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Mathematical Critical Thinking Ability and Adversity Quotient in Mathematics Learning: A Systematic Literature Review

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Abstract

This study aims to systematically review the literature discussing mathematical critical thinking skills and Adversity Quotient in the context of mathematics learning, with a focus on the ability conditions, indicators used, and a synthesis of research findings. The method used is Systematic Literature Review with reference to the PRISMA stages. Articles were obtained through searches on Google Scholar and SCOPUS databases using related keywords, then selected based on inclusion and exclusion criteria. The selected articles were analyzed descriptively-qualitatively. The results of the study indicate that students' mathematical critical thinking skills at various levels of education are generally in the low to moderate category, especially in the analysis, evaluation, and conclusion drawing indicators. The indicators of mathematical critical thinking skills used in the study are dominated by the Ennis and Facione framework, while the Adversity indicator Quotient generally refers to Stoltz 's CORE model which includes Control, Origin Ownership, Reach, and Endurance. Synthesis of findings shows that students with the highest level of Adversity Students with a higher AQQ tend to have better mathematical critical thinking skills, particularly in terms of persistence and reflection in solving mathematical problems. This study emphasizes the importance of developing mathematical critical thinking skills integrated with strengthening Adversity. Quotient in mathematics learning

Keywords: *Mathematical Critical Thinking, Adversity Quotient, Mathematics Learning, Systematic Literature Review*

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Introduction

Mathematical critical thinking skills are essential competencies in mathematics learning, especially in facing the demands of the 21st century which emphasize analytical, evaluation, and decision-making skills based on logical reasoning. This ability enables students to understand problems in depth, link mathematical concepts, and develop appropriate and reflective solution strategies [1]. However, various research results indicate that students' mathematical critical thinking skills have not yet developed optimally, especially when they are faced with non-routine and contextual problems that require high-level reasoning [2]. The low level of critical mathematical thinking skills cannot be separated from the influence of affective factors, which also determine the quality of students' thinking processes in mathematics learning. Affective factors play a significant role in shaping students' attitudes, motivation, and perseverance when facing difficulties in learning mathematics [3]. One affective factor that plays a strategic role is *Adversity. Quotient* (AQ), namely an individual's ability to face difficulties, survive under pressure, and recover from failure [4].

In the context of learning mathematics, which is often perceived as a difficult and challenging subject, Adversity AQ is a factor that influences students' tenacity, fighting spirit, and readiness to solve complex mathematical problems. Students with good AQ tend to have higher self-control, are less likely to give up, and are able to manage learning difficulties more constructively [5]. Various studies have examined Adversity AQ in relation to mathematical critical thinking skills at various levels of education. These research findings generally indicate that students with high AQ levels tend to have better mathematical critical thinking

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[1] Robert H Ennis, "A Taxonomy of Critical Thinking Dispositions and Abilities.," 1987; Peter A Facione, "Critical Thinking: What It Is and Why It Counts. Millbrae," *California Academic Press. Haziran* 13 (1998): 2009; F Joe Crosswhite, John A Dossey, and Shirley M Frye, "NCTM Standards For School Mathematics: Visions For Implementation," *The Arithmetic Teacher* 37, no. 3 (1989): 55–60, https://doi.org/https://doi.org/10.5951/AT.37.3.0055.

[2] OECD, "PISA 2018 Results (Volume I): What Students Know and Can Do," PISA, OECD Publishing, Paris, 2019, https://doi.org/https://doi.org/10.1787/5f07c754-en.

[3] Donald R Woods, "An Evidence-Based Strategy For Problem Solving," *Journal of Engineering Education* 89, no. 4 (2000): 443–59, https://doi.org/https://doi.org/10.1002/j.2168-9830.2000.tb00551.x; Julia F Pounds and Jon J Fallesen, "Understanding Problem Solving Strategies," 1994.

[4] Paul G Stoltz, *Adversity Quotient: Turning Obstacles Into Opportunities* (John Wiley & Sons, 1999).

[5] Alexander T Vazsonyi, Magda Javakhishvili, and Marek Blatny, "Does Self-Control Outdo IQ in Predicting Academic Performance?," *Journal of Youth and Adolescence* 51, no. 3 (2022): 499–508; Stoltz, *Adversity Quotient: Turning Obstacles Into Opportunities.*

skills, because they are able to persist in the face of difficulties, continue to try various strategies, and are more reflective in evaluating steps to solve mathematical problems [6].

However, the results of research on mathematical critical thinking skills and Adversity The quotient is still scattered across various articles with varying contexts, study focuses, and methodological approaches. Differences in educational levels, mathematical materials, and research methods mean that the findings are not yet presented in a complete and integrated picture[7]. Research developments on mathematical critical thinking skills and Adversity The quotient also shows variation in terms of publication year, research design, and research subjects. This situation results in the lack of a systematic mapping of the direction of research development, dominant study characteristics, and the relationship between these two variables in mathematics learning [8].

The lack of a comprehensive literature synthesis has the potential to hinder the optimal use of research findings, both in mathematics learning practices and in the development of further research. However, a systematic literature synthesis can provide a strong conceptual foundation for learning design and the development of measurement instruments for mathematical critical thinking and adversity. Quotient [9]. Based on these problems, a study is needed that is able to systematically examine and synthesize the research that has been carried out regarding mathematical critical thinking skills and Adversity. Quotient. Therefore, this research was conducted through a *systematic approach. Literature Review* (SLR) to answer several research questions, namely: (1) What are the trends and developments in research that discuss mathematical critical thinking skills and Adversity Quotient in mathematics learning; (2) At what level of education is the most research related

[6] Ivo Novinda, IRNI Latifa Irsal, and Dini Palupi Putri, "Analisis Kemampuan Literasi Matematis Siswa Ditinjau Dari Adversity Quotient (Aq) Dan Gender" (Institut Agama Islam Negeri Curup, 2024); Nadila Almubarokah, Roseli Theis, and Dewi Iriani, "Analisis Kemampuan Berpikir Kritis Siswa Dalam Pemecahan Masalah Matematika Ditinjau Dari Adversity Quotient (AQ) Pada Materi Aritmatika Sosial," *Jurnal Pendidikan MIPA* 14, no. 1 (2024): 163–74, https://doi.org/https://doi.org/10.37630/jpm.v14i1.1501.

[7] Ton Ellermeijer and André Heck, "Differences Between The Use Of Mathematical Entities In Mathematics And Physics And The Consequences For An Integrated Learning Environment," *Developing Formal Thinking in Physics*, 2002, 52–72; Marija Kaplar et al., "The Influence of Interactive Learning Materials on Solving Tasks That Require Different Types of Mathematical Reasoning," *International Journal of Science and Mathematics Education* 20, no. 2 (2022): 411–33; Roslyn Arlin Mickelson and Martha Bottia, "Integrated Education and Mathematics Outcomes: A Synthesis of Social Science Research," *NCL Rev.* 88 (2009): 993.

[8] OECD, "PISA 2018 Results (Volume I): What Students Know and Can Do."

[9] Robert H Ennis, "Critical Thinking Assessment," *Theory into Practice* 32, no. 3 (1993): 179–86, https://doi.org/https://doi.org/10.1080/00405849309543594; Ennis, "A Taxonomy of Critical Thinking Dispositions and Abilities."; Facione, "Critical Thinking: What It Is and Why It Counts. Millbrae."

to these two variables conducted; (3) What research methods are predominantly used; and (4) How do research findings explain the relationship between Adversity Quotient and mathematical critical thinking ability.

By answering these questions, this research is expected to provide a comprehensive research mapping and strengthen understanding of the role of Adversity. Quotient in developing critical mathematical thinking skills. Furthermore, the results of this study are expected to provide a conceptual foundation for developing mathematics learning that is not only oriented toward mastering procedures but also toward strengthening critical reasoning and student learning resilience.

Research Methods

This research uses a *systematic approach. Literature Review* (SLR) to comprehensively and systematically examine scientific articles that discuss mathematical critical thinking skills and *Adversity Quotient* in the context of mathematics learning. The SLR approach was chosen because it can systematically synthesize research findings through structured and well-documented procedures [10]. The SLR implementation process is carried out with reference to the *Preferred stages. Reporting Items for Systematic Reviews and Meta- Analyses* (PRISMA) which includes the stages of identification, screening, eligibility assessment, and inclusion of relevant articles. The PRISMA framework is used to ensure that the process of selecting and reporting studies is carried out transparently, systematically, and can be replicated by other researchers[11].

This approach was chosen to ensure that the process of collecting, filtering, and analyzing literature was carried out objectively and consistently, so that the results of the

[10] Ntombiyokusa Nyoni, Annlizé L Marnewick, and Carl Marnewick, "Improving Systematic Literature Reviews: A Narrative Guideline to Structure The Analysis Stage," *Electronic Journal of Business Research Methods* 23, no. 2 (2025): 70–87, https://doi.org/https://doi.org/10.34190/ejbrm.23.2.4033; Mohamed Hamza Bennani and Driss Helmi, "Rethinking Systematic Literature Reviews: A Critical and Evolving Perspective on the SPAR-4-SLR Protocol," *Revue Internationale Des Sciences de Gestion* 8, no. 4 (2025): 519–39; Salifu Yusif and Abdul Hafeez-Baig, "Evidence-Based Information Systems (IS) Research: The Case of Systematic Literature Review (SLR)," *Authorea Preprints*, 2024, https://doi.org/https://doi.org/10.22541/au.170668933.33258272/v1.

[11] David Moher et al., "Preferred Reporting Items For Systematic Reviews and Meta-Analyses: The PRISMA Statement," *BMJ* 339 (2009), https://doi.org/https://doi.org/10.1136/bmj.b2535; Matthew J Page et al., "Updating Guidance For Reporting Systematic Reviews: Development Of The PRISMA 2020 Statement," *Journal of Clinical Epidemiology* 134 (2021): 103–12, https://doi.org/https://doi.org/10.1016/j.jclinepi.2021.02.003.

study could provide a comprehensive picture of research developments, methodological trends, and main findings related to mathematical critical thinking skills and *Adversity. Quotient* in mathematics learning [12].

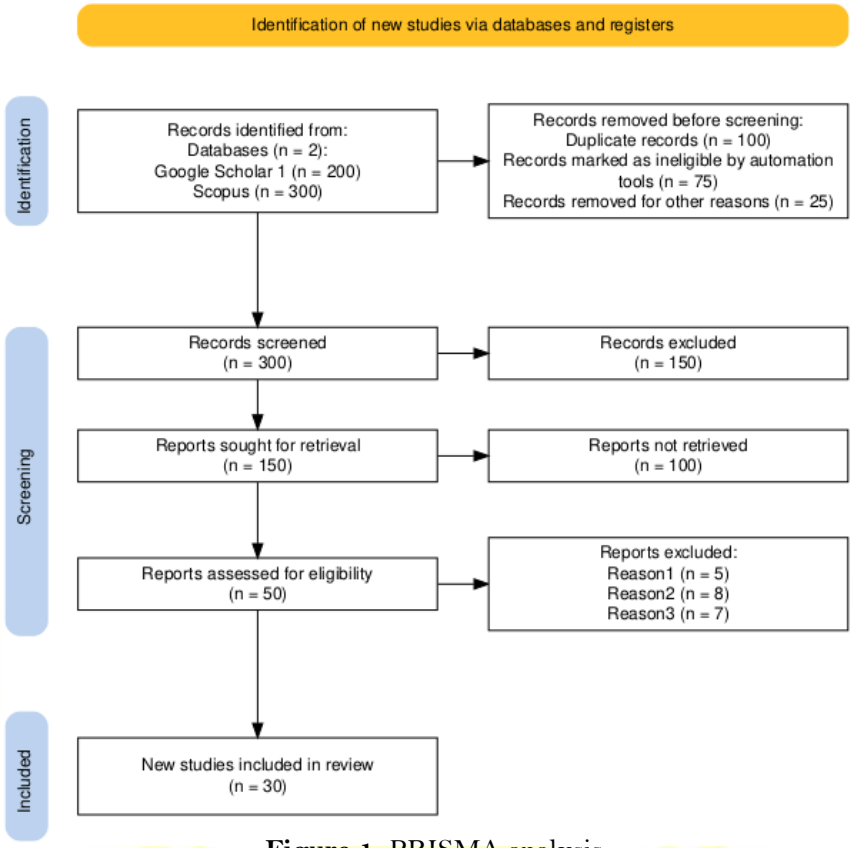


Figure 1. PRISMA analysis

The figure shows the literature selection flow using the PRISMA diagram. In the identification stage, the researcher found 500 records from two databases, namely Google Scholar (200) and Scopus (300). Before screening, 200 records were removed, consisting of 100 duplicate data, 75 records that were not suitable based on automated tools, and 25 records that were eliminated for other reasons, leaving 300 records. In the screening stage, 300 records were selected based on title and abstract, which resulted in 150 records being excluded due to irrelevance. Next, 150 reports were searched in full text, but 100 reports were not successfully retrieved. In the eligibility stage, 50 available reports were assessed for eligibility, and 30 reports were excluded for various reasons (5 for reason 1, 8 for reason 2,

[12] Mark Petticrew and Helen Roberts, *Systematic Reviews In The Social Sciences: A Practical Guide* (John Wiley & Sons, 2008).

and 7 for reason 3). Finally, in the inclusion stage, 30 studies were declared to meet the criteria and were included in the systematic review.

The research data sources come from scientific databases relevant to the field of mathematics education, namely Google Scholar and SCOPUS related to international journals that can be accessed online. Article searches were conducted using a combination of keywords, including "mathematical critical thinking," "critical mathematical thinking", "adversity quotient ", and "mathematics education", combined using the Boolean operators AND and OR. The search process was limited to articles published within a specific year range to obtain an overview of the latest research developments. Articles obtained from the search results were then selected based on established inclusion and exclusion criteria. Inclusion criteria included research articles published in scientific journals discussing mathematical critical thinking skills and/or Adversity. Quotient, is in the context of mathematics learning or education, and is available in full-text form. Exclusion criteria included non-journal articles such as theses, dissertations, proceedings, articles irrelevant to the research focus, and articles that were not fully accessible.

The article selection process was carried out in stages by reviewing the title and abstract to assess topic suitability, followed by reading the full text to determine the article's suitability based on predetermined criteria. Articles that met the inclusion criteria were then analyzed through a data extraction process that included information on the year of publication, educational level, research method, study focus, and key findings related to the relationship between mathematical critical thinking skills and Adversity. Quotient. The extracted data were analyzed using descriptive-qualitative analysis techniques by grouping and synthesizing research findings based on relevant characteristics. The results of the analysis were then presented in the form of narrative descriptions and synthesis tables to provide a comprehensive overview of research trends, methodological characteristics, and patterns of relationships between Adversity. Quotient and critical mathematical thinking ability in mathematics learning

Results and Discussion

Result

Table 1. Indicators and Findings of Mathematical Critical Thinking Ability in Research

No	Focus/Indicator	Key Research Findings	Source
1	Analysis of non-routine mathematical problems	Students have difficulty explaining important information in complex questions.	[13]
2	Giving reasons/arguments	The justification for the settlement steps is still weak and illogical.	[14]
3	Evaluation of settlement strategies	Students rarely evaluate the correctness of the strategies used.	[15]
4	Inference/drawing conclusions	Conclusions do not always correspond to mathematical processes	[16]
5	Identify relevant information	Students tend to use all data without selection.	[17]
6	Mathematical modeling	Difficulty converting contextual problems into mathematical models	[18]
7	Selection of problem solving strategies	Strategies are chosen procedurally without analysis of alternatives.	[19]
8	Reflection on completion results	Students rarely recheck their answers	[20]
9	Critical thinking process (not just the result)	Students focus on the formula, not on understanding the problem	[21]

[13] Ennis, "A Taxonomy of Critical Thinking Dispositions and Abilities."

[14] Balihar Sanghera, "Justice, Power and Informal Settlements: Understanding The Juridical View of Property Rights in Central Asia," *International Sociology* 35, no. 1 (2020): 22–44, https://doi.org/https://doi.org/10.1177/0268580919877596; Ennis, "A Taxonomy of Critical Thinking Dispositions and Abilities."

[15] Ronald A Berk and Michael Theall, *Thirteen Strategies To Measure College Teaching: A Consumer's Guide To Rating Scale Construction, Assessment, And Decision-Making For Faculty, Administrators, And Clinicians* (Routledge, 2023).

[16] Danielle J Navarro, "If Mathematical Psychology Did Not Exist We Might Need To Invent It: A Comment On Theory Building In Psychology," *Perspectives on Psychological Science* 16, no. 4 (2021): 707–16, https://doi.org/https://doi.org/10.1177/1745691620974769.

[17] John H Conway and George Polya, *How to Solve It: A New Aspect of Mathematical Method* (Princeton university press, 1945).

[18] Crosswhite, Dossey, and Frye, "NCTM Standards For School Mathematics: Visions For Implementation."

[19] Woods, "An Evidence-Based Strategy For Problem Solving"; Pounds and Fallesen, "Understanding Problem Solving Strategies."

[20] Ennis, "A Taxonomy of Critical Thinking Dispositions and Abilities."

[21] Ardi Dwi Susandi, "Critical Thinking Skills of Students in Solving Mathematical Problem," *Numerical: Jurnal Matematika Dan Pendidikan Matematika* 5, no. 2 (2021): 115–28, https://doi.org/https://doi.org/10.25217/numerical.v5i2.1865; Jonathan Haber, *Critical Thinking* (MIT Press, 2020).

10	Level of critical thinking ability	Generally in the low-medium category at the middle level	[22]
11	Clarification of the problem	Students are not yet able to reformulate the problem in their own language clearly.	[23]
12	Interpretation of representation	Students have difficulty interpreting graphs, tables, or diagrams into mathematical models.	[24]
13	Assumption checking	Students rarely identify and test the assumptions used in solving problems.	[25]
14	Generalization of results	Students have difficulty drawing generalizations or patterns from the results of problem solving.	[26]
15	Critical mathematical communication	Reasons and conclusions are presented procedurally without in-depth logical explanation.	[27]

The results of a review of the analyzed articles indicate that students' mathematical critical thinking skills are generally in the low to moderate category. This condition is particularly evident in indicators of problem analysis, evaluation of solution strategies, and drawing logical conclusions. Most studies report that students experience difficulties in analyzing non-routine problems, identifying relevant information, and providing appropriate justification for the solution steps used [28]. This finding appears consistently across various levels of education, particularly at the secondary level, when students begin to be exposed to more abstract and complex mathematical concepts [29].

[22] OECD, "PISA 2018 Results (Volume I): What Students Know and Can Do."

[23] Susheela Shanta and John G Wells, "T/E Design Based Learning: Assessing Student Critical Thinking and Problem Solving Abilities," *International Journal of Technology and Design Education* 32, no. 1 (2022): 267–85; Haber, *Critical Thinking*.

[24] OECD, "PISA 2018 Results (Volume I): What Students Know and Can Do."

[25] Ennis, "A Taxonomy of Critical Thinking Dispositions and Abilities."

[26] Conway and Polya, *How to Solve It: A New Aspect of Mathematical Method*.

[27] Kaixuan Gong and Hongmei Pang, "Profiling The Outcomes Of Academic Discourse Socialisation Through Academic Writing: AQ Methodology Study On Student Writers' Self-Reflections," *Journal of English for Academic Purposes* 77 (2025): 101562, https://doi.org/https://doi.org/10.1016/j.jeap.2025.101562.

[28] Liming Jiang et al., "Evaluating The Critical Thinking of Large Language Models: Insights and Limitations.," *Journal of Pacific Rim Psychology* (Luo, Fang: Department of Psychology, Beijing Normal University, Beijing, China, 100875, luof@bnu.edu.cn: Sage Publications, 2025), https://doi.org/10.1177/18344909251406111; Peter A Facione, "The Disposition Toward Critical Thinking: Its Character, Measurement, and Relationship To Critical Thinking Skill," *Informal Logic* 20, no. 1 (2000): 61–84, https://doi.org/https://doi.org/10.22329/il.v20i1.2254; Facione, "Critical Thinking: What It Is and Why It Counts. Millbrae."

[29] OECD, "PISA 2018 Results (Volume I): What Students Know and Can Do."

Several articles emphasize that low mathematical critical thinking skills are not only evident in the final results of problem solving, but also in students' thought processes during problem-solving. Students tend to immediately apply memorized formulas or procedures without conducting an in-depth analysis of the context of the given problem. This pattern indicates that mathematical critical thinking skills, particularly in the aspects of reflection and evaluation, have not been optimally internalized in mathematics learning [30].

The analysis results show that the articles reviewed use a variety of indicators of mathematical critical thinking skills, referring to several figures and theoretical frameworks. Most studies refer to the critical thinking indicators developed by Ennis, which include the ability to analyze problems, provide reasons or arguments, evaluate problem-solving strategies, and draw logical conclusions. These indicators are widely used because they are considered capable of comprehensively representing the critical thinking process in the context of mathematical problem solving [31]. In addition, several studies have used critical thinking indicators developed by Facione, specifically those encompassing interpretation, analysis, evaluation, and inference skills. In the context of mathematics learning, these indicators translate into the ability to understand information in a problem, analyze relationships between concepts, evaluate the accuracy of solution steps, and draw conclusions based on logical and consistent mathematical reasoning [32].

Some other articles develop indicators for mathematical critical thinking tailored to the characteristics of the material and the learning context. Frequently used indicators include the ability to identify relevant information, formulate mathematical models, select problem-solving strategies, and reflect on the results obtained. This approach aligns with the NCTM (2000) recommendations, which emphasize the importance of authentic assessment in mathematics learning. Although variations in the indicators used could potentially lead to differences in the measurement of mathematical critical thinking skills across studies.

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[30] Shipra Sachdeva and Per-Odd Eggen, "Learners' Critical Thinking About Learning Mathematics," *International Electronic Journal of Mathematics Education* 16, no. 3 (2021): 1–18, https://doi.org/https://doi.org/10.29333/iejme/11003; Erpin Evendi et al., "Assessing Students' Critical Thinking Skills Viewed from Cognitive Style: Study on Implementation of Problem-Based e-Learning Model in Mathematics Courses.," *Eurasia Journal of Mathematics, Science and Technology Education* 18, no. 7 (2022): 1–15, https://doi.org/https://doi.org/10.29333/ejmste/12161.

[31] Ennis, "A Taxonomy of Critical Thinking Dispositions and Abilities."

[32] Facione, "The Disposition Toward Critical Thinking: Its Character, Measurement, and Relationship To Critical Thinking Skill"; Facione, "Critical Thinking: What It Is and Why It Counts. Millbrae."

Table 2. Adversity Indicators and Findings Quotient in Mathematics Education Research

No	Indicator	Description in Mathematics Learning	Source
1	Control	The ability to control responses when faced with difficult problems	[33]
2	Origin	Ability to recognize sources of difficulties in learning mathematics	[34]
3	Ownership	Willingness to take responsibility for failure	[35]
4	Reach	The impact of mathematics difficulties on other subjects	[36]
5	Endurance	Resilience in the face of difficulties in learning mathematics	[37]
6	Climbers Type	Persistent, trying various problem-solving strategies	[38]
7	Camper Types	Try to a certain limit and then stop	[39]
8	Types of Quitters	Give up easily when encountering math difficulties	[40]
9	AQ and critical thinking	High AQ correlates with better critical thinking	[41]
10	AQ in the problem solving process	AQ influences students' persistence and depth of analysis	[42]
11	Emotional regulation	Ability to manage negative emotions (anxiety, frustration) when facing difficult math problems	[43]
12	Achievement motivation	An internal drive to keep trying until you find a mathematical solution.	[44]

[33] Stoltz, *Adversity Quotient: Turning Obstacles Into Opportunities.*
[34] Stoltz.
[35] Stoltz.
[36] Stoltz.
[37] Stoltz.
[38] Stoltz.
[39] Stoltz.
[40] Stoltz.
[41] Almubarokah, Theis, and Iriani, "Analisis Kemampuan Berpikir Kritis Siswa Dalam Pemecahan Masalah Matematika Ditinjau Dari Adversity Quotient (AQ) Pada Materi Aritmatika Sosial."
[42] Novinda, Latifa Irsal, and Palupi Putri, "Analisis Kemampuan Literasi Matematis Siswa Ditinjau Dari Adversity Quotient (Aq) Dan Gender."
[43] Stoltz, *Adversity Quotient: Turning Obstacles Into Opportunities.*
[44] Allan Wigfield, Katherine Muenks, and Jacquelynne S Eccles, "Achievement Motivation: What We Know and Where We Are Going," *Annual Review of Developmental Psychology* 3, no. 1 (2021): 87–111,

13	Learning persistence	Consistency of effort in completing math assignments despite initial failures	[45]
14	Academic coping strategies	Ability to choose adaptive strategies (seeking help, trying other approaches) when faced with difficulties	[46]
15	Academic resilience	The ability to bounce back and improve performance after experiencing failure in learning mathematics	[47]

Analysis of the articles reviewed shows that the Adversity indicator Quotient generally refers to the concept proposed by Stoltz, namely the CORE model consisting of Control, Origin Ownership, Reach, and Endurance. The Control indicator describes the ability of students to control emotional and cognitive responses when facing difficulties in learning mathematics. Origin Ownership is related to the ability to recognize the source of difficulties and take responsibility for the problems faced, while Reach and Endurance each reflect the extent to which difficulties affect other aspects of learning and the resilience of students in facing them [48]. Some studies also group Adversity Quotient of students into the categories of climber, camper, and quitter. Students in the climber category show high perseverance, a tendency to try various problem-solving strategies, and do not give up easily when faced with difficult math problems. Conversely, students in the quitter category tend to quickly stop trying and not continue the thinking process when experiencing difficulties, which has an impact on the low quality of mathematical critical thinking displayed [49].

https://doi.org/https://doi.org/10.1146/annurev-devpsych-050720-103500; Stoltz, *Adversity Quotient: Turning Obstacles Into Opportunities.*

[45] Peter Sullivan et al., "Ways That Relentless Consistency And Task Variation Contribute To Teacher And Student Mathematics Learning," *For the Learning of Mathematics*, 2020, 32–37.

[46] M Kay Alderman, *Motivation for Achievement: Possibilities for Teaching and Learning* (Routledge, 2013); James A Middleton and Photini A Spanias, "Motivation for Achievement in Mathematics: Findings, Generalizations, and Criticisms of the Research," *Journal for Research in Mathematics Education* 30, no. 1 (1999): 65–88, https://doi.org/https://doi.org/10.2307/749630.

[47] Cecile Mary Foshee, *Conditions That Promote the Academic Performance of College Students in a Remedial Mathematics Course: Academic Competence, Academic Resilience, and the Learning Environment* (Arizona State University, 2013).

[48] Paul Gordon Stoltz and Erik Weihenmayer, *The Adversity Advantage: Turning Everyday Struggles Into Everyday Greatness* (Simon and Schuster, 2007); Stoltz, *Adversity Quotient: Turning Obstacles Into Opportunities.*

[49] Padliadi, Marwan, and C M Zubainur, "The Thinking Process of Quitter Students in Solving Open-Ended Mathematical Problems," in *Journal of Physics: Conference Series*, vol. 1460 (IOP Publishing, 2020), https://doi.org/10.1088/1742-6596/1460/1/012007; Sachdeva and Eggen, "Learners' Critical Thinking About Learning Mathematics"; Stoltz, *Adversity Quotient: Turning Obstacles Into Opportunities*; Stoltz and Weihenmayer, *The Adversity Advantage: Turning Everyday Struggles Into Everyday Greatness.*

The synthesis results show that each article has different strengths and research focuses. Articles with a correlational approach have the advantage of describing the relationship between levels of adversity. Quantitative mathematical quotient and critical thinking skills in a specific population. This type of research provides a general overview of the tendencies of relationships between variables, although it is not yet able to reveal in depth the thought processes of students in solving mathematical problems [50]. Articles with a qualitative approach and case studies provide a more in-depth contribution in revealing the characteristics of students' mathematical critical thinking processes based on the level of Adversity. Different Quotients. Through analysis of written answers and interviews, these studies were able to explain the differences in analysis, evaluation, and reflection patterns between students with high, medium, and low AQ [51].

Meanwhile, experimental and quasi-experimental articles stand out in showing how the application of certain learning strategies, such as problem-based learning or contextual problem solving, can facilitate the development of mathematical critical thinking skills while increasing Adversity. Student Quotient. The main advantage of this type of article lies in its practical implications for mathematics learning, although the focus of the study is more directed at improving general abilities than at mapping critical thinking and AQ indicators in detail [52].

Discussion

The results of this systematic literature review indicate that students' mathematical critical thinking skills at various levels of education remain in the low to moderate category. This is particularly evident in their weak problem-analyzing, problem-solving strategy evaluation, and logical conclusion drawing abilities. These findings align with [53], who assert

[50] Sachdeva and Eggen, "Learners' Critical Thinking About Learning Mathematics"; Padliadi, Marwan, and Zubainur, "The Thinking Process of Quitter Students in Solving Open-Ended Mathematical Problems."

[51] Ellermeijer and Heck, "Differences Between The Use Of Mathematical Entities In Mathematics And Physics And The Consequences For An Integrated Learning Environment"; Kaplar et al., "The Influence of Interactive Learning Materials on Solving Tasks That Require Different Types of Mathematical Reasoning"; Mickelson and Bottia, "Integrated Education and Mathematics Outcomes: A Synthesis of Social Science Research."

[52] Crosswhite, Dossey, and Frye, "NCTM Standards For School Mathematics: Visions For Implementation."

[53] Ennis, "A Taxonomy of Critical Thinking Dispositions and Abilities."; Ennis, "Critical Thinking Assessment"; Facione, "Critical Thinking: What It Is and Why It Counts. Millbrae"; Facione, "The Disposition Toward Critical Thinking: Its Character, Measurement, and Relationship To Critical Thinking Skill."

that critical thinking requires analytical and reflective skills that cannot develop optimally if learning focuses solely on procedures and outcomes. The dominance of procedural approaches in mathematics learning leads students to directly apply formulas without fully understanding the problem's structure. This pattern reinforces the findings of [54] who stated that mathematics learning with minimal exploration and reflection will limit the development of students' critical reasoning, particularly in solving non-routine problems.

The diversity of critical mathematical thinking indicators used in research indicates a lack of uniformity in the measurement framework. Although the critical thinking indicators developed by [55] are widely used as references, some studies have adapted them contextually to suit the characteristics of the material and educational level. This demonstrates conceptual flexibility, but also has the potential to lead to differences in interpretation in measuring critical mathematical thinking skills. In the context of mathematics education, contextual adaptation of critical thinking indicators can be seen as an effort to increase the authenticity of assessment. Indicators such as mathematical modeling, strategy selection, and reflection on the results of the solution are more representative of actual mathematical thinking activities, as recommended by the National Council. of Teachers of Mathematics [56]. However, the development of these indicators still needs to be based on an established theoretical framework to ensure the consistency and validity of the instrument.

On the aspect of Adversity Quotient , the results of the study indicate that the CORE model proposed by [57] has become the dominant framework in mathematics education research. The Control, Origin - Ownership, Reach, and Endurance indicators are considered capable of describing how students respond to mathematics learning difficulties, both in terms of self-control, responsibility, and resilience in facing academic challenges. Classifying students into climber, camper, and quitter categories provides a clear picture of the variation in learning resilience. Students in the climber category demonstrate persistence and a

[54] Woods, "An Evidence-Based Strategy For Problem Solving"; Pounds and Fallesen, "Understanding Problem Solving Strategies."

[55] Ennis, "A Taxonomy of Critical Thinking Dispositions and Abilities."; Ennis, "Critical Thinking Assessment"; Facione, "Critical Thinking: What It Is and Why It Counts. Millbrae"; Facione, "The Disposition Toward Critical Thinking: Its Character, Measurement, and Relationship To Critical Thinking Skill."

[56] NCTM, "Principles and Standards for School Mathematics," NCTM (National of Teachers of Mathematics), 2000.

[57] Stoltz and Weihenmayer, *The Adversity Advantage: Turning Everyday Struggles Into Everyday Greatness*; Stoltz, *Adversity Quotient: Turning Obstacles Into Opportunities.*

tendency to continue trying various problem-solving strategies, while students in the quitter category tend to give up easily when faced with mathematical difficulties [58]. These differences in characteristics have direct implications for the quality of critical thinking processes displayed by students.

The Relationship between Adversity Mathematical intelligence and critical thinking skills appear consistent across studies. Students with high AQ, particularly in the Control and Endurance indicators, tend to be able to conduct more in-depth analyses, critically evaluate strategies, and reflect on the results of their solutions [59]. This suggests that resilience in the face of adversity is an important factor in supporting the development of mathematical critical thinking. These findings indicate that low mathematical critical thinking skills are influenced not only by cognitive factors but also by affective and motivational factors. Students with low AQ tend to stop the thinking process early when faced with difficulties, thus preventing them from reaching the stage of in-depth evaluation and drawing conclusions [60].

Qualitative research and case studies have significantly contributed to explaining mathematical critical thinking processes based on AQ levels. Through analysis of written responses and interviews, these studies have shown that students with high AQ have more structured, reflective, and flexible thinking processes than students with low AQ [61]. In synthesis, this study confirms that the development of mathematical critical thinking skills needs to be carried out in an integrated manner with strengthening Adversity. Student quotient Mathematics learning should not only focus on mastering concepts and procedures, but also be designed to foster resilience, self-confidence, and a never-give-up attitude. Thus, students are expected to be able to face mathematical challenges critically, reflectively, and sustainably.

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[58] Stoltz and Weihenmayer, *The Adversity Advantage: Turning Everyday Struggles Into Everyday Greatness*; Stoltz, *Adversity Quotient: Turning Obstacles Into Opportunities.*

[59] Almubarokah, Theis, and Iriani, "Analisis Kemampuan Berpikir Kritis Siswa Dalam Pemecahan Masalah Matematika Ditinjau Dari Adversity Quotient (AQ) Pada Materi Aritmatika Sosial"; Novinda, Latifa Irsal, and Palupi Putri, "Analisis Kemampuan Literasi Matematis Siswa Ditinjau Dari Adversity Quotient (Aq) Dan Gender."

[60] Ellermeijer and Heck, "Differences Between The Use Of Mathematical Entities In Mathematics And Physics And The Consequences For An Integrated Learning Environment"; Kaplar et al., "The Influence of Interactive Learning Materials on Solving Tasks That Require Different Types of Mathematical Reasoning"; Mickelson and Bottia, "Integrated Education and Mathematics Outcomes: A Synthesis of Social Science Research."

[61] Gong and Pang, "Profiling The Outcomes Of Academic Discourse Socialisation Through Academic Writing: AQ Methodology Study On Student Writers' Self-Reflections."

RQ1. Trends and Developments in Research on Mathematical Critical Thinking Skills and Adversity Quotient

The results of the synthesis show that research on mathematical critical thinking skills has developed earlier and more massively than research on Adversity. Quotient in mathematics learning. Early studies generally focused on measuring mathematical critical thinking skills as a cognitive learning outcome, with an emphasis on indicators of analysis, evaluation, and inference. In recent years, research trends have begun to shift toward integrating affective aspects, including Adversity. Quotient, as a factor that influences the quality of students' critical thinking processes. This development indicates a growing awareness that low mathematical critical thinking skills are not only caused by cognitive limitations, but also by students' low resilience, tenacity, and responsiveness to mathematics learning difficulties. Recent research tends to link mathematical critical thinking with non-cognitive variables such as motivation, resilience, and adversity. Quotient, either through correlational studies or qualitative approaches.

RQ2. Educational Levels That Are the Focus of the Research

Reviewed articles , research on mathematical critical thinking skills and Adversity The quotient is most commonly used at the secondary education level (middle school and high school). This level is considered strategic because students begin to encounter abstract and complex mathematical material, thus requiring higher levels of critical thinking skills and resilience in the face of learning difficulties. Research at the elementary education level is generally limited and focuses more on introducing basic critical thinking skills, while research at the higher education level is relatively limited and tends to focus on students in mathematics education programs. These findings indicate opportunities for further research, particularly at the elementary and higher education levels, to obtain a more comprehensive picture of the development of mathematical critical thinking and Adversity. Quotient throughout the education level.

RQ3. Dominant Research Methods Used

The results of the study show that quantitative research methods, especially correlational research, are the most dominant approach used to study the relationship between Adversity Quotient and critical mathematical thinking skills. This approach was chosen because it allows researchers to statistically identify the closeness of relationships

between variables in a relatively large sample. In addition, qualitative research and case studies are also widely used to describe in depth the mathematical critical thinking process of students based on the level of Adversity. Different Quotients. Experimental and quasi-experimental research is used in a more limited number, generally to test the effectiveness of certain learning models or strategies in improving mathematical critical thinking skills as well as Adversity. Quotient.

RQ4. Relationship between Adversity Mathematical Quotient and Critical Thinking Ability

Synthesis of research findings shows a consistent relationship between Adversity Mathematical Quotient and Critical Thinking Ability. Students with Adversity Level A high quotient tends to indicate better mathematical critical thinking skills, especially in the aspects of persistence in analyzing problems, evaluating solution strategies, and reflecting on the results obtained. Adversity Intelligence quotient (AQ) plays a supporting role, enabling students to persist in thought processes that require high cognitive effort. AQ indicators such as Control and Endurance are closely related to students' ability to persist, manage frustration, and continue the thought process until they reach a deeper understanding. Conversely, students with low AQ tend to stop the problem-solving process prematurely, thus limiting their critical mathematical thinking skills. Overall, these findings confirm that the development of critical mathematical thinking skills in mathematics learning needs to be accompanied by efforts to strengthen Adversity. Quotient. Integrating cognitive and affective aspects is key to creating mathematics learning that can shape critical, resilient, and reflective students.

Conclusion

This Based on the results of a systematic literature review of articles discussing mathematical critical thinking skills and Adversity Based on the mathematical quotient (QoQ) in mathematics learning, it can be concluded that students' mathematical critical thinking skills at various levels of education generally fall within the low to moderate range. This is particularly evident in students' weaknesses in analyzing non-routine problems, evaluating solution strategies, and providing logical justification and conclusions. These findings indicate that mathematical critical thinking skills have not yet developed optimally and still

require ongoing reinforcement in the learning process. This study also shows that the indicators of mathematical critical thinking skills used in mathematics education research are still diverse. The most dominant indicators refer to the critical thinking framework proposed by Ennis and Facione, which includes analysis, evaluation, inference, and conclusion-drawing skills. In addition, several studies have developed more contextual indicators according to the characteristics of the material and educational level. This diversity of indicators reflects the flexibility in measuring mathematical critical thinking skills, but also demonstrates the need for consistency and clarity in conceptual frameworks so that research results can be compared more systematically.

In the context of Adversity Quotient, most studies refer to the CORE model proposed by Stoltz, which includes Control, Origin Ownership, Reach, and Endurance. These indicators are used to describe students' resilience in facing difficulties in learning mathematics. The synthesis results show that students with the Adversity level High quotients, particularly in the control and endurance aspects, tend to indicate better mathematical critical thinking skills, particularly in terms of persistence, reflection, and flexibility of problem-solving strategies. Overall, the results of this study confirm that there is a strong relationship between mathematical critical thinking skills and Adversity. Quotient in mathematics learning. The development of mathematical critical thinking skills needs to be integrated with strengthening students' learning resilience. Therefore, it is recommended that mathematics learning not only focus on mastering procedures and final results, but also on students' thinking processes and attitudes in facing learning challenges. These findings are expected to serve as a conceptual foundation for educators and researchers in designing learning and further research oriented towards developing mathematical critical thinking skills and Adversity. Quotient holistically.

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