



AN ANALYSIS OF FIRST YEAR STUDENTS' ERRORS IN SOLVING MATHEMATICAL LOGIC PROBLEMS BASED ON NEWMAN'S PROCEDURE IN THE INFORMATION SYSTEMS PROGRAM

ANALISIS KESALAHAN MAHASISWA TINGKAT PERTAMA DALAM MENYELESAIKAN SOAL LOGIKA MATEMATIKA BERDASARKAN PROSEDUR NEWMAN PADA PROGRAM SISTEM INFORMASI

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Abstract

The identification of error types based on Newman's Procedure includes reading, comprehension, transformation, process skills, and answer encoding. The objective of this study is to describe the analysis of students' errors in solving mathematical logic problems based on Newman's Procedure. This research adopts a descriptive qualitative approach involving first year students enrolled in the mathematical logic course within the Information Systems program. Data were collected through a diagnostic test administered to three students representing different levels of academic ability: one low ability student, one moderate ability student, and one high ability student. Students' ability levels were measured based on tests covering compound propositional logic and logical operations. Data analysis was conducted by classifying errors at each stage of Newman's Procedure, tracing the underlying factors contributing to these errors, and relating them to students' logical reasoning abilities. Accordingly, the research method employed in this study is descriptive qualitative research. The resulting error classifications were subsequently used by lecturers as a basis for recommending improvements in instructional strategies. The results indicate that students with low ability made errors across all stages from K1 to K5, students with moderate ability tended to make errors at the case exploration and process skills stages, while students with high ability were able to complete all stages systematically and consistently. These findings confirm that the Newman Procedure is effective in mapping students' thinking errors. Therefore, the implementation of differentiated learning strategies that emphasize problem comprehension, case exploration, and logical verification is recommended to enhance students' reasoning abilities.

Keywords : Newman's Errors; Mathematical Logic; Students First Year; Information System.



Abstrak

Identifikasi jenis kesalahan berdasarkan prosedur Newman meliputi membaca, memahami, mentransformasi, keterampilan proses, dan penulisan jawaban. Tujuan penelitian yang akan dicapai adalah mendeskripsikan analisis kesalahan mahasiswa dalam menyelesaikan soal-soal logika matematika berdasarkan Prosedur Newman. Pendekatan penelitian menggunakan metode deskriptif kualitatif dengan melibatkan mahasiswa tingkat pertama yang menempuh mata kuliah logika matematika pada program studi sistem informasi. Data dikumpulkan melalui tes diagnostik yang diberikan kepada 1 mahasiswa dengan kemampuan rendah, 1 mahasiswa dengan kemampuan sedang, dan 1 mahasiswa dengan kemampuan tinggi. Tingkat kemampuan mahasiswa diukur dari uji soal logika pernyataan majemuk dan operasi pernyataan. Analisis terhadap data dilakukan dengan mengklasifikasikan kesalahan pada setiap tahap Newman, menelusuri faktor penyebabnya, serta mengaitkannya dengan kemampuan penalaran logis mahasiswa. Oleh karena itu, metode penelitian yang digunakan adalah penelitian kualitatif deskriptif. Temuan klasifikasi kemudian digunakan oleh dosen sebagai dasar rekomendasi perbaikan strategi pembelajaran. Hasil penelitian menunjukkan bahwa mahasiswa dengan kemampuan rendah mengalami kesalahan pada seluruh tahapan K1 hingga K5, mahasiswa dengan kemampuan sedang cenderung mengalami kesalahan pada tahap eksplorasi kasus dan keterampilan proses, sedangkan mahasiswa dengan kemampuan tinggi mampu menyelesaikan seluruh tahapan secara sistematis dan konsisten. Temuan ini menegaskan bahwa Prosedur Newman efektif dalam memetakan kesalahan berpikir mahasiswa. Oleh karena itu, direkomendasikan penerapan strategi pembelajaran diferensiatif yang menekankan pemahaman soal, eksplorasi kasus, dan verifikasi logis untuk meningkatkan kemampuan penalaran mahasiswa.

Kata Kunci : Kesalahan Newman; Logika Matematika; Mahasiswa Tingkat Pertama; Sistem Informasi.

1. INTRODUCTION

Mathematical logic is a fundamental subject in higher education that underpins formal reasoning, programming, and algorithm design. Mathematical logic is studied by first year students in the Information Systems program at Sekolah Tinggi Teknologi Bontang. This topic constitutes one of the core materials in the Discrete Mathematics course, which carries a credit weight of three theoretical credits and does not include practicum activities. At the senior high school and vocational school levels, mathematical logic is introduced to students, particularly in Grade 11. This indicates that first year university students have acquired basic prior knowledge from their previous educational levels. Therefore, students entering higher education are expected to possess sufficient initial readiness to understand mathematical logic at the university level.

Mathematical logic plays a crucial role in developing students' logical thinking skills and serves as a foundation for evaluating the validity of procedures in a scientific manner. In cognitive activities, language functions as an essential supporting tool for reasoning (Buyung & Burhanuddin, 2023). Logical reasoning is central to computational thinking; thus, both conceptual and operational understanding must be emphasized in its instruction (Bacelo & G'omez-Chac'on, 2023). However, empirical studies on conceptual and operational understanding reveal that students often require non verbal communication, such as gestures, to support comprehension (Elvierayani, Rivatul Ridho Hanifah, Ayu Ismi Sustyorini, Emalia Nova Fahruziah, 2024). Other findings indicate that students' creative thinking skills remain



relatively low (Wijaya, Ariska Juwita Pujiastuti, Heni Hendrayana, 2022) and that at various educational levels, both male and female students demonstrate only modest development in mathematical logic skills (Vera-zambrano & Reyes-meza, 2022).

Despite having prior exposure to mathematical logic, students' initial knowledge has not yet functioned optimally as a foundational basis for solving logic related problems. Students experience conceptual difficulties and exhibit limited operational abilities when dealing with problems that require language interpretation, symbolic transformation, and multi-step reasoning. In the context of higher education learning, students often struggle to connect previously learned logical concepts with systematic and consistent problem solving procedures. This condition indicates a gap between students' mastery of basic mathematical logic concepts and their ability to apply these concepts appropriately to given problems.

The difficulties encountered by students lead to the emergence of errors in problem-solving processes. Therefore, these errors need to be identified systematically to ensure that the instructional support provided is appropriate and effective in addressing students' learning difficulties. In identifying such errors, Newman's Error Analysis Procedure consists of five essential stages: reading, comprehension, transformation, process skills, and encoding. Previous studies implementing Newman's procedure have identified various issues, including students' confusion regarding the formulas used and their tendency to rush in writing final answers (Natalia et al., 2023), students' inability to read problems carefully (Hidayanto & Lisrahmat, 2023), incomplete written solutions (Ningsi et al., 2022) and solutions that are incomplete and inaccurate (Arsandy et al., 2025).

Error identification analysis in this study encompasses both students' final answers and their problem solving processes. Errors identified in these processes and outcomes are subsequently classified and structured into specific patterns based on Newman's procedure. Newman's procedure provides a systematic and structured framework for identifying types of student errors, ranging from reading and comprehension errors to transformation, process skills, and final answer encoding errors. By recognizing the patterns of errors experienced by students at each stage, lecturers can gain deeper insights into the sources and underlying causes of learning difficulties. This information serves as a basis for selecting appropriate instructional strategies, improving teaching methods, and designing targeted interventions to enhance students' understanding and problem solving abilities. In other words, identifying students' errors enables instructors to refine learning practices that emphasize conceptual understanding (Sambo & Makgakga, 2025) and to develop more effective instructional strategies (Siti et al., 2024).

These research findings provide a strong rationale for employing Newman's Procedure as the analytical framework in this study. The procedure allows for systematic tracing of error sources and facilitates the formulation of more focused instructional strategies and scaffolding recommendations. Newman's Procedure also helps students recognize their own mistakes and minimize recurring errors (Rusli et al., 2024). Furthermore, it can be used to identify student errors from the perspective of learning styles (Ulfa & Zuhri, 2023). Considering the strategic



role of mathematical logic in shaping computational thinking skills, an indepth analysis of student errors is essential to prevent the accumulation of misconceptions in subsequent courses. Through the application of Newman's Procedure, this study aims to reduce conceptual, procedural, and operational errors. Accordingly, this research focuses on analyzing students' errors in mathematical logic using Newman's framework and exploring the factors underlying each error category to formulate effective instructional improvement strategies.

2. RESEARCH METHOD

Descriptive qualitative research is a type of research in which the formulation of hypotheses is not required to verify a particular truth (Subandi, 2011). Descriptive research focuses primarily on portraying situations and behaviors through direct observation of the research objects or data sources (Natalia et al., 2023). Referring to these definitions, the research method employed in this study is descriptive qualitative research. This choice is made because the primary objective of the study is to describe the classification of students' errors based on Newman's procedure in solving mathematical logic problems. Therefore, this study does not aim to test or validate any hypothesis. The subjects of this study consisted of three students with different levels of academic ability, namely one student with low ability is M1, one with moderate ability is M2, and one with high ability is M3. The classification of students' ability levels was determined based on the results of a compound logic test and its operations, as well as the lecturer's observations during the teaching of the Discrete Mathematics course. The data collection techniques used in this study were tests and interviews. The researcher administered the same essay type questions related to mathematical logic to all three research subjects. Data analysis was conducted using the Miles and Huberman data analysis model, which consists of data reduction, data display, and conclusion drawing (Wardana et al., 2020). Prior to administering the test to the students, the researcher developed a set of coded stages representing the problem solving process. These stages are presented in the form of a table 1.

Tabel 1 Codes of Problem-Solving Stages and Thinking Processes

No	Error Identification	Deskripsi of Problem-Solving Thinking	Thinking Code
1	Reading Error	Identifying all given information and determining what is being asked	K1
2	Comprehension Error	Representing all given information in symbolic form	K2
3	Transformation Error	Presenting predictions of various possible cases	K3
4	Process Skill Error	Examining each case and identifying contradictions with one of the four statements	K4
5	Encoding Error	Determining the correctness of the final answer	K5



3. RESULT AND DISCUSSION

The mathematical logic problem administered in this study falls into the category of reasoning based questions. The problem referred to is as follows:

Budi is a prospective undergraduate student who is going to enroll in a university. Each prospective student is required to choose exactly one academic program. The university offers three study programs: Digital Business, Informatics, and Information Systems.

The following logical statements are given:

1. *Budi chooses exactly one study program from the three available programs.*
2. *If Budi chooses Informatics and does not choose Information Systems, then he also chooses Digital Business.*
3. *The following statement is true:
(Budi chooses Information Systems and Digital Business) or (Budi does not choose Informatics).*
2. *If Budi chooses Digital Business, then Budi chooses Informatics.*

Determine which study program is chosen by Budi based on all the statements above. Provide a logical justification for your answer!

Each research subject, namely M1, M2, and M3, was given the same problem and instructed to complete it. The problem solving processes of M1, M2, and M3 were conducted within the same time frame and under close supervision. The solutions produced by each subject were then subjected to an in-depth analysis to identify errors in accordance with Newman's Procedure. In identifying errors based on Newman's Procedure, the researcher employed a set of problem solving thinking codes, namely K1, K2, K3, K4, and K5, representing the respective stages of the procedure. Based on the results of this analysis, the research team subsequently conducted unstructured interviews with all three subjects. The purpose of these interviews was to obtain a detailed understanding of the reasoning steps and decision making processes adopted by the students in solving the given problem.

a. Achievement of Problem Solving Performance by M1

Subject M1 is a first year student categorized as having a low level of academic ability. The student's ability level was determined based on the initial score obtained from solving the given mathematical logic problems. During the study, subject M1 was assigned a reasoning-type problem. The student initially read the problem and attempted to understand it in order to identify essential information. At the early stage, subject M1 appeared confused about the appropriate steps required to solve the problem. Observing this condition, the lecturer provided guidance to help identify which information in the problem should be considered important. At stage K1, subject M1 failed to identify all the given information and did not clearly understand what was being asked in the problem. This condition indicates a weakness in mathematical reading ability and initial problem comprehension. Reading errors have been identified as a dominant factor contributing to failure in solving reasoning-based problems (Hidayanto & Lisrahmat, 2023).



The difficulties experienced by subject M1 at stage K1 directly affected performance at stage K2, which involves illustrating the given information in symbolic form. Subject M1 was unable to accurately and consistently transform verbal statements into mathematical logic symbols. The symbolic representations used were either incorrect or incomplete, preventing the construction of logical relationships among statements. This finding is consistent with previous studies indicating that limited symbolic transformation ability hinders students from continuing the reasoning process systematically (Ningsi et al., 2022).

Stage K3 focuses on constructing and predicting various possible cases. At this stage, subject M1 did not demonstrate a structured attempt to develop logical possibilities. Instead, the student tended to move directly toward a conclusion without considering relevant alternative cases. This behavior reflects weak deductive and inductive reasoning skills, as well as insufficient understanding of case exploration strategies in mathematical logic. This result supports findings that low ability students often skip the case exploration stage and proceed directly to a final answer without adequate control (Natalia et al., 2023). At stage K4, subject M1 did not investigate each case to identify contradictions with the given statements. The student failed to demonstrate the ability to test logical consistency among statements, resulting in the absence of a verification process. This inability indicates weak process skills and a low level of hierarchical logical thinking. This finding further strengthens prior research showing that failure at the process skills stage directly leads to recurring conceptual errors (Sambo & Makgakga, 2025). As a consequence of errors occurring from stages K1 through K4, subject M1 produced an incorrect final answer at stage K5. The written response was not supported by logical reasoning and did not reflect a coherent thinking process. These findings indicate that the errors made by subject M1 were systemic and interrelated across stages. Therefore, subject M1 requires instructional intervention that emphasizes strengthening basic conceptual understanding, practicing meaningful problem reading, and fostering step by step logical reasoning habits.

b. Achievement of Problem Solving Performance by M2

Subject M2 is a first year student classified as having a moderate level of ability, as indicated by the assessment results obtained from the given mathematical logic problems. During the research implementation, subject M2 was provided with the same reasoning-based problem as subject M1. At stage K1, M2 was able to identify most of the given information and understand the objective of the problem, although several pieces of information were not examined thoroughly. This indicates that M2 possesses basic reading and comprehension skills in mathematical logic, but these skills have not yet reached an optimal level. At stage K2, M2 was able to illustrate the statements in the problem into logical symbols with sufficient accuracy. The symbolic representations used were generally aligned with the correct logical structure. Nevertheless, inconsistencies in the use of symbols and logical operators were still observed. This finding suggests that M2 has acquired foundational conceptual understanding but still requires reinforcement in terms of accuracy and consistency in symbolic representation. This result supports previous findings indicating that students require



continuous reinforcement to improve symbolic representation skills (Elvierayani, Rivatul Ridho Hanifah, Ayu Ismi Sustyorini, Emalia Nova Fahruziah, 2024).

Although subject M2 successfully completed stages K1 and K2, errors emerged at stage K3. These errors were evident in M2's inability to present all possible cases that could occur. The student considered only a limited number of logical alternatives while neglecting others, resulting in an incomplete reasoning process. This condition is consistent with the findings of Wijaya et al. (2022), which state that students' creative and exploratory thinking abilities remain relatively low, thereby limiting their capacity to construct diverse solution possibilities. At stage K4, subject M2 conducted investigations of several cases; however, the analysis was not comprehensive. The student did not consistently examine each case to identify contradictions with the given statements. This limitation indicates that M2 continues to experience difficulties in applying process skills in a systematic and meticulous manner. This finding reinforces the results reported by Natalia et al. (2023), which revealed that students with moderate ability tend to rush through the verification process. At stage K5, M2 was able to produce a final answer; however, the response was not entirely correct or was insufficiently supported by strong logical arguments. The error at this final stage represents an accumulation of the shortcomings observed at stages K3 and K4. Therefore, subject M2 requires instructional strategies that emphasize strengthening case analysis skills, logical verification, and the cultivation of reflective thinking habits in solving mathematical logic problems.

c. Achievement of Problem-Solving Performance by M3

Subject M3 is a student with a high level of academic ability and demonstrated strong performance from the initial stage of problem solving. At stage K1, M3 was able to identify all the given information and clearly understand what was being asked in the problem. The student exhibited careful reading and accurate comprehension, resulting in no misinterpretation at the initial stage. This competence continued at stage K2, where M3 accurately illustrated all statements in the form of mathematical logic symbols. The symbolic representations were consistent and aligned with the principles of formal logic. This indicates strong conceptual mastery and symbolic transformation skills, as emphasized by Bacelo and Gómez-Chacón (2023) regarding the importance of conceptual and operational understanding in computational thinking.

At stage K3, M3 was able to present all possible cases in a systematic and well-structured manner. The student demonstrated comprehensive case exploration by considering every plausible logical alternative. This process reflects well-developed deductive and inductive reasoning abilities, as well as creativity in logical reasoning. Subsequently, at stage K4, M3 conducted an in-depth investigation of each constructed case. The student consistently tested every possibility to identify contradictions with one of the four given statements. This verification process was carried out in an orderly and logical manner, indicating a high level of process skills. This finding is consistent with the study by Arsandy et al. (2025), which reported that high-ability students tend to demonstrate procedural consistency and analytical accuracy.



At stage K5, M3 successfully produced a correct final answer supported by strong logical justification. The response reflects effective integration of conceptual understanding, procedural skills, and logical reasoning ability. Thus, M3 demonstrated comprehensive mastery of mathematical logic concepts. These findings confirm that proficiency across all stages from K1 to K5 contributes significantly to successful reasoning-based problem solving.

4. CONCLUSION

Based on the results of the analysis of students' errors in solving mathematical logic problems using the Newman's Procedure framework, which was operationalized through stages K1 to K5, a clear depiction of differences in problem solving achievement among the research subjects M1, M2, and M3 was obtained. Subject M1, who demonstrated a low level of ability, exhibited sequential errors starting from stage K1 (information identification) through stage K5 (final answer construction). Subject M2, categorized as having a moderate level of ability, was relatively able to complete the initial stages, namely K1 and K2. However, difficulties were identified in the intermediate to final stages, specifically at stages K3 and K4. Consequently, these errors led to inaccuracies in the final answer at stage K5. In contrast, subject M3, who possessed a high level of ability, successfully carried out all stages systematically and consistently, resulting in correct and logically justified solutions.

These findings indicate that students' academic ability levels are closely associated with the types and stages of errors that emerge during the process of solving mathematical logic problems. Students with low ability tend to experience fundamental difficulties in problem comprehension and symbolic transformation, while students with moderate ability encounter obstacles primarily in case exploration and process skills. Meanwhile, students with high ability are able to integrate conceptual, procedural, and operational understanding in a comprehensive manner. Thus, the designed coding stages have proven effective in precisely mapping students' error positions and providing a comprehensive picture of the logical thinking processes involved in problem solving.

A positive contribution of this study is the evidence that the use of stages K1 through K5 functions not only as an error identification tool but also as a means of revealing students' cognitive potential and strengths at each ability level. This is particularly evident in subjects M2 and M3, who demonstrated symbolic representation skills and logical reasoning abilities that can be further developed through appropriate instructional strategies. Furthermore, students with high ability illustrate that mastery across all thinking stages can minimize both conceptual and procedural errors, thereby serving as a reference model for the design of reasoning based mathematical logic instruction. Based on these results, it is recommended that lecturers implement more structured and differentiated instructional strategies aligned with the characteristics of students' errors at each stage. Strengthening reading comprehension and problem understanding should be emphasized for low ability students, while training in case exploration and logical verification should be prioritized for students with moderate ability. For high ability students, higher order reasoning problems can be utilized to further develop



their potential. In addition, integrating Newman's Procedure into both instruction and assessment is expected to enhance students' conceptual understanding, process skills, and problem solving abilities in a sustainable manner within mathematical logic courses and other related subjects.

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