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Critical Thinking Skills of Slow Learners in Mathematical Problem-Solving: A Systematic Literature Review

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ABSTRACT

Although much research has highlighted slow learners' difficulties in learning mathematics, most studies have focused only on the final learning outcomes without delving into the thinking processes during problem-solving. The lack of research on the cognitive steps slow learners take to develop critical thinking skills creates a gap in the literature that needs to be filled. The article examines the connection between the "critical thinking ability of slow learner students" and "solving mathematical problems." We recommend using the PRISMA flowchart article selection steps for systematic literature reviews. This systematic literature review investigates the critical thinking skills of slow learners in mathematical problem-solving. We screened 756 studies using the PRISMA framework, which yielded 8 relevant articles. Findings identify four main categories of errors (conceptual, principled, algorithmic, and computational) commonly encountered by slow learners, emphasizing the necessity of tailored teaching methods and technological interventions. Clinical teaching is crucial for guiding slow learners through their educational journey. Recommendations include employing open-ended tasks and integrating real-world problems to develop critical thinking skills effectively. The study offers valuable insights for educators and curriculum developers aiming to enhance inclusive mathematics education.

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1. INTRODUCTION

Critical thinking skills are one of the most essential skills in 21st-century education [1], [2]. It is an indicator of intellectual intelligence, and critical thinking is also a foundation for students in analyzing information, solving problems, and making decisions based on logic and facts [3], [4]. Current education seeks to train students to become independent and adaptive learners who not only rely on memorization skills but can also think logically and critically [5], [6]. Critical thinking skills play a central role in

mathematics learning because they require students to solve complex problems with a systematic and structured approach [7], [8].

Mathematics is not just a science that teaches calculations or numbers but also functions to develop broader thinking skills, such as logic, analysis, and creativity in solving problems [9]. For students, understanding mathematical concepts through a critical approach greatly helps them to be able to apply these concepts in various situations in everyday life [10], [11], [12]. Students who think critically will find it easier to understand the relevance of mathematics in practical contexts, both in science and technology and in data-based decision-making [13], [14]. However, developing this ability does not always run smoothly for every student, especially for those classified as slow learners.

They generally have slightly below-average cognitive abilities and tend to slow down the processing of new information and understanding abstract concepts [15]. Even though they do not qualify as having special needs, students in the slow learner category have limitations in their learning speed. In learning mathematics, students who learn at a slower pace often have difficulty following the learning flow, which is generally faster and more abstract [16], [17]. Such behavior has an impact on their low motivation and self-confidence, which ultimately hinders the achievement of optimal learning outcomes.

In addition, slow learner students often face various challenges in learning mathematics that involve understanding abstract concepts, applying complex formulas, and solving problems that require logical steps [18], [19]. These challenges not only hinder their intellectual development but can also cause ongoing frustration. In this context, inclusive education that pays special attention to the needs of slow learner students is critical to implement [20]. Educators must use more adaptive teaching methods and approaches to support the gradual development of critical thinking skills [21].

One of the main obstacles experienced by slow learners is difficulty in comprehending complex information [22]. They tend to think more slowly, which increases the time it takes to comprehend the problem and identify the question. Students often exacerbate this difficulty by failing to extract relevant information from the questions. As a result, they easily feel confused and lose focus when trying to solve problems [23]. Another challenge is the weak ability of slow-learner students to organize problem-solving steps. They often have difficulty developing logical and systematic strategies to reach solutions. As a result, their approach tends to be trial and error, without understanding the underlying concepts underlying the solution. This ineffective strategy lowers their self-confidence, leading many slow learners to avoid tasks that involve solving more complex problems [15].

Mathematical and scientific tasks requiring modeling and analysis are particularly challenging for slow learners because of their difficulties with abstract thinking [24], [25]. They are more comfortable with concrete concepts and avoid imagination or visualization tasks. As a result, problems that involve variables, patterns, or graphical representations often present a major challenge for them [26].

Although much research has highlighted slow learners' difficulties in learning mathematics, most studies have focused only on the final learning outcomes without delving into the thinking processes during problem-solving. The lack of research on the

cognitive steps slow learners take to develop critical thinking skills creates a gap in the literature that needs to be filled. This SLR article is expected to provide a more profound understanding of the critical thinking patterns of slow-learner students and produce practical recommendations to improve the quality of inclusive mathematics learning.

Problem of Study

This study employed the systematic literature review approach to analyze publications on "Critical Thinking Ability" and "Slow Learner Type Students in Solving Mathematical Problems" from the Web of Science and Scopus databases. This approach seeks to offer a comprehensive perspective to anyone engaged in this issue by examining all research collectively. We anticipate analyzing international research on this topic will enhance national and international literature. It plays a crucial role in directing future research by highlighting the areas of attention and identifying gaps. Consolidating the resources acquired from the literature review for an individual undertaking future research on this topic would facilitate their investigative process. This study intends to address the following research questions:

1. What is the distribution of education and educational research articles about "critical thinking ability" and "slow learner type students in solving mathematical problems" in Scopus, Wiley, Springer, and Taylor & Francis according to the years of publication?
2. What methods are used in education and educational research articles about "critical thinking ability" and "slow learner type students in solving mathematical problems" in Scopus, Wiley, Springer, and Taylor & Francis?
3. What is the content analysis of education and educational research articles about "critical thinking ability" and "slow learner type students in solving mathematical problems" in Scopus, Wiley, Springer, and Taylor & Francis?
4. How is "the critical thinking ability of slow-learning students in solving mathematical problems" in Scopus, Wiley, Springer, and Taylor & Francis?

2. METHOD

The article selection method, inclusion and exclusion criteria, and more objective analysis methods used in this study are all part of choosing SLR (systematic literature review) studies. This section details the research methodology, data gathering, and analysis. A systematic literature review is a method for locating, assessing, and comprehending all research pertinent to a research question, topic, or phenomenon [27]. In the article selection procedure, it is recommended to use the steps for selecting PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) articles, also known as the PRISMA flow diagram, for SLR [28]. We obtained journals from Scopus, Wiley, Springer, and Taylor & Francis.

The keywords in the title of the journal that has been published are "critical thinking ability" and "slow learner type students." The keyword search yielded 756 journal results. Applying the filter for journal publication years from 2018 to 2024 yielded 756 journals. Out of the 756 journals, we could access 73 of them, and 8 of them demonstrated sufficient relevance. The findings referenced the codes assigned to each article. The coding scheme assigned a number to each article, generating these codes by prefixing the letter 'A'

to the respective numbers. The codes of these eight articles, which will be analyzed using the systematic literature review method, are provided in the references (A1, A2, A3, A4 ...). The following is a flow diagram of the article screening method using PRISMA in Figure 1.

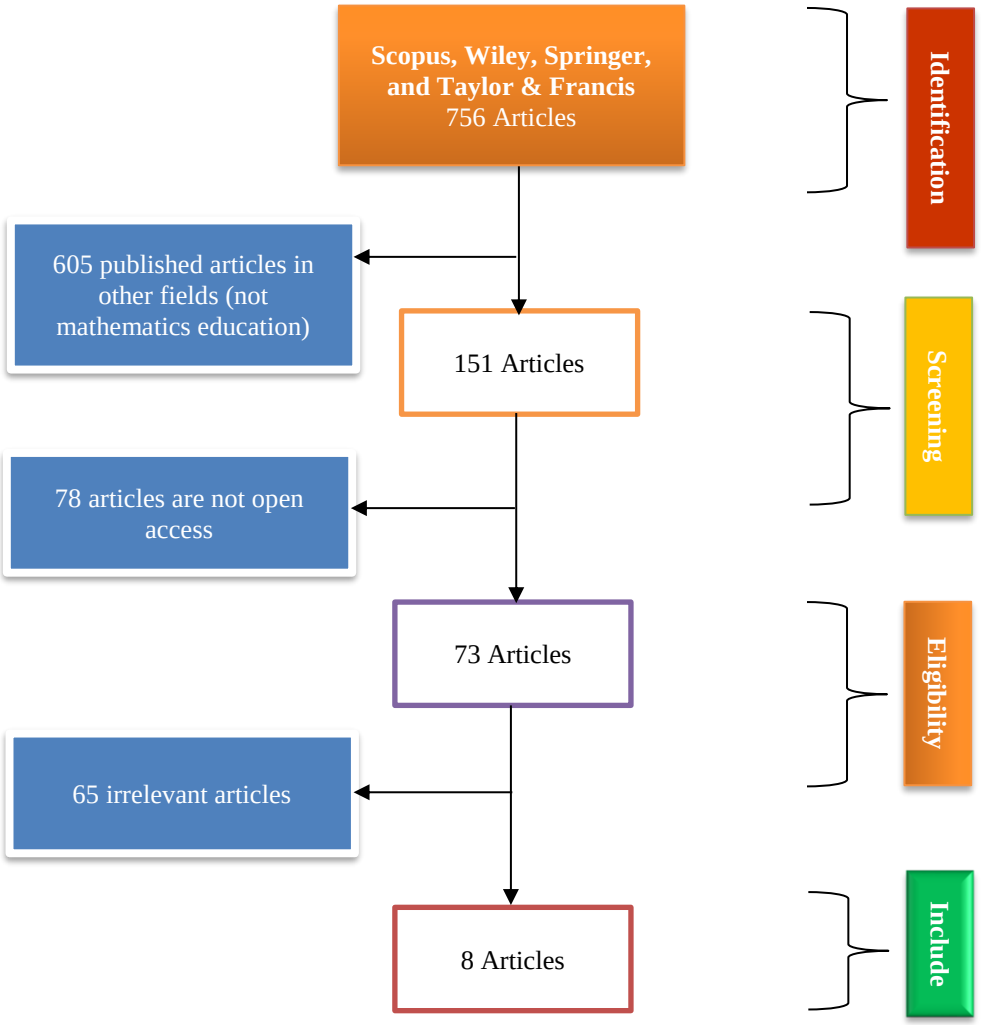

Figure 1. PRISMA filtering method flow chart

Inclusion and Exclusion Criteria

We organize this research into four primary phases, each of which we elaborate upon. These phases will adhere to the implementation methodology. The literature search process necessitates the filtration of results based on established criteria. We utilize inclusion and exclusion criteria as the foundation for literature selection. The search technique is categorized into four phases: identification, screening, eligibility, and inclusion. These sequences, grounded in scant evidence, assist authors in presenting diverse systematic reviews and meta-analyses. The designated investigation period is from 2018 to 2024. This strategy, supported by limited evidence, assists authors in presenting diverse systematic reviews and meta-analyses that evaluate the advantages. The designated

investigation period is from 2018 to 2024, focusing on critical thinking and slow learners in mathematics education.

The systematic review exclusively examines article-based research. The authors use research articles that have passed peer review and appeared in English-language publications. The writers utilize the Mendeley tool to organize papers sourced from web databases. In the identification phase, we will perform three literature searches. We will research internet databases containing substantial collections of academic research, such as Scopus, Wiley, Springer, and Taylor & Francis. During the second phase of identification, we also seek corroborative data.

The subsequent phase, screening, has three distinct techniques. Initially, identify the list of keywords for the investigation. We segmented the utilization of sets into multiple phases. The preliminary phase of the inquiry employed the terminology "expert" and "system." Upon completing the search process, the subsequent screening phase entailed identifying redundant or duplicate data. We additionally examined abstracts, keywords, and publication titles. We evaluated and chose titles, abstracts, and keywords from the search results, conforming to established eligibility criteria. The screening phase encompassed the duration from 2018 to 2024. Upon completing this phase, we assessed the quantity of data utilized and what remained for subsequent evaluation.

During the eligibility phase, a comprehensive assessment of whole or individual articles not discarded in the prior stage was conducted to ascertain their inclusion in the subsequent study based on the eligibility criteria. We examined the reference lists of the chosen publications to uncover supplementary related research. Consequently, we were left with two categories: those that fulfilled the criteria and those that did not. At this juncture, suitable research methodologies and approaches must be established. We classify the data based on the employed techniques, case study regions, and methodologies, differentiating them into two kinds of research methods: qualitative and quantitative. The concluding phase is also incorporated.

3. RESULTS AND DISCUSSION

3.1. Results

Utilizing the Scopus, Wiley, Springer, and Taylor & Francis databases, we may examine 756 papers. We utilize the conclusive outcomes of the articles classified according to field groupings throughout the eligibility phase. We utilize the previously established flowchart to elucidate all steps of systematic reviews. This part discusses the findings from educational and educational research articles on Scopus, Wiley, Springer, and Taylor & Francis about "critical thinking ability" and "slow learner type students solving mathematical problems." The focus is on the research questions, how the articles were written, and what they discussed.

3.1.1. Distribution by Publication Year

Identification

The identification process revealed the use of the Scopus, Wiley, Springer, and Taylor & Francis databases. We used the string "critical thinking ability" in the first search.

Table 1 below displays the search results based on three sources. Seven hundred fifty-six article identifications based on "critical thinking ability" and "slow learner type students solving mathematical problems" were entered, corresponding to the topic.

Table 1. Amount of identified data

Source	URL	Search result
Wiley	https://onlinelibrary.wiley.com/	125
Scopus	https://www.elsevier.com/products/scopus/search	321
Springer	https://link.springer.com/	174
Taylor & Francis	https://www.tandfonline.com/	136
	Total	756

Analysis showed that most research occurred between 2018–2024, with minimal studies before 2018 indicating an emerging focus on this topic.

3.1.2. Search String

Screening

The screening procedure encompasses multiple strings rather than being confined to a single string. Strings are defined according to the methodologies employed in data mining, as previously explained and illustrated in Table 2 below.

Table 2. Search string

Keywords	Search Results
Critical thinking ability	*Critical thinking ability*
Slow learner	*Slow learner*
Mathematical problems solving	*Mathematical problems*
Association	*Association*
Classification	*Classification*
Clustering	*Clustering*

Most of the research was focused on "concepts connected to learning and teaching methodologies," according to an examination of the publications regarding the used keywords.

3.1.3. The Results of the Screening Article

Eligibility

We picked 756 appropriate articles from the screening results and excluded 748 for the subsequent round. This technique employed a total of 8 articles. This approach contrasts with the preceding 756 articles since we engaged in a comprehensive reading of the articles in their entirety or segments.

We exclusively obtained the preceding figures from the titles. Upon examining the methodologies and abstracts of 756 articles, it became evident that numerous studies utilized various techniques, leading to redundancy in clustering outcomes. Consequently, a reassessment of the abstract, keywords, and research approach is required. We identified 8 appropriate papers, as illustrated in Table 3.

Table 3. Article search results

No	Article Code	Findings
1.	A1	"The results reveal four categories of failures: comprehension, transformation, process skills, and encoding faults. There are four categories of errors: conceptual, principled, algorithmic, and computational faults. This error analysis will assist educators in pinpointing the underlying causes of mistakes produced by slow learners in mathematics problem-solving."
2.	A2	"This study revealed that students classified as slow learners received insufficient support to meet their mathematics learning objectives. Slow learners require extended study periods compared to their peers, necessitating specialized educational services in solving mathematics problems. An alternative solution for teachers is to provide focused attention, allowing slow learners additional time to engage with the subject material and participate in clinical teaching. The significance of clinical teaching lies in guiding slow learners through the educational process and assisting them in overcoming the challenges they encounter."
3.	A3	"The results indicated that slow learners predominantly experienced difficulties in solving mathematical problems, particularly in comprehending mathematical concepts and relationships related to circles, especially in novel situations involving various problems. This was attributed to challenges in recalling mathematical ideas post-instruction. Strategies to mitigate these difficulties included encouraging students to develop clear conceptual understanding through teaching aids, such as paper circles or cylindrical cans, to facilitate problem-solving in mathematics."
4.	A4	"This paper presents outcomes from a three-year study aimed at identifying and assisting slow learners in mathematics inside elementary schools in Vietnam. Research reveals home and school obstacles to the academic achievement of slow-learning students, underscoring the necessity for individualized assistance and customized instruction in solving mathematical problems."
5.	A5	"The findings revealed that students in these clusters, excluding slow progressors, substantially improved their comprehension of mathematical problems. In particular, the students who were slow-steady progressors and often tried the same problem again compared to their peers showed the biggest gains in absolute learning. This showed that behavioral engagement had a big effect on learning outcomes. We demonstrated variety in students' problem-solving approaches inside the game through data visualizations, suggesting potential avenues for exploring how behavioral variances affect learning outcomes."
6.	A6	"The study advises that mathematics educators build and implement computer systems for instructing slow learners in solving mathematics problems. The study ultimately advocates for equipping educators to assist slow learners with computer programs, emphasizing the teacher's pivotal role in the learning process rather than solely depending on technology."
7.	A7	"The research showed that (1) most students, regardless of their performance level, prefer interactive classroom activities like games, real-life application tasks, and listening exercises to reading and writing; and (2) high-achieving and moderately-achieving students' critical thinking skills were judged to be fair, but those of low-achieving students were judged to be inadequate in solving

No	Article Code	Findings
		mathematics problems. Analysis was the predominant critical thinking subskill across high-achieving and low-achieving students, whereas interpretation was the foremost among fair-achieving students. Open-ended inquiries and activities tailored to students' choices seem effective for cultivating critical thinking abilities across all proficiency levels in solving mathematics problems."
8.	A8	"According to critical thinking test outcomes, slow learners can divide variables utilized in solving mathematical problems. According to the questionnaire answers, slow learners construct their comprehension and resolve problems based on their experiences when responding to questions during the learning process. Furthermore, the interviewees believe the instructor can address the issue by providing analogies to other materials. In summary, RMcT may facilitate the critical thinking of slow learners through its characteristics, such as employing rigorous questions. The findings benefit designers, service providers, and special needs higher education policymakers when implementing teaching strategies that integrate real-life problems into mathematical modeling for slow learners."

The analysis results in Table 3 relate to 8 scientific articles on critical thinking, slow learners, and mathematical problem-solving. The findings show that the analysis identifies four kinds of failures (understanding, changing information, process skills, and encoding mistakes) and four types of errors (conceptual, principled, algorithmic, and computational mistakes) in how slow learners tackle math problems (see A1). Slow learners require longer study periods, resulting in specialized services for math problems. Teachers can provide focused attention and clinical teaching to help them overcome challenges and engage with the subject material (A2). Slow learners struggle with mathematical problem-solving, especially in novel situations. Strategies include teaching aids to foster conceptual understanding and facilitate problem-solving in mathematics (A3). The study highlights the need for personal assistance and instruction in solving mathematical problems for slow-learning students despite home and school obstacles (A4).

Students who were slow, steady, and repeated problem-solvers showed significant gains in learning, indicating that behavioral engagement significantly impacts learning outcomes. Data visualizations showed various problem-solving approaches, suggesting potential avenues for understanding behavioral variances (A5). The study suggests that mathematics educators should develop computer systems to aid slow learners in solving problems, emphasizing the teacher's role in the learning process rather than solely relying on technology (A6). The study found that students prefer interactive classroom activities over reading and writing, and high-achieving students' critical thinking skills are fair while low-achieving students are inadequate. Open-ended inquiries and activities effectively develop critical thinking abilities across all proficiency levels (A7). Slow learners use real-life problems to solve issues, and RMcT can facilitate critical thinking by employing rigorous questions. Such an approach benefits service providers and policymakers in special needs higher education (A8).

3.1.4. Methodological Approaches Included

At this juncture, we seek qualitative and quantitative methodologies, comprehensively analyze the piece, and meticulously examine data collection techniques, including observation, visual analysis, literature review, and interviews. The subsequent points unequivocally illustrate this:

This dynamic qualitative research indicates that it remains receptive to modifications, augmentations, and substitutions throughout the analytical process. The qualitative method emphasizes comprehensive observation. Consequently, employing qualitative methodologies in research can yield a more thorough examination of a phenomenon. Humanism, centering on individual individuals and their behaviors, is the primary focus of qualitative research, recognizing that internal factors significantly impact the outcomes of human acts.

Researchers gather, evaluate, and analyze data sets in quantitative research to uncover links among the variables under investigation. The variables employed may consist of two or more. Quantitative research utilizes numerical data and quantifies objective outcomes through statistical analysis. Quantitative approaches seek to gather data sets and formulate generalizations to elucidate specific phenomena the population encounters. In quantitative research, prediction is the predominant technique employed. This research uses predictive methodologies to anticipate micrometeorological data. The research utilized diverse data from the search results of the ten publications in Table 3. Table 4 below delineates the search outcomes for the 8 publications.

Table 4. Search results for qualitative data, quantitative data, and others

No	Article Code	Data Type
1.	A1, A3, A4, and A8	Descriptive-qualitative
2.	A2	Case Study
3.	A5	Quantitative Analysis
4.	A6	Experimental Group
5.	A7	Mixed-Method Design

Building upon Table 4 showed that most studies applied qualitative methodologies, while few utilized quantitative or mixed-method approaches.

3.2. Discussion

This part aims to convey the discussion and recommendations from the study's findings. This study analyzed articles published between 2018 and 2024 that included "critical thinking ability" and "slow learner type students solving mathematical problems" in the topic section. After the analysis, we identified and evaluated eight publications using the systematic literature review, following the PRISMA approach.

An examination of the publication years of these eight publications on "critical thinking ability" and "slow learner type students solving mathematical problems" reveals that the research predominantly occurred between 2018 and 2024. The paucity of work on this issue prior to 2018 may be attributed to the increased emphasis on research concerning games and following mathematics in this period.

An analysis of the publications reveals that the qualitative method predominates in the studies undertaken in this sector. The number of mixed-methods, qualitative case studies, and experimental research studies is approximately equal to the number of studies employing quantitative methods. Research within this domain can employ qualitative, quantitative, and mixed approaches interchangeably, leading to the absence of a dominant method in the literature.

A comparison of the studies shows that more sample groups of elementary, middle, and high school students were used. Research on high school students succeeds in this, albeit with a minor variation. Alternative sample groups have been the subject of fewer studies than these groupings. Future studies on this topic should consider incorporating a distinct sample group of elementary and high school students to enhance the existing literature.

An examination of the articles reveals that they predominantly pertain to mathematics and mathematics education. This article focuses on research about "critical thinking ability" and "slow learner type students solving mathematical problems"; hence, it is anticipated that the topic areas explored pertain to mathematics and mathematics education. Future research in this domain, concentrating on disciplines beyond mathematics and mathematics education, will likely enhance existing literature.

An analysis of the publications about the utilized keywords reveals that the predominant research focus was on 'concepts connected to learning and teaching methodologies.' This effort is succeeded by research on students classified as slow learners addressing mathematical issues. Research on "critical thinking ability" is as scarce as in other areas. Analysis of keyword sub-terms reveals that most research focused on "slow learner type students solving mathematical problems" within the framework of 'issues necessitating specialized intervention for slow learners. The data indicates that "critical thinking ability" and "slow learner type students in solving mathematical problems" are significant challenges in mathematics education that require targeted intervention from educators and relevant stakeholders in educational institutions. Facilitating the development of critical thinking skills in this group of people can be done in several ways, including using technology, games, and teaching methods with slow learners.

A comprehensive assessment reveals four sorts of errors: conceptual, principled, algorithmic, and computational, typically made by slow learners in mathematics problem-solving. Students with slower learning rates necessitate prolonged study durations relative to their counterparts, requiring tailored educational services for mathematical problem-solving. An alternative method for educators is to offer concentrated attention, granting slow learners extra time to interact with the subject matter and partake in clinical instruction. Clinical teaching is important in directing slow learners through the educational journey and aiding them in surmounting the obstacles they face. Moreover, strategies to alleviate the challenges faced by slow learners involved promoting the development of clear conceptual understanding using teaching aids, such as paper circles or cylindrical cans, to enhance problem-solving in mathematics.

4. CONCLUSION

This systematic literature review highlights significant patterns of errors among slow learners in mathematics, emphasizing tailored teaching methods, the use of technology, and real-life problem integration. Educators should adopt these approaches to foster critical thinking and effective problem-solving skills in slow learners. Future research should focus on longitudinal studies assessing the impact of specific interventions and comparative studies on teaching methods tailored for slow learners in mathematics.

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Appendix 1. Article for research

Article Code	Article references
A1	Novitasari, N., Lukito, A., & Ekawati, R. (2018). Slow Learner Errors Analysis in Solving Fractions Problems in Inclusive Junior High School Class. *Journal of Physics: Conference Series*, *947*(1), 012035. https://doi.org/10.1088/1742-6596/947/1/012035
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