers aiming to broaden their studies. By utilizing different instruments or modifying existing ones, researchers can reveal new perspectives and develop innovative methodologies to tackle the challenges that students encounter. Additionally, the investigation of various instruments promotes further examination of the effectiveness and relevance of different measurement tools in educational research.

Analysis Methods in Publications Studied

In research on anxiety and self-regulated learning, a variety of data analysis methods were utilized. Regression analysis was the most commonly used method, appearing in 9 studies. This technique is favored for its ability to identify and quantify relationships between variables and predict the effects of one variable on another, which is especially relevant for studying anxiety and self-regulated learning.

Structural Equation Modeling (SEM) and descriptive analysis each appeared in 6 studies. SEM is used to evaluate complex theoretical models and relationships among latent variables, while descriptive analysis provides an overview of the collected data and helps understand its distribution and characteristics (Villavicencio & Bernardo, 2016).

The correlation method was used in 3 studies, offering a straightforward way to assess the linear relationship between two variables. The T-test, found in 4 studies, was employed to compare the means of two groups, helping to identify significant differences in anxiety levels or self-regulated learning between different groups. In contrast, Chi-Square, Pant Analysis, ANOVA, and non-parametric statistics were the least frequently used methods, each appearing in only 1 study. This limited use may be due to specific constraints or conditions required for these techniques. Nonetheless, each method has its utility and provides valuable insights within the appropriate context.

Objectives & Findings in Published Research Works

Research on Self-Regulated Learning (SRL) and math anxiety has provided valuable insights into their effects on students' academic performance. Singh (2019), Cahyawati (2023), and Gabriel (2020) found that enhanced instructional strategies are crucial for helping students better understand math concepts and manage their anxiety. Balali (2023) and Andres (2023) highlighted the importance of cognitive understanding and supportive learning environments in reducing math anxiety and improving educational outcomes. According to Fajri & Amir (2022) and Atsnan (2023), self-directed learning and metacognitive support are effective in decreasing math anxiety, contributing to a more positive learning experience. Siregar (2023) and Roick (2018) emphasized that innovative methods and metacognitive strategies are essential for fostering independent learning and addressing math anxiety. Research by Rayoan (2021) and Gursel (2023) indicated that the relationship between test scores, SRL strategies, and math anxiety varies by factors like gender and grade level, underscoring the need for tailored interventions for students with high anxiety.

Delima (2024) noted that technology, such as ChatGPT, positively influences self-directed learning, although music did not have a significant impact on reducing math anxiety, technology such as ChatGPT positively influences self-directed learning. Priharvian (2024) and Vahidi (2018) discussed how math anxiety and self-directed

learning influence academic performance, with variations based on gender and learning conditions. Overall, this body of research underscores the necessity of developing strategies to support self-directed learning and mitigate math anxiety to enhance students' math performance and create more effective learning environments.

The objectives and results of existing research on self-regulated learning and math anxiety offer crucial insights that can greatly enhance the field. The varied aims of these studies—ranging from examining the relationship between anxiety and self-regulated learning to investigating effective interventions—provide a robust framework for future research.

These findings not only deepen our understanding of the factors influencing students' academic success but also emphasize the necessity for targeted strategies to assist learners. By pinpointing key areas where anxiety and self-regulated learning overlap, future researchers can concentrate their efforts on creating innovative approaches and interventions.

The knowledge gained from these studies can serve as a valuable resource for other researchers wishing to broaden their investigations in this domain. By building upon these objectives and findings, they can help foster a deeper comprehension of the challenges students face and contribute to the development of more effective educational environments. Additionally, recognizing gaps in the current research can direct future studies, ensuring that emerging issues are thoroughly examined and addressed.

CONCLUSION

Based on the findings and analyses, it can be concluded that there is a clear link between self-regulated learning and mathematics anxiety. Students with higher levels of self-regulated learning tend to experience lower levels of mathematics anxiety, suggesting that self-regulation plays an important role in managing anxiety related to mathematics. Additionally, students with stronger self-regulated learning skills are generally more confident in their mathematical abilities, which further helps reduce anxiety in this subject area.

These insights have significant implications for educational practice, as understanding the relationship between self-regulated learning and mathematics anxiety can help educators develop more effective learning strategies. Educators can potentially reduce students' mathematics anxiety by integrating approaches that enhance self-regulated learning and improve their overall performance. This study provides a detailed examination of how self-regulated learning and mathematics anxiety are related in educational settings, supporting the development of strategies that foster ease and success in learning mathematics.

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