

Students' Mathematical Difficulties and Error Patterns in Arithmetic and Geometric Sequences and Series: A Systematic Literature Review

Syipa Lisfianisa, Jarnawi Afgani Dahlan*, Sugeng Sungkono

Program Studi Pendidikan Matematika, Fakultas Pendidikan Matematika dan Ilmu Pengetahuan Alam, Universitas Pendidikan Indonesia, Bandung, Indonesia

*Corresponding Author: jarnawi@upi.edu

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Abstract : *This study systematically examines students' mathematical difficulties and error patterns encountered in learning arithmetic sequences and series. Using a Systematic Literature Review (SLR) approach, the literature search was conducted through international databases (Scopus), supporting databases (Google Scholar), and manual searches to ensure comprehensive coverage of relevant studies. Following the stages of identification, screening, and eligibility assessment, a total of 14 relevant empirical articles were selected for analysis. Data from these articles were extracted and analyzed using thematic analysis, focusing on types of mathematical difficulties, students' error patterns, contributing factors, and remediation strategies reported in the literature. The findings indicate that students' difficulties in arithmetic sequences and series are predominantly characterized by weak conceptual understanding, difficulties in transforming contextual problems into mathematical models, and reliance on formula memorization without deep understanding. The most frequently observed error patterns include misinterpretation of problems, incorrect selection and application of formulas, procedural errors in calculations, and failure to verify solutions. The underlying causes of these difficulties are generally associated with memorization-oriented instruction, limited use of mathematical representations, and insufficient exposure to non-routine problems. These findings highlight the importance of instructional approaches that emphasize conceptual understanding, problem-solving skills, and the development of metacognitive awareness in teaching sequences and series.*

Keywords: *difficulties, error patterns, mathematical systematic literatur riview, sequence, series*

INTRODUCTION

Mathematical learning difficulties are a phenomenon that consistently emerges across various educational levels and is not limited to Students with special needs. Many students with typical academic abilities also experience obstacles in understanding mathematical concepts, including fundamental concepts such as sequences and series. These difficulties may be influenced by several factors, such as weak conceptual understanding, limitations in processing numerical information, lack of procedural accuracy, and difficulties in connecting different mathematical representations (Booth & Newton, 2012; Hwang & Riccomini, 2021). Consequently, some students experience mathematical difficulties despite having no formal diagnosis of learning disabilities.

In the context of sequences and series, mathematical difficulties are often evident in students' inability to recognize growth patterns, errors in determining subsequent terms, and misconceptions related to the general structure of a sequence, whether arithmetic or geometric. These obstacles also appear in the application of formulas for the n th term and the sum of n terms, particularly when students are required to convert verbal information into symbolic representations (Noto et al., 2019; Wijaya et al., 2022). Such difficulties not only reflect a weak understanding of basic concepts but are also associated with recurring procedural errors that indicate specific patterns in how students process information. In this study, basic conceptual

understanding of sequences and series is operationally defined as students' understanding of (1) the meaning of fundamental symbols and variables (e.g., first term, common difference or ratio, and the n th term), (2) the underlying structure and relationships between terms in arithmetic and geometric sequences, and (3) the appropriate use of operations and formulas to represent these relationships symbolically. Weaknesses in any of these aspects may lead to systematic errors, such as incorrect formula selection, misinterpretation of variables, or failure to recognize growth patterns within a sequence or series.

In mathematics education research, error analysis has become an important approach for identifying misconceptions and the roots of students' errors. This approach allows teachers and researchers to distinguish whether an error is random or represents a consistent pattern of errors (error patterns) that reflects a more fundamental lack of conceptual understanding (Hwang & Riccomini, 2021; Lewis et al., 2020). In the topic of sequences and series, error analysis helps identify whether students' mistakes arise from incorrect formula selection, misinterpretation of variables, interference between concepts, or difficulties in detecting the structure of numerical patterns.

International studies indicate that students frequently repeat the same types of errors across different contexts, such as substitution errors, mistakes in basic operations, and failures to connect information in a problem with an appropriate mathematical model (Barbieri & Booth, 2016; Newton et al., 2014). This suggests that error patterns are not only found in topics such as fractions or word problems, but also in topics generally considered routine, including sequences and series. Examining these error patterns is important for understanding how students process numerical patterns and relationships between terms in a sequence.

For the purpose of this review, conceptual, procedural, and representational difficulties are defined operationally to ensure clarity and consistency in analyzing prior studies. Previous research has classified students' mathematical errors into several interrelated categories, most commonly including conceptual, procedural, and representational difficulties. This classification is grounded in theoretical perspectives in mathematics education that emphasize the interconnected roles of conceptual understanding, procedural fluency, and representational competence in mathematical learning (Newton et al., 2014; Raghubar et al., 2009). As such, students' errors are not viewed as isolated mistakes, but as indicators of deeper cognitive difficulties in understanding, applying, and representing mathematical ideas.

In the context of sequences and series, conceptual difficulties refer to students' limited understanding of the underlying relationships between terms, such as recognizing constant change in arithmetic sequences or multiplicative growth in geometric sequences. These difficulties often manifest as confusion between arithmetic and geometric structures, misconceptions about the meaning of the n th term, or failure to identify the type of sequence correctly (Hwang & Riccomini, 2021; Raghubar et al., 2009). Procedural difficulties, on the other hand, involve errors in the selection, application, or execution of formulas. Common examples include incorrect substitution of values, misuse of formulas for the sum of terms, or applying arithmetic formulas to geometric sequences and vice versa. Such errors suggest that students may rely on memorized procedures without fully understanding the conceptual basis of the operations involved (Lewis et al., 2020). In particular, procedural difficulties in sequences and series are often characterized by students' dependence on rote memorization of formulas, which results in mechanical application and persistent errors when problem contexts vary or require deeper reasoning.

Representational difficulties arise when students struggle to translate between verbal descriptions, numerical patterns, and symbolic representations. In sequences and series problems,

this is evident when students are unable to express a verbally described pattern in symbolic form or misinterpret variables and notation in sequence formulas (Barbieri & Booth, 2016; Noto et al., 2019). Taken together, these categories provide a clear framework for understanding the cognitive processes underlying students' errors in sequences and series. The recurring nature of such errors indicates that students are not merely making computational mistakes, but are experiencing deeper difficulties in linking concepts, representations, and mathematical procedures.

Previous studies have also reported that error patterns may arise due to interference from other concepts, such as confusion between arithmetic and geometric sequences, or errors in interpreting exponential growth in the context of series. These recurring errors indicate gaps in deeper conceptual understanding (Hwang & Riccomini, 2021; Lewis et al., 2020).

Several studies employing in-depth error analysis have found that students with mathematical difficulties often rely on intuitive strategies that are inconsistent with formal mathematical principles. For example, when determining the value of the n th term, some students construct patterns manually without referring to general formulas, leading to inappropriate logical jumps. Similar errors also occur when students are asked to determine the sum of n terms or the sum of a geometric series, particularly when they do not understand the relationship among the first term, n , and the growth structure of the sequence (Barbieri & Booth, 2016; Sharpe et al., 2014).

Although numerous studies have examined students' errors in various mathematical topics such as fractions, number operations, and problem solving, research that specifically documents mathematical difficulties and error patterns in sequences and series remains very limited. Some studies address this topic only partially, without providing a comprehensive classification. Yet, sequences and series are essential concepts in secondary education and serve as a foundation for advanced topics such as functions, limits, exponential growth, and mathematical modeling.

The limitations of previous research highlight the need for a systematic study that compiles, organizes, and analyzes empirical findings related to students' learning obstacles and error patterns in sequences and series. Therefore, this study conducts a Systematic Literature Review (SLR) to provide a comprehensive overview of the most common mathematical difficulties experienced by students, recurring error patterns, and pedagogical implications that may support improvements in the quality of instruction.

To date, there has been no systematic review that specifically synthesizes findings on students' mathematical difficulties and error patterns in sequences and series. Many existing studies are general in nature or focus on specific groups, thus failing to integrate empirical evidence comprehensively. Moreover, the diversity of research foci has made the consolidation of findings related to students' errors and learning obstacles less than optimal.

Despite the growing body of empirical studies examining students' errors and learning difficulties in mathematics, research focusing specifically on sequences and series remains fragmented and largely descriptive. Existing studies often address isolated aspects of students' errors or focus on limited contexts, without providing a comprehensive synthesis grounded in established theoretical frameworks of conceptual, procedural, and representational understanding. As a result, there is a lack of integrative knowledge regarding the dominant research characteristics, the specific aspects of sequences and series that pose difficulties for students, and the recurring error patterns that emerge across studies. This gap highlights the need for a systematic literature review that synthesizes empirical findings to clarify the nature of students'

mathematical difficulties and error patterns in sequences and series and to inform instructional practice.

To address this research gap, this study aims to systematically examine and synthesize existing research related to students' mathematical difficulties and error patterns in sequences and series. Specifically, the review seeks to identify and classify the types of conceptual, procedural, and representational difficulties, as well as recurring error patterns experienced by students in understanding sequences and series. Furthermore, this study aims to derive pedagogical implications from the synthesized findings to support educators and researchers in designing more effective instructional interventions related to sequences and series.

Guided by these objectives, this review seeks to answer the following research questions: What are the characteristics and trends of research on students' mathematical difficulties and error patterns in sequences and series? Which conceptual, procedural, and representational aspects of sequences and series are most frequently identified as sources of student difficulties in existing studies? What recurring error patterns do students exhibit in understanding and solving problems involving sequences and series?

METHOD

This study employed a qualitative approach through a Systematic Literature Review (SLR). A qualitative approach was chosen because the primary aim of this study was to explore, interpret, and synthesize patterns of students' mathematical difficulties and error types in sequences and series as reported in previous studies, rather than to quantify effect sizes or test statistical relationships. Understanding students' errors requires in-depth analysis of how difficulties are conceptualized, described, and interpreted across different research contexts, which is more appropriately addressed through qualitative synthesis.

The SLR method provides a systematic and transparent procedure for identifying, selecting, critically appraising, and synthesizing relevant literature related to mathematical difficulties and error patterns. By using this approach, the study seeks to integrate diverse theoretical perspectives, research designs, and analytical frameworks to construct a comprehensive understanding of conceptual, procedural, and representational difficulties in sequences and series. This method is particularly suitable for addressing the identified research gap, namely the lack of a coherent and theoretically grounded synthesis of students' difficulties in this topic.

To operationalize this review process, the data sources consisted of scholarly articles obtained from various academic databases, namely Scopus and Google Scholar, accessed with the assistance of the Publish or Perish application. This study focused on articles published within the last ten years (2015–2025) that are relevant to research examining students' mathematical difficulties and error patterns in sequences and series.

The data collection technique used in this study was a documentation study following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, which establishes minimum standards for reporting systematic reviews. The article selection process involved predefined inclusion and exclusion criteria to determine eligible studies. Table 1 presents the inclusion and exclusion criteria used in this study.

Table 1. Inclusion and Exclusion Criteria

No	Inclusion Criteria	Exclusion Criteria
1.	Articles published within the period 2015–2025	Articles published before 2015

No	Inclusion Criteria	Exclusion Criteria
2.	Articles published in peer-reviewed academic journals	Publications in the form of bibliometric studies, systematic literature reviews (SLRs), conference papers, proceedings, books, book chapters, etc.
3.	Articles addressing mathematics education, particularly the topic of sequences and series	Articles not related to mathematics education or not discussing sequences and series
4.	Articles written in English	Articles not written in English
5.	Articles providing empirical data on mathematical difficulties or error patterns	Articles that do not present empirical contexts relevant to students' difficulties or errors
6.	Open-access articles (full text available)	Not open access

It should be acknowledged that the inclusion and exclusion criteria applied in this review may have influenced the scope of the findings. In particular, restricting the analysis to English-language and open-access articles may have led to the exclusion of relevant studies published in other languages or in subscription-based journals. Such studies could potentially provide additional perspectives shaped by different educational contexts and curricular traditions. However, these criteria were applied to ensure transparency, replicability, and full access to empirical data for qualitative synthesis. Therefore, the findings of this review should be interpreted as representing patterns identified within accessible English-language empirical literature rather than an exhaustive account of all research on students' mathematical difficulties and error patterns in sequences and series. Nevertheless, the synthesized results still provide valuable insights into dominant trends and recurring error patterns reported across diverse educational settings.

Identification

The identification stage was conducted by determining keywords, related terms, and synonyms associated with the main focus of the study, namely arithmetic sequences, arithmetic series, students' mathematical difficulties, and error patterns. The selection of keywords was based on recommendations from online thesaurus services, keywords used in previous studies in the field of mathematics education, and automated suggestion features provided by Scopus. Searches were carried out in the primary database (Scopus) and supporting database (Google Scholar) by applying advanced search techniques such as Boolean operators, phrase searching, field codes, truncation, and wildcards. This combination of techniques was employed to broaden the search coverage and minimize the loss of relevant studies. In addition to electronic database searches, manual searching (hand-searching) was conducted to identify potentially relevant studies that were not indexed or did not appear in the initial search results. This process involved screening the reference lists of selected primary studies and relevant review articles to locate additional empirical research on students' mathematical difficulties and error patterns in sequences and series. Manual searching was focused on identifying peer-reviewed journal articles that met the established inclusion criteria. Major conference proceedings were not included in this process, as the review prioritized empirical studies published in peer-reviewed journals to ensure the quality and consistency of the data synthesized.

Table 2. Keyword Identification Decisions

Objective	Main Keywords	Enrichment Keywords (Synonyms/Variations)
Identifying students' difficulties and errors in	Sequences series	sequence, arithmetic, geometry series, arithmetic, geometry

Objective	Main Keywords	Enrichment Keywords (Synonyms/Variations)
arithmetic sequences and series	Student's difficulties	mathematical difficulties, learning difficulties, conceptual (sequence and series) difficulties
	Error patterns	students' errors, error analysis, misconceptions, procedural errors

Table 3. Search Strings Used in the Databases

Database	Search String
Scopus	TITLE-ABS-KEY "SEQUENCE AND SERIES"
Google Scholar	TITLE-ABS-KEY "SEQUENCE AND SERIES"

Screening

From the search process conducted through Scopus, Google Scholar, and hand-searching, a total of 213 records were identified (Scopus = 100; Google Scholar = 113). After removing duplicate entries ($n = 16$), 197 records remained for title and abstract screening. At this stage, the application of the initial criteria resulted in the exclusion of 20 articles because they did not address mathematics education. Subsequently, 177 records were recorded as reports sought for retrieval to verify the availability and eligibility of the full texts. At this stage, 18 documents were found to be inaccessible and therefore could not proceed to the eligibility stage. As a result, 159 articles that met the criteria were successfully downloaded and evaluated at the eligibility stage.

Eligibility

The eligibility stage represents the third step in the systematic search process, during which researchers assess the suitability of the remaining articles after screening. At this stage, the researchers reviewed the titles and abstracts of the articles that passed the initial screening to ensure their alignment with the research focus. When the information provided in the abstracts was insufficient to determine relevance, the researchers proceeded to examine the full texts in greater depth. This process aimed to exclude articles that did not meet the criteria, such as those not written in English, not published as journal articles, or not addressing students' mathematical difficulties or error patterns in sequences and series. In addition, articles that discussed mathematical errors only in a general sense without a specific focus on sequences and series were also eliminated.

The results of the eligibility stage yielded 14 articles deemed suitable for further analysis and selected as the primary sources for this study. The complete procedure of identification, screening, eligibility, and final inclusion of articles is presented in detail through the PRISMA flow diagram in Figure 1.

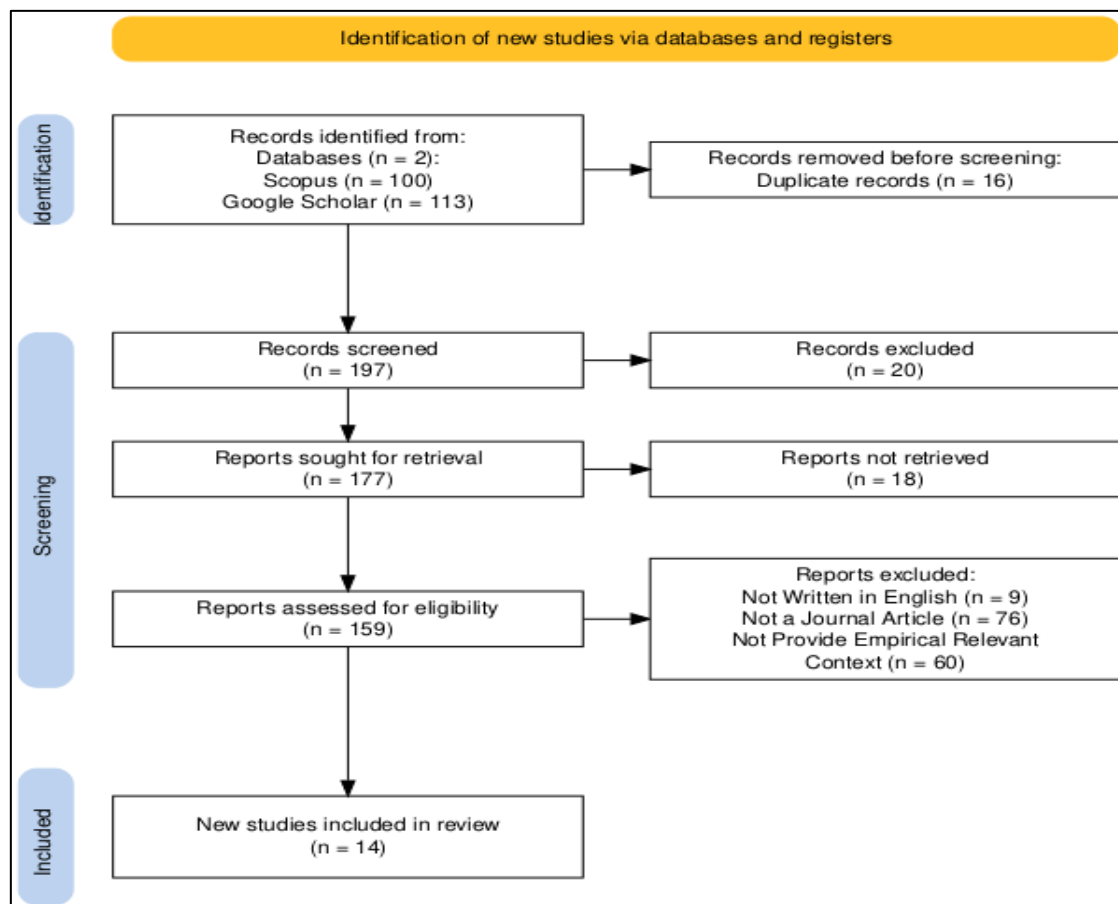


Figure 1. Flowchart of the selection process of materials to be reviewed

A total of 14 articles that passed the eligibility stage were then analyzed further using a qualitative approach. At this stage, the first step undertaken by the researchers was to carefully review all selected articles, particularly the abstracts, results, and discussion sections that contained information related to mathematical difficulties and error patterns in sequences and series.

Data directly related to the research questions namely, types of learning difficulties, forms of error patterns, factors contributing to these difficulties, and strategies used in previous studies to address conceptual errors were collected, summarized, and evaluated.

Subsequently, the researchers conducted a thematic analysis of the summarized data. This analytical process included:

1. Identifying themes and subthemes emerging from the articles,
2. Noting similarities and differences in findings across studies,
3. Categorizing forms of students' difficulties and errors,
4. Detecting recurring patterns, and
5. Analyzing relationships among themes, such as the relationships between misconceptions, limited conceptual understanding, procedural errors, or errors in applying formulas for sequences and series.

As explained by Clarke & Braun (2013), thematic analysis aims to identify and examine key elements of the data, using the research questions as the primary guiding framework. The final stage involved synthesizing the findings and presenting them in a structured manner. The results of this synthesis are presented in the results and discussion sections, including a summary

of difficulty patterns, types of error patterns, contributing factors, and the implications of the findings for the teaching and learning of sequences and series.

RESULTS AND DISCUSSION

After completing the identification, screening, and eligibility assessment processes, 14 articles met the inclusion criteria and were included in the final analysis. The selected studies represent various educational levels vocational high school (SMK), senior high school (SMA/MA), and higher education and employ qualitative, quantitative, and mixed research approaches.

To enhance clarity and analytical coherence, the findings were synthesized and organized into three major categories of mathematical difficulties and error patterns, namely conceptual difficulties, procedural errors, and metacognitive errors, which consistently emerged across the reviewed studies. Table 4 provides a structured overview of the analyzed articles, including authors, year of publication, educational level, research method, research focus, dominant types of difficulties, and identified error patterns related to sequences and series.

Note that Newman's Error Analysis (NEA) classifies students' errors into five stages: reading, comprehension, transformation, process skills, and encoding. Polya's problem-solving stages consist of understanding the problem, devising a plan, carrying out the plan, and looking back.

Table 4. Summary of Students' Difficulties and Error Patterns in Sequences and Series

Author(s) & Year	Title	Level	Method	Focus	Mathematical Difficulties	Error Patterns
Putri & Hastari (2022)	<i>Analysis of Student Errors in Solving HOTS-Type Sequence and Series Problems Based on Newman Error Analysis</i>	Vocational High School (SMK)	Qualitative	Analyzing students' errors in HOTS-type sequence and series problems using Newman's stages	Difficulties reading terms, symbols, and key information in HOTS problems; difficulties understanding given and asked information; difficulties transforming verbal information into mathematical models; difficulties performing calculations with large numbers and variables; lack of accuracy, rushing, and failure to recheck; weak understanding of arithmetic and geometric sequences and series	Reading error (T1): inability to read or recognize problem information; Comprehension error (T2): failure to state given/asked information; Transformation error (T3): incorrect formulation of models/formulas; Process skill error (T4): computational errors or incomplete procedures; Encoding error (T5): incorrect notation (e.g., $\times$ written as +), omission of units or conclusions

Darmayanti et al (2022)	<i>Analysis of Students' Adaptive Reasoning Ability in Solving HOTS Problems on Arithmetic Sequences and Series in Terms of Learning Style</i>	Senior High School (SMA)	Qualitative	Arithmetic sequences and series (HOTS problems)	Difficulties in deep conceptual understanding; weak adaptive reasoning; limited prior knowledge; difficulty linking problem information with mathematical concepts; difficulty identifying patterns and generalizations; limited ability to look back, especially among accommodator and diverger learning styles	Errors at Polya's stages: misunderstanding the problem; inappropriate or incomplete planning; errors in execution (substitution and procedures); failure to look back; error patterns vary by learning style
Qolbi et al (2022)	<i>Analysis of Students' Mathematical Understanding on Arithmetic Sequences and Series in 12th Grade Senior High School</i>	Senior High School (SMA)	Quantitative	Students' understanding in solving arithmetic sequence and series problems	Difficulties understanding concepts; incorrect solution steps; lack of accuracy in calculations; difficulties with non-routine/UTBK problems; ineffective learning processes	Procedural errors in determining solution steps; formula substitution errors in complex problems; logical errors in UTBK items; errors due to carelessness
Muliyana et al (2024)	<i>Analysis of Teaching Material Needs for Sequences and Series to Improve SMA/MA Students' Mathematical Problem-Solving Capability</i>	Senior High School (SMA/MA)	Qualitative	Needs analysis of teaching materials for sequences and series	Conceptual difficulties due to non-contextual materials; rote learning; overly brief explanations; lack of examples and practice (routine and non-routine); dependence on teacher explanations; low student engagement	Errors in contextual problem solving; procedural errors from using formulas without conceptual understanding; computational and accuracy errors; inability to apply concepts to non-routine problems

Agustiani (2021)	<i>Analyzing Students' Errors in Solving Sequence and Series Application Problems Using Newman Procedure</i>	Higher Education	Qualitative	Error analysis in application problems of sequences and series	Difficulties understanding application contexts; difficulty transforming verbal problems into mathematical forms; weak process skills in calculation; inability to write correct final answers due to early-stage errors	Newman's errors: reading (8.9%), comprehension (18.9%), transformation (32.2%), process skills/calculation (42.2%), encoding/final answer (43.3%)
Magfiroh et al (2024)	<i>Learning Obstacle of Students in Geometrical Sequence and Series</i>	Senior High School (SMA)	Qualitative	Identifying learning obstacles in geometric sequences and series	Ontogenetic obstacles (lack of basic understanding); didactical obstacles (preference for manual methods over formulas); epistemological obstacles (difficulty with unfamiliar contexts)	Conceptual errors in determining ratio and nth term; misuse or avoidance of geometric series formulas; inability to adapt concepts to non-routine or unfamiliar problems
Resiyana et al (2023)	<i>Mathematical Problem-Solving Ability in Solving Sequence and Series Problems Using Polya Stages</i>	Senior High School (SMA)	Qualitative	Problem-solving ability using Polya's stages	Moderate-ability students misidentify what is asked; low-ability students struggle with reflection and evaluation (re-checking) and experience cognitive fatigue	Incomplete Polya stages (especially omission of looking back); misidentification of information; repeated attempts due to misinterpretation; procedural inaccuracy among moderate and low achievers
Irawati et al (2022)	<i>Mathematical Representation of High School Students in Understanding the Concept of Arithmetic Sequences and Series</i>	Senior High School (SMA)	Qualitative	Students' mathematical representations	Difficulty linking concepts to appropriate representations; inability to relate nth term and sum of n terms; incomplete conceptual understanding; lack of visual representations; dominance of verbal/symbolic forms without flexibility	Conceptual errors in formulas for nth term and sum; failure to build appropriate models; incomplete or incoherent representations; transformation errors from word problems; incomplete solutions

Iswara et al (2021)	<i>Students' Critical Thinking Skills in Solving on the Topic of Sequences and Series</i>	Senior High School (SMA)	Qualitative	Critical thinking in online learning	Difficulty analyzing information; limited evaluation of strategies; difficulty linking concepts with logical steps; moderate critical thinking level (56.92%)	Errors in strategy formulation; incomplete answers; logical reasoning errors; failure to evaluate and verify results; errors in planning and checking stages
Risnawati et al (2023)	<i>Students' Mathematical Problem-Solving Ability Based on the Level of Learning Outcomes on Sequence and Series</i>	Senior High School (SMA)	Qualitative	Problem-solving ability by achievement level	Conceptual and formula-selection difficulties (low achievers); procedural and arithmetic errors (moderate); metacognitive difficulties—no rechecking (high achievers)	Misinterpretation error; formula selection error; procedural error; guessing strategy error; verification omission; non-routine problem error
Rachma & Rosjanuardi (2021)	<i>Students' Obstacles in Learning Sequence and Series Using Onto-Semiotic Approach</i>	Senior High School (SMA)	Qualitative	Learning obstacles in sequences and series	Conceptual, ontogenetic, and didactical difficulties in understanding meaning	Concept definition error; semiotic misinterpretation; model–procedure disconnect; procedural confusion
Lorenza et al (2024)	<i>Students' Specializing Thinking in Solving Arithmetic Sequence and Series Problems</i>	Senior High School (SMA)	Qualitative	Specializing thinking via schematic representations	Difficulty connecting specific information to generalization	Representation errors (implicit and explicit) in modeling problem situations
Mailizar et al (2024)	<i>Students' Achievement and E-Learning Acceptance in Remedial Mathematics: A Case on Sequences and Series</i>	Senior High School (SMA)	Quantitative	Effectiveness of e-learning–based remedial instruction	Conceptual and procedural difficulties indicated by low pre-test scores	Error patterns not analyzed per item; inferred from low initial achievement and significant pre–post differences
Winarso et al (2022)	<i>Type of Error in Completing Mathematical Problems Based on Newman's Error Analysis (NEA) and Polya Theory</i>	Senior High School (SMA)	Qualitative	Error types based on NEA and Polya	Difficulty distinguishing sequences and series; misunderstanding compound interest; weak conceptual and procedural understanding; lack of calculation accuracy	NEA: reading (1%), comprehension (0%), transformation (3%), process skills (5%), encoding (7%); Polya: understanding (31%), planning (11%), execution (9%), looking back (33%)

A cross-study synthesis indicates that conceptual difficulties were the most dominant type of difficulty reported across all educational levels, particularly at the senior high school (SMA/MA) level. These difficulties mainly involved students' inability to distinguish between arithmetic and geometric sequences, misunderstandings of the n th term and the sum of n terms, and weak comprehension of application contexts such as compound interest and growth problems. Studies conducted at the vocational high school (SMK) and higher education levels also reported similar conceptual challenges, especially in contextual and non-routine tasks.

Procedural errors were frequently reported as a consequence of these conceptual weaknesses. Across most studies, students demonstrated difficulties in selecting appropriate formulas, substituting values correctly, and executing solution steps in a logical sequence. Although procedural errors appeared at all educational levels, they were more explicitly documented in studies employing Newman's Error Analysis and Polya's problem-solving framework. Quantitative evidence from several studies further showed that transformation and process skill errors accounted for a relatively high proportion of total errors.

Metacognitive errors, particularly the omission of the "looking back" or solution verification stage, were consistently reported but with lower explicit frequency compared to conceptual and procedural errors. These errors were more prominent among students with moderate and high achievement levels, indicating that failure to recheck solutions is not solely associated with low academic performance. Overall, the qualitative synthesis suggests that errors at the understanding and transformation stages occur most frequently, while encoding errors tend to appear least often and are usually the result of undetected errors in earlier stages. To clarify the distribution and relative frequency of errors identified across the reviewed studies, Table 5 summarizes the qualitative frequency and typical characteristics of errors at each problem-solving stage.

Table 5. Qualitative Distribution of Students' Errors Across Problem-Solving Stages in Sequences and Series

Problem-Solving Stage	Frequency Across Studies	Typical Error Characteristics
Understanding	Frequently reported	Misinterpreting problem, misidentifying sequence type
Transformation	Commonly reported	Incorrect formula selection, faulty modeling
Process Skills	Occasionally reported	Substitution and computational errors
Encoding	Rarely reported	Incorrect notation, failure to conclude

Based on the results presented in Table 4, the reviewed articles originate from various educational contexts, with a predominance of studies conducted at the senior high school level (SMA/MA) and vocational high schools (SMK), and a smaller number focusing on first-year university students. In terms of methodology, most studies employed a descriptive qualitative approach, while several others adopted quantitative approaches or mixed methods. The primary focus of these studies was to reveal students' mathematical difficulties and error patterns in understanding and solving sequences and series problems, including routine, non-routine, contextual, and Higher Order Thinking Skills (HOTS) tasks.

The findings indicate that students' mathematical difficulties in sequences and series are complex and interrelated. Conceptual difficulties emerged as the most dominant issue, characterized by students' inability to distinguish between sequences and series, understand the meaning of the n th term and the sum of n terms, and correctly determine the common difference or common ratio. In addition, students experienced difficulties in understanding applied concepts

such as compound interest and growth, which require a deep understanding of sequences and series. These conceptual difficulties were not limited to low-achieving students but were also observed among students with moderate and high achievement, particularly when dealing with non-routine and contextual problems. These findings are consistent with recent studies in mathematics education which emphasize that students' difficulties in sequences and series primarily stem from weak conceptual understanding rather than procedural shortcomings (Lewis et al., 2020; Wijaya et al., 2022).

Beyond conceptual difficulties, students also encountered challenges in mathematical transformation and representation. Many studies reported that students struggled to convert verbal problems into appropriate mathematical models and were unable to build coherent connections among verbal, symbolic, and mathematical representations. Students tended to rely on a single type of representation and lacked flexibility in using alternative representations that could otherwise support problem-solving processes. These representational difficulties may be attributed to instructional practices that emphasize formula application over the exploration and coordination of multiple representations. As a consequence, errors in constructing mathematical models often triggered subsequent errors in later stages of problem solving. Similar representational difficulties have also been reported in studies published in *Mathematics Education Media*, which highlight that students' inability to coordinate verbal, symbolic, and graphical representations often leads to systematic errors in problem modeling and solution planning.

Procedural and arithmetic difficulties were also consistently identified across studies. These included errors in selecting formulas, incorrect substitution of values, arithmetic calculation errors, and incomplete or non-sequential solution steps that ended before reaching a final answer. Importantly, these procedural errors were rarely isolated; rather, they frequently emerged as a consequence of earlier conceptual misunderstandings and representational failures. Many students relied on rote memorization of formulas without understanding their underlying meaning or contextual applicability, which increased the likelihood of procedural breakdowns in non-routine problems.

From a metacognitive perspective, most students did not engage in rechecking their solutions. The reflection or "looking back" stage, as proposed in George Pólya's problem-solving framework, was frequently neglected across different ability levels. As a result, students failed to detect errors made in earlier stages, leading to final answers that still contained conceptual and procedural inaccuracies. This tendency aligns with previous findings indicating that insufficient emphasis on metacognitive regulation during instruction contributes to students' limited ability to monitor, evaluate, and revise their solutions, particularly in multi-step problems such as sequences and series (Hwang & Riccomini, 2021; Newton et al., 2014; Rahmawati et al., 2025).

In addition to Polya's problem-solving framework, several studies in this review employed Newman's Error Analysis as a diagnostic tool to identify students' errors in a more detailed and sequential manner. Newman's Error Analysis classifies errors into five stages: reading errors, which occur when students fail to correctly read mathematical symbols or information; comprehension errors, which arise when students misunderstand what is given or required; transformation errors, which involve difficulties in translating verbal problems into appropriate mathematical models; process skill errors, which refer to mistakes in executing procedures or calculations; and encoding errors, which occur when students fail to express final answers correctly, including errors in notation or conclusions. This framework highlights that errors at later stages often originate from failures at earlier stages, making it particularly useful

for tracing how conceptual misunderstandings develop into procedural and final-answer errors in sequences and series problems.

Further analysis indicates that students' ability levels influenced the types of errors observed. Students with lower achievement levels predominantly exhibited conceptual and comprehension errors, such as misidentifying sequence types or misunderstanding given information. Students with moderate achievement levels more frequently demonstrated procedural and transformation errors, including incorrect formula selection and flawed execution of solution steps. Meanwhile, higher-achieving students, although generally able to apply correct procedures, often displayed metacognitive errors, particularly failing to recheck solutions or evaluate the reasonableness of final answers. This pattern suggests that increased procedural fluency does not necessarily correspond to stronger metacognitive awareness.

Overall, the findings of this review confirm that mathematical difficulties and error patterns in sequences and series are systemic and recurring, with conceptual difficulties serving as the primary underlying cause. The dominance of transformation, procedural, and metacognitive errors suggests that instruction in sequences and series still tends to emphasize procedural execution and formula memorization rather than conceptual understanding, representational fluency, and reflective thinking. Therefore, the pedagogical implications of this review highlight the importance of instruction oriented toward strengthening conceptual understanding, developing representational and problem-solving skills, and fostering habits of reflection and answer verification. Instructional approaches that integrate contextual and non-routine problems, as well as explicit error analysis, are expected to help reduce students' difficulties and recurring error patterns in learning sequences and series more meaningfully.

CONCLUSIONS AND SUGGESTIONS

Based on a systematic analysis of 14 articles that met the inclusion criteria, several conclusions can be drawn in direct relation to the research questions of this study. With respect to RQ1, which concerns the characteristics and trends of research on students' mathematical difficulties and error patterns in sequences and series, the findings indicate that existing studies are predominantly qualitative in nature. Most research has been conducted at the senior high school (SMA/MA) and vocational high school (SMK) levels, with relatively limited attention given to other educational levels. The primary research focus across studies is the analysis of students' errors in solving sequences and series problems, including routine, non-routine, contextual, and Higher Order Thinking Skills (HOTS) tasks, using frameworks such as Newman's Error Analysis and Polya's problem-solving stages.

In response to RQ2, which examines the conceptual, procedural, and representational aspects that most frequently cause student difficulties, the synthesis reveals that conceptual difficulties are the most dominant. Students commonly struggle to understand the fundamental concepts of sequences and series, such as distinguishing between arithmetic and geometric structures, interpreting the meaning of the n th term and the sum of n terms, and identifying common differences or ratios. Procedural difficulties, including incorrect formula selection and substitution errors, and representational difficulties, particularly in transforming verbal problems into mathematical models, were also consistently reported. These difficulties are often interconnected and tend to intensify in non-routine and contextual problem situations.

Regarding RQ3, which addresses recurring error patterns in solving sequences and series problems, the reviewed studies show relatively consistent patterns across contexts. Based on Newman's Error Analysis, common errors include reading, comprehension, transformation,

process skill, and encoding errors. Meanwhile, from the perspective of Polya's problem-solving stages, errors most frequently occur during the stages of understanding the problem and looking back. These patterns indicate that students' errors are not solely procedural but also reflect deeper conceptual misunderstandings and limited metacognitive awareness, particularly in monitoring and evaluating solution processes.

Based on these conclusions, several recommendations can be proposed. For educators, instruction in sequences and series should place greater emphasis on strengthening conceptual understanding, developing representational fluency, and fostering metacognitive habits such as rechecking and reflecting on solutions. Learning activities should move beyond formula memorization and encourage reasoning, model construction, and interpretation of problem contexts. For future researchers, it is recommended to design and evaluate instructional interventions that explicitly target students' conceptual, representational, and metacognitive difficulties, as well as to extend research to diverse educational levels and learning contexts to provide a more comprehensive understanding of students' mathematical difficulties and error patterns in sequences and series.

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