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ANALYSIS OF ERRORS MADE BY YEAR 8 PUPILS AT DARUT TAQWA SECONDARY SCHOOL IN UNDERSTANDING THE CONCEPT OF POWERS OF NUMBERS BASED ON NEWMAN'S STAGES

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Abstract

An analysis of pupils' errors in solving problems involving powers is essential to identify where learning difficulties lie, thereby providing a basis for designing more effective teaching. This study aims to describe the errors made by Year 8 pupils at Darut Taqwa Junior High School in solving problems involving powers, based on Newman's stages. This study employed a descriptive qualitative approach with six students selected through *purposive sampling*, comprising students of high, medium and low academic ability. Data were collected through written tests and interviews, then analysed using data reduction, data presentation and conclusion-drawing techniques, with triangulation of methods. The results of the study indicate that pupils' errors occurred across all stages of Newman's model, namely *reading, comprehension, transformation, process skills,* and *encoding*. The characteristics of the errors differed across each academic ability category, with low-ability pupils making more complex errors than high- and medium-ability pupils. These findings suggest that error analysis based on Newman's stages can be utilised as a basis for designing instruction and diagnostic assessment to minimise pupils' errors in the topic of powers.

Keywords: *error analysis; powers; Newman; conceptual understanding; problem-solving.*

INTRODUCTION

Education is a process that plays a vital role in developing pupils' potential, in terms of knowledge, skills and thinking abilities (Chaidir et al., 2024; Nurjadid et al., 2025) . In mathematics learning, pupils are not only required to master concepts, but also to develop logical reasoning, critical thinking and the ability to solve various problems systematically. One of the topics that plays a fundamental role at lower secondary school (SMP) level is powers. Mastery of this concept is a prerequisite for understanding more advanced topics, such as radicals, exponential equations and logarithms. However, the abstract nature of the concept means that many pupils struggle to understand the meaning of the questions or to determine the correct procedure for solving them.

Previous research has shown that pupils' errors in solving problems involving powers are caused not only by poor numeracy skills, but also by difficulties in understanding the problem, transforming the problem into a mathematical model, and applying the appropriate solution strategies. Wahyuni et al., 2026) found that the most prevalent errors occurred at the process skills stage. Furthermore, research utilising Newman's procedure indicates that pupils still make errors at the stages of reading, understanding the problem, transformation, process

skills, and writing the final answer (Lestari & Afriansyah, 2022; Lubis et al., 2025) . However, most studies remain limited to identifying the types of errors without examining the characteristics of these errors based on pupils' academic ability levels, particularly regarding the topic of powers at lower secondary school level, and few have integrated the results of written tests and interviews to uncover pupils' thought processes. Therefore, this study aims to describe the characteristics of pupils' errors based on the categories of high, medium and low ability, thereby providing a more comprehensive understanding of pupils' thought processes when solving problems involving powers.

Based on this research gap, this study aims to describe the types of errors made by Year 8 pupils at Darut Taqwa Junior High School when solving problems involving powers, based on Newman's stages, and to identify the contributing factors according to the pupils' academic ability levels. *The novelty* of this study lies in the comparative analysis of students' error patterns categorised as high, medium and low ability through the integration of written test data and interviews, thereby not only identifying the types of errors at each stage of Newman's model but also revealing the thought processes underlying the errors. It is hoped that the research findings will serve as a basis for teachers in designing more appropriate learning strategies to minimise students' errors in the topic of powers.

METHOD

This study employs a qualitative approach using a descriptive research design. This approach was chosen to gain an in-depth understanding of the types of errors made by pupils in understanding the concept of powers, based on Newman's stages. The research was conducted at Darut Taqwa Junior High School with Year 8 pupils as the research subjects. The subjects were selected using *purposive sampling* based on the results of an initial ability test, resulting in six research subjects comprising two high-ability pupils, two medium-ability pupils and two low-ability pupils. This grouping aimed to identify variations in the characteristics of errors that emerged in each category of academic ability.

Research data were collected through a written test in the form of word problems on the topic of powers of numbers and semi-structured interviews. The test instrument was used to identify the types of errors made by pupils at each stage of Newman's model, whilst the interviews were conducted to explore the reasons and factors underlying these errors, based on the pupils' thought processes whilst solving the problems. Prior to use, all instruments underwent a validation process by subject-matter experts and subject teachers to ensure the appropriateness of the content, the clarity of the test items, and the achievement of the research objectives.

Data analysis was carried out in stages through data reduction, data presentation and drawing conclusions. Pupils' answers were analysed based on Newman's five stages, namely *reading*, *comprehension*, *transformation*, *process skills*, and *encoding*, and were then combined with the interview results to identify the causes of each type of error. Data validity was achieved through triangulation by comparing the results of the written test and the interviews, thereby ensuring that the resulting interpretation had a higher level of credibility.

RESULTS AND DISCUSSION

Analysis of the written test results and interviews revealed that pupils made a variety of errors at each of Newman's stages. These variations were influenced by academic ability levels, meaning that the characteristics of the errors differed between high-, medium- and low-ability pupils (Amelina et al., 2026; Rahman et al., 2026) . Generally, high-ability students only make errors at the final stage, whilst students of moderate and low ability make more complex errors from the transformation stage right through to writing their final answers (Amalia & Kaltsum, 2026; Fimillatika & Haerudin, 2023) . These findings form the basis for a further examination of the types of errors at each stage of Newman's model, along with the underlying factors.

Data analysis was conducted on six pupils grouped according to high, medium and low ability levels. Based on the results of the written test and interviews, it was found that the types of errors made by pupils when solving word problems involving powers of numbers encompassed the five stages of Newman's model, namely *reading*, *comprehension*, *transformation*, *process skills* and *encoding*. The frequency and characteristics of errors showed differences across each category of student ability. The lower the students' academic ability, the more complex the errors committed and the longer the sequence of errors that occurred. These findings form the basis for further examination of the characteristics of errors at each stage of Newman's model, along with the underlying factors.

Types of Student Errors Based on Newman's Stages

The results of the analysis of the six research subjects indicate that pupils' errors in solving word problems involving powers of numbers occurred at five of Newman's stages: *reading*, *comprehension*, *transformation*, *process skills*, and *encoding*. However, the frequency of errors at each stage varied according to the pupils' academic ability levels. High-ability pupils tended to complete all stages correctly and only occasionally made errors at the *encoding* stage due to a lack of care when writing down their final answers. Conversely, students of moderate ability began to make errors at the transformation, process skills and final answer writing stages, whilst students of low ability exhibited errors at almost all of Newman's stages. This pattern indicates that the lower a student's academic ability, the more complex the errors that arise during the problem-solving process. The overall results are presented in the following table:

Table 1. Overall results of the analysis of pupils' errors based on Newman's stages

Subject Category	Question number	Newman Stages				
		Reading stage	Question *Comprehension* Stage	*Trans*formation stage	*Process* Skills Stage	Final Answer Writing Stage (*encoding*)
KT1	1	✓	✓	✓	✓	✓
	2	✓	✓	✓	✓	✓

	3	✓	✓	✓	✓	-
KT2	1	✓	✓	✓	✓	✓
	2	✓	✓	✓	-	-
	3	✓	✓	✓	✓	✓
KS1	1	✓	✓	-	-	-
	2	✓	✓	✓	✓	✓
	3	✓	✓	✓	✓	✓
KS2	1	✓	✓	-	-	-
	2	✓	✓	✓	✓	✓
	3	✓	✓	✓	-	-
KR1	1	✓	-	-	-	-
	2	✓	✓	✓	✓	✓
	3	✓	✓	-	-	-
KR2	1	✓	-	-	-	-
	2	✓	✓	✓	✓	✓
	3	✓	-	-	-	-

The reading stage is the stage with the lowest error rate (Ismiasih, 2023; Khoirunnisa et al., 2023) . The majority of participants were able to read the questions, symbols, numbers and mathematical terms fluently without encountering any significant difficulties. The interview results also indicated that the pupils understood the written sentences, meaning there were no errors in verbally identifying the information. These findings suggest that reading ability is not the primary factor causing errors in solving exponent problems in this study. Consequently, pupils' difficulties arise more frequently in the thinking stages following the reading process—namely, ' '—when they must comprehend the meaning of the information, determine a mathematical model, and carry out the solution process systematically. These findings indicate that pupils' basic literacy skills are relatively good, but these have not yet been fully complemented by mathematical problem-solving skills.

The problem-comprehension stage also showed a relatively low error rate, as the majority of pupils were able to identify both the given information and the information being asked for in the 'questions . However, some pupils with lower abilities still struggled to distinguish between key information and supporting information, resulting in an incomplete understanding of the question's context. This situation has an impact on the subsequent stages, as misinterpreting information will affect pupils' accuracy in determining problem-solving strategies. This finding is consistent with Newman's theory, which explains that an understanding of the question's content is a prerequisite before pupils are able to transform a problem into a mathematical form. If this stage has not been mastered optimally, the likelihood of errors occurring in subsequent stages will be significantly greater.

The differences in the characteristics of errors across each ability category indicate that pupils' thought processes when solving maths problems occur in stages (Fatih et al., 2025;

Simbolon et al., 2025) . High-ability pupils tend to make only technical errors, whilst medium- and low-ability pupils make conceptual errors that affect subsequent stages of problem-solving. These findings indicate that Newman's stages do not stand alone but form a sequence of interrelated thinking processes. When pupils fail to understand or transform information at an early stage, the likelihood of errors occurring at the process skills stage and in the final written answer increases. Therefore, identifying the location of errors based on Newman's stages can serve as a basis for teachers to determine the form of learning support (*scaffolding*) appropriate to pupils' needs. These findings reinforce the view that error analysis serves not only to evaluate learning outcomes but also as a basis for improving the learning process.

Transformation Errors in Solving Exponential Problems

The transformation stage indicates that not all pupils are able to convert the information in word problems into an appropriate mathematical model (Ahmadi et al., 2024; Primrose & Masamah, 2025) . Pupils with high ability generally succeed in determining a mathematical model in line with the given information, whilst those with moderate and low ability still make errors when selecting formulas or converting contextual information into mathematical form. The most common errors involve the use of values that do not correspond to the information in the problem, such as failing to convert units of time or incorrectly determining the exponent used in operations involving powers. These errors lead to inaccuracies in the subsequent ' ' stage of problem-solving, even though the pupils have understood the content of the problem. The types of errors are listed in the following table:

Table 2. Types of Errors at the Transformation Stage

Findings	Interpretation
Failure to translate information into a mathematical model	Understanding of the relationships between pieces of information is still poor
Incorrect choice of formula	Difficulty in selecting a problem-solving strategy
Incorrectly determining the value of an exponent	Conceptual understanding is not yet optimal

Table 2 shows that transformation errors were predominantly due to pupils' inability to convert information in word problems into appropriate mathematical models. These errors were evident when pupils selected the wrong formula, misinterpreted the relationships between pieces of information, or used values that did not fit the context of the problem. These findings indicate that some pupils are not yet able to link their understanding of the problem's content to the mathematical representations required to solve the problem. Consequently, the problem-solving process in the subsequent stages becomes inaccurate, even though the pupils have understood the given and required information. Thus, transformation errors are one of the main factors influencing the occurrence of errors in the process skills stage and in writing the final answer.

These findings suggest that the ability to understand information is not necessarily accompanied by the ability to transform it into a correct mathematical model. Based on the interview results, some pupils were actually able to explain the information they knew and were asked about, but still experienced confusion when determining the appropriate form of solution. This indicates that errors in transformation are more influenced by a weak ability to link verbal information to mathematical concepts than by the ability to read the problem. According to Newman's procedure, the transformation stage is a crucial process that bridges the understanding of the problem with the mathematical solution. Therefore, failure at this stage has the potential to cause a chain of errors in both the calculation process and the writing of the final answer.

The findings of this study are consistent with the research at, and (Amalia & Kaltsum, 2026**,**)), which indicate that pupils often struggle to transform information in word problems into mathematical models because they are not yet able to link the given information to the appropriate concepts or procedures. The consistency of these findings suggests that errors in transformation remain one of the main obstacles in solving mathematical problems, particularly in topics that require abstract thinking, such as powers. Therefore, teachers need not only to train pupils in applying formulas but also to guide them in identifying key information, determining relationships between pieces of information, and selecting an appropriate mathematical model before carrying out calculations.

The results of this study also indicate that errors in transformation serve as the starting point for errors in subsequent stages. When pupils incorrectly identify the mathematical model, the entire subsequent problem-solving process is also affected, resulting in an incorrect final answer. This situation indicates that the ability to transform information is a competence that must be specifically developed through contextual problem-solving exercises that encourage pupils to identify key information before selecting a solution procedure. Consequently, mathematics learning should not be solely focused on mastering formulas, but must also foster mathematical representation skills as a bridge between contextual problems and abstract concepts.

Errors in Process Skills in Exponential Operations

Errors at *the process skill* stage were found primarily among pupils with moderate and low abilities (Lutfiyah & Masrurotullaily, 2026; Mursyidah et al., 2023) . The results of the analysis showed that some pupils were able to identify the mathematical model correctly, but still made errors when solving operations involving powers. The types of errors that arose included miscalculating the value of exponents, arithmetic errors, and a lack of attention to detail when carrying out the calculation steps. Based on the interview results, some pupils admitted to rushing through the problems, meaning they did not double-check their calculations. Consequently, the answers obtained were incorrect even though the solution procedure had been chosen correctly.

These results indicate that pupils' procedural skills in solving operations involving powers still require reinforcement. The errors made were not solely due to a lack of knowledge

of the formulas, but also to a lack of accuracy and the habit of verifying the results of their calculations. In the Newman procedure, the *'process skill'* stage serves to ensure that the specified mathematical model can be solved using correct arithmetic operations. Therefore, if pupils make a mistake at this stage, the final answer will also be incorrect, even if the previous stages have been carried out correctly. This situation indicates that conceptual understanding must be balanced with procedural skills to ensure that problem-solving is carried out accurately.

In addition to being influenced by accuracy, errors at the *process skill* stage also indicate that some pupils do not yet possess a strong procedural mastery of operations involving powers of . Although they are familiar with the formulae used, some pupils still make mistakes in the calculation steps, resulting in answers that do not align with the relevant mathematical concepts. These findings indicate that procedural practice remains necessary, but must be balanced with a strengthening of conceptual understanding so that pupils do not merely memorise the steps involved in solving problems. Therefore, teachers need to provide a variety of exercises that require pupils to explain the reasoning behind each step of the solution, so that conceptual and procedural skills can develop in a balanced manner.

Errors in Writing the Final Answer (*Encoding*)

Errors at the *encoding* stage were one of the most frequently observed findings in this study (Purnamasari et al., 2025; Wahyuni et al., 2026) . The analysis revealed that such errors were experienced by pupils of varying ability levels, although the causes differed. Among high-ability pupils, *encoding* errors were more frequently caused by a lack of attention to detail when writing down the final result, even though the transformation and calculation processes had been carried out correctly. Conversely, among pupils of moderate and low ability, errors in writing the final answer were generally a consequence of errors that had already occurred at the transformation stage or in process skills. Consequently, the final answer written did not correspond to the intended solution. These findings indicate that the accuracy of the final answer is influenced not only by computational ability but also by students' habits regarding checking their work.

These findings show that the *encoding* stage serves as a final indicator reflecting the overall quality of the problem-solving process. Based on interview results, some pupils stated that they rushed to complete the questions and therefore did not double-check the answers they had written. This situation led to discrepancies between the calculation results and the final answers presented, as observed in the case of one high-achieving pupil who obtained the correct calculation result but wrote down the final answer incorrectly. This finding reinforces Newman's view that the verification process is a crucial part of mathematical problem-solving as it can minimise errors arising from a lack of precision. Consequently, mathematics teaching should encourage pupils to reflect on their work before submitting their answers.

These findings indicate that the *encoding* stage cannot be viewed merely as an administrative process, but rather as a final indicator reflecting the success of the entire problem-solving process. Incorrect final answers are often not caused by pupils' inability to understand concepts, but by a lack of the habit of reflecting on and double-checking their work. Therefore, teachers need to encourage pupils to carry out *self-checking* activities before

submitting their answers as part of the learning process. This habit can reduce errors caused by a lack of attention to detail whilst enhancing pupils' metacognitive abilities in evaluating their own thought processes.

Factors Contributing to Students' Errors in Understanding Exponential Numbers

The interview results indicate that pupils' errors are influenced not only by their mastery of the concept of powers, but also by various interrelated factors during the problem-solving process. Some pupils admitted to experiencing difficulties when converting information from word problems into appropriate mathematical models. These difficulties led them to choose an inappropriate formula or to incorrectly determine the values to be used in the solution process. Furthermore, some pupils admitted to rushing through the problems, resulting in a lack of care when performing calculations or writing down their final answers. These findings suggest that pupils' errors do not always stem from an inability to understand the subject matter, but are also influenced by their learning strategies and habits when solving problems. A summary of the factors causing pupils' errors is presented in Table 3:

Table 3. Factors Causing Students' Errors According to Newman's Stages

Newman's Stages	Causes Identified
Reading	Pupils did not read the questions carefully enough, resulting in information being missed or misinterpreted.
Comprehension	Pupils are not yet able to understand the information provided and that which is being asked for, and have difficulty identifying the intent of the question.
Transformation	Pupils have difficulty converting the information in the question into a mathematical model and determining the appropriate formula.
Process Skills	Pupils make errors in the solution procedure and arithmetic operations, and lack attention to detail during the calculation process.
Encoding	Pupils do not check their work, resulting in answers that are incorrect or incomplete.

Table 3 shows that the factors causing pupils' errors are complex and interrelated across the various stages of problem-solving. The errors that occur are influenced not only by a poor grasp of the concept of powers, but also by a lack of care when reading the question, difficulty in transforming information into a mathematical model, weaknesses in applying problem-solving procedures, and a lack of the habit of checking their answers. These findings indicate that errors at the initial stage tend to affect subsequent stages, resulting in an inaccurate final answer. Therefore, teachers need to pay attention not only to the final result but also to the students' thought processes whilst solving problems so that the learning support provided can be more targeted.

The differences in the characteristics of errors across each ability category indicate that the level of conceptual mastery influences the complexity of the errors made by students (Al Malik et al., 2025; Isnani, 2025) . High-ability students tend to be able to understand the question, identify the mathematical model, and carry out the calculations correctly, so that any errors that arise are merely technical in nature. Conversely, students of average ability begin to make procedural errors at the transformation and process skills stages, whilst students of low ability exhibit errors in sequence, ranging from understanding the information to writing down the final answer. This pattern indicates that an error at one stage of Newman's model can trigger errors at subsequent stages, thereby forming a chain of interrelated errors. This situation highlights the importance of identifying the source of errors at an early stage so that teachers can provide more targeted learning interventions.

The findings of this study have important implications for mathematics learning, particularly in the area of powers. It is not enough for teachers simply to emphasise the mastery of formulas and computational skills; they must also develop pupils' abilities to understand information, construct mathematical models, carry out calculations systematically, and get into the habit of checking their answers. The implementation of problem-solving-based learning, the gradual introduction of contextual problems, and reflective activities after completing problems can serve as alternatives to reduce errors at each stage of Newman's model. Thus, error analysis serves not only as a tool for evaluating learning outcomes but also as a basis for designing more effective learning strategies to enhance the understanding of the concept of powers.

Based on the overall research findings, the factors causing pupils' errors stem not only from cognitive aspects but are also influenced by their learning habits and the problem-solving strategies they employ. Pupils who are accustomed to performing calculations straight away without analysing the information in the question tend to make more errors than those who first seek to understand the context of the problem. This indicates that success in solving maths problems is influenced by the ability to think systematically, from understanding the information to evaluating the answers obtained. Therefore, problem-solving-based learning needs to be consistently applied so that pupils become accustomed to following a coherent and logical sequence of steps.

The research findings show that error analysis based on Newman's stages not only serves to identify where students' errors lie but also provides information regarding the thought processes that led to those errors. Teachers can utilise this information as a basis for designing more adaptive teaching approaches tailored to the characteristics of students' learning difficulties. For example, pupils who make errors at the transformation stage require guidance in converting contextual information into a mathematical model, whilst those who make errors at the *process skill* stage require reinforcement of procedural skills. Thus, the findings of this study suggest that teaching strategies should be tailored to the type of error made by pupils so that the learning process becomes more effective. This finding expands the function of error analysis from mere evaluation to a basis for improving learning.

This study contributes to the field of mathematical error analysis by demonstrating that the characteristics of students' errors differ across categories of academic ability. High-ability

students tend to make errors only at the *encoding* stage, whilst students of moderate and low ability experience a sequence of errors beginning at the transformation stage and continuing through to the writing of the final answer. This pattern indicates that Newman's stages are interrelated, meaning that errors at one stage have the potential to influence subsequent stages. These findings enrich previous research as they not only identify the types of errors but also reveal the relationship between pupils' academic ability levels and the patterns in which errors occur when solving problems involving powers.

Based on the research findings, teachers need to pay greater attention to pupils' thought processes rather than merely focusing on whether answers are correct or incorrect. Learning can be guided by the gradual provision of contextual problems, discussions regarding the reasons for choosing particular solution strategies, and encouraging the habit of checking one's work. In addition to improving procedural skills, this approach can help pupils develop a deeper conceptual understanding, enabling them to solve mathematical problems systematically. Consequently, the application of Newman's analysis can serve as an alternative diagnostic assessment method to identify pupils' learning difficulties whilst determining the form of support best suited to their needs.

Overall, the research findings indicate that pupils' errors in solving problems involving powers are part of an interrelated process, ranging from understanding the information, transforming the problem, carrying out calculations, to writing down the final answer. Therefore, efforts to reduce pupils' errors cannot be achieved solely by improving their computational skills; they must also be accompanied by strengthening their ability to understand problems, select solution strategies, and independently evaluate their work. These findings confirm that Newman's procedure provides a comprehensive picture of students' thought processes, thereby serving as a basis for the development of more effective mathematics teaching strategies and as a foundation for further research on different topics or educational levels.

The results of this study show that patterns of student errors can not only be identified based on Newman's stages but can also be understood through differences in students' academic ability. These findings indicate that high-ability students tend to make technical errors, whilst students of moderate and low ability experience conceptual and procedural errors in that order. Consequently, this study contributes to the development of research on the analysis of mathematical errors by demonstrating the relationship between academic ability levels and students' error patterns in the topic of powers. These findings expand the application of Newman's procedure as a basis for designing more adaptive diagnostic learning tailored to the characteristics of students' errors.

CONCLUSION

This study shows that the types of errors made by Year 8 pupils at Darut Taqwa Junior High School in understanding the concept of powers, as categorised by Newman's stages, include *reading*, *comprehension*, *transformation*, *process skills* and *encoding*. The level of errors made by pupils varied according to their academic ability. Pupils with high ' ' ability

tended to make errors only at the *encoding* stage, due to a lack of accuracy in writing down their final answers. Meanwhile, students with moderate ability made more errors at the *transformation*, *process skills* and *encoding* stages. Students with low ability, on the other hand, made errors at almost all of Newman's stages. These findings address the research objective that Newman's analysis is capable of systematically identifying the location and characteristics of students' errors, thereby providing an insight into students' thought processes when solving word problems on the topic of powers.

The findings of this study suggest that teachers need to focus not only on students' mastery of concepts and numeracy skills, but also on their ability to understand information, transform problems into mathematical models, and encourage them to check their work. This study is still limited to six participants at a single school, focusing on the topic of powers, so the results cannot yet be widely generalised. Therefore, it is recommended that future research involve a more diverse sample of participants, cover different areas of mathematics, or combine Newman's analysis with other approaches to obtain a more comprehensive picture of the errors students make when solving mathematical problems.

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