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CORRESPONDENCE BETWEEN MODELS AND FACTORS OF STUDENT ERRORS IN SOLVING CONTEXTUAL PROBLEMS

Fiki Alghadari[1*], Audi Yundayani[2], Abdul Halim Abdullah[3]

[1*,2] STKIP Kusuma Negara, Jakarta, Indonesia
[3] Universiti Teknologi Malaysia, Johor, Malaysia
*Corresponding author. Raya Bogor KM24 Cijantung, 13770, Jakarta Timur, Indonesia.
E-mail: *fiki_alghadari@stkipkusumanegara.ac.id* [1*)]
audi_yundayani@stkipkusumanegara.ac.id [2)]
p-halim@utm.my [3)]

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Abstract

The acquisition of knowledge assists students in navigating life, but their skill configuration is unstable when confronted with contextual problems. The fact that they make problem-solving errors is a stability problem that stems from existential situations. This study examined students' errors in solving contextual math word problems. The respondents were 36 Jakarta junior high school students. This work employs an existential design informed by phenomenology to lessen the connection between the model and error-causing. Newman's strategy found various types of errors. The researchers then investigated the error model and the root causes of the detected errors through interviews. According to the ontological investigation, seven correspondences were discovered between the error models and the causative factors, namely comprehension, transformation, and process skills, so that the origin of occurrences remained unchanged. Deficiencies in process skills cause the majority of correspondence. The phenomenological reduction of the correspondence demonstrates that students are not always engaged in higher-order thinking and tend to concentrate on the procedural knowledge learning process. It can be concluded that the learning process must encourage students' higher-order thinking. When students learn and gain experience through misunderstandings and transformations, they will demonstrate constructive efforts and computational thinking by troubleshooting the problem-solving strategy.

Keywords*:* Contextual problem; error factors; error models; math word problems.

Abstrak

Pengetahuan memfasilitasi siswa dalam menghadapi kehidupan, tetapi konfigurasi kemampuan mereka belum mantap ketika dihadapkan pada tantangan kontekstual. Siswa membuat kesalahan dalam penyelesaian adalah masalah stabilitas yang bersumber dari kondisi eksistensial. Penelitian ini bertujuan untuk mengevaluasi kesalahan siswa dalam penyelesaian soal cerita matematika pada setting kontekstual. Responden adalah 36 siswa SMP di Jakarta. Penelitian ini menggunakan desain eksistensial pada perspektif fenomenologis untuk mereduksi korespondensi antara model dan faktor penyebab kesalahan. Jenis kesalahan diidentifikasi dengan pendekatan Newman, kemudian peneliti mengeksplorasi model kesalahan dan faktor penyebab dari jenis-jenis kesalahan yang teridentifikasi melalui wawancara. Hasil penelitian menemukan tujuh korespondensi antara model kesalahan dengan faktor penyebabnya adalah pemahaman, transformasi, dan keterampilan proses, sehingga sumber kejadian menurut kajian ontologis juga tetap konstan. Mayoritas korespondensi dihasilkan dari kesalahan keterampilan proses. Reduksi fenomenologis dari korespondensi tersebut mengungkapkan bahwa siswa tidak selalu terlibat dalam pemikiran tingkat tinggi dan cenderung menitikberatkan proses pembelajaran pada pengetahuan prosedural. Dapat disimpulkan bahwa proses pembelajaran harus mendorong berpikir tingkat tinggi siswa. Ketika siswa belajar dan memperoleh pengalaman melalui kesalahpahaman dan transformasi, mereka akan mendemonstrasikan upaya konstruktif dan pemikiran komputasi dengan pemecahan masalah strategi pemecahan masalah.

Kata kunci*: Faktor kesalahan; masalah kontekstual; model kesalahan; soal cerita matematika.*

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INTRODUCTION

Mathematics courses are designed to teach students how to learn fundamental concepts and then use them to solve real-world issues (Lathiifah & Kurniasi, 2020; Son, Darhim, & Fatimah, 2021). This is consistent with Farida (2015) assertion that mathematics is a tool for cultivating a way of thinking when applying mathematical principles is required in daily life. However, resolving issues is not sufficient; processes and strategies must also be addressed (Alghadari, Herman, & Prabawanto, 2020; Elita et al., 2019). Alghadari (2016) asserted that while students must accomplish certain goals in problem-solving, they must also accomplish specific technical issues or techniques that are critical to the process. Students should examine this to ascertain their suitability for resolving contextual mathematics problems (Lathiifah & Kurniasi, 2020).

Indonesia's center for educational assessment published a report on the results of the national mathematics exam, which stated that 85.47% at the junior high school level across over were able to solve the problem of linear equations with two variables, according to the report data from the center for educational assessment (Sirait, Alghadari, & Huda, 2021). At the same time, 36.90% can analyze problems involving linear equations with two variables. Both percentages indicate that student mastery has not yet reached a steady state. In particular, according to the data collected, only 27.10% of students can analyze a problem involving linear equations in two variables in a junior high school in South Jakarta, Indonesia. The percentage of students' abilities at this school is lower than the national level. Furthermore, the percentage of students who correctly answered all of the numbers in each material was as follows: 33.26% for numbers; 47.66% for algebra; 35.66% for geometry and measurement; and 54.52% for statistics and probability, indicating a low level of mastery competence when compared to the school's minimum completeness criteria score of 75.

In order to increase the quality of student learning, policymakers should use this data as a source of evaluation material. Because the students' capacity to address contextual problems may be unstable, their learning outcomes may be poor, and they may require scaffolding learning concepts to keep their analogous structure intact (Cipta, Ratnaningsih, & Muhtadi, 2020; Raharti & Yunianta, 2020; Rahayuningsih & Qohar, 2014). Only if an error analysis has been performed and the location of the problem in the configuration is identified will the new scaffolding capability function properly (Ainin, 2020; Son et al., 2021). By the end, it may be concluded that error analysis is the first step in investigating stability difficulties.

Several studies on relevant contexts have been conducted. Zahra (2019) described the difficulties that junior high school students have in solving concept understanding problems and concludes that students cannot arrange the meaning of the sentences that they think into mathematical models because they have not had enough practice working on story problems. Hanipa and Sari (2019) also examined student errors in problem-solving, concluding that students made conceptual errors, misread questions, and made incorrect calculations due to a lack of conceptual mastery and practice. Moreover, Islamiyah, Prayitno, and Amrullah (2018) described the different

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types and levels of failure to complete a task. The highest proportion of responses discovered that erroneous answer formats and misconceptions were the most common.

According to Ilmiyah, Purnama, and Mayangsari (2018), process skill errors were the sort of error that had the highest number of occurrences. Furthermore, Dewi and Kartini (2021) discussed the forms of student errors, and their findings indicate that the types of transformation errors account for the most significant percentage of all errors. Interestingly, the study's findings differed from those of Silvia, Supratman, & Madawistama (2020), who revealed that students occasionally completed all of the complete processes. On the other hand, they have a terrible habit of failing to consider the solution to the problem (Mulyadi, Riyadi, & Subanti, 2015). These findings provide information that may be used to determine the best solution to improve and repeat mathematics learning and boost the effectiveness of mathematics learning. The Newman criteria were used in all of these studies to conduct error analysis, which is the same approach. The approach developed by Newman was used to analyze errors in written math assignments (Dewi & Kartini, 2021; Ilmiyah et al., 2018; Islamiyah et al., 2018; Mulyadi et al., 2015; Son, Darhim, & Fatimah, 2019; Zahra, 2019).

Several relevant research studies have used the Newman technique as an analytical approach in their investigations. On the other hand, according to the data, the type of student error does not appear to result from an existential situation in any of these investigations. This study's strength is that it takes an ontological approach to study the correspondence between student error models and their causal factors, which is unique in the field. The analytical criteria in the Newman process are used to determine the error model and the causal factors in this study, which is similar to the previous one. Based on this point of view, the purpose of this study is to gain a better understanding of certain existential conditions by analyzing students' errors in answering contextual issues. This research is focused primarily on the material of linear equations with two variables.

RESEARCH METHOD

On the functional level, this study aims to identify members of the domain that are emerging in existential situations. According to the error model, the domain is made up of a collection of components that contribute to error production. The existential design by Edmonds and Kennedy (2016), a phenomenological study, was being used in this study. Three operational stages according to the existential design were presented in other paragraphs in this research method section. Additionally, this study included various word math problems in a contextual setting for 36 students in eighth grade at a junior high school in the South Jakarta area, Indonesia, in the academic year 2020-2021. They were who are students from the school is a lower achievement than the national level in analyzing problems involving linear equations. Three written tests were utilized to explore students' problem-solving experiences with a two-variable system of linear equations.

Three contextual problems that have been presented to students. The first, Given that the age gap between the mother and child is currently 36 years, and that the total of their ages was 44

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years eight years ago, what age will the mother and child be in the following two years?. Second, The circumference of a rectangle is 36 cm. What is the rectangle area if the width is 2 cm less than the length?. Third, An inter-provincial bus travel agent can sell 60 economy and executive tickets, generating Rp 5,500,000.00 in ticket sales. If the price of an economy ticket is Rp 75,000.00 and the price of an executive ticket is Rp 100,000.00, then each economy and the executive class ticket price is Rp 75,000.00.

The contextual problem encompasses all of the error criteria in the Newman procedure and is therefore complete. The goal of this study is to employ all exams with relevant indicators to examine transformation errors focused on students' capacity to develop mathematical models throughout the problem-solving process (Rahmawati & Permata, 2018; Toha, Mirza & Ahmad, 2018).

Three stages are involved in abstracting and then reducing domain members that are included in existential conditions. The first is an investigation into student experiences in problem-solving in a context. The second is in discovering correspondence models and factors contributing to errors. Furthermore, the third involves doing ontological investigations in the context of existential circumstances. The first stage involves examining student experiences to gain a general understanding of the error model and the elements that contribute to it. As a result of an analysis based on five criteria created hierarchically in the Newman approach and categorized as follows: reading and comprehension; transformation; process skills; and encoding errors, this process is produced (Amini & Yunianta, 2018; Clements & Ellerton, 1996; Karnasih, 2015). The initial stage of this study included 36 students who served as research data sources. The test results were analyzed to determine the completion error position, carefully critique the error, and determine one of the models in a specific type of error based on Newman's criteria and its indicators.

The next stage identifies the factors causing the error, which is carried out to confirm and obtain the inverse of the error model identified by the Newman procedure through interviews. The interview material was broken down from each model of student errors in their completion to find causal factors of error. The identified error factors are open coding. Students involved in this second process are selected based on certain types and models of errors on written tests with different indications, and in this study three students were selected who met these criteria. The last stage is reviewing the source of the incident, namely the inverse of the correspondence between the error model and its causal factors, based on interview data, and the analysis is carried out using selective coding techniques. This process is carried out using open coding of the error model and the identified causal factors. The coding pairs are made to correspond to the source of the incident and then determine the existential conditions according to supporting theory. The elements included in the realm of existential conditions result from phenomenological reduction. It is the link between axial coding and the results of ontological studies.

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RESULTS AND DISCUSSION

Table 1 shows the analysis results for each type of error according to Newman's criterion. Their experiences errors are derived from calculating the number of students in the class.

Table 1. Recapitulation of the number of students based on error experience.

Question number	Error type			Total
	Comprehension	Transformation	Process skill	
1	7	5	0	12
2	12	11	2	25
3	5	9	4	18
Total	24	25	6	

It can be shown from Table 1 that there are no students that have reading and encoding errors. Students continue to make comprehension errors, with an average proportion of around 22.22%, and transformations, with an average ratio of approximately 23.15%. Both of these errors are made by a large number of students. Only 5.55% of process skill errors were discovered. Furthermore, the average proportion of students who make errors is approximately 50.93%, with the most significant proportion occurring when students are attempting to solve contextual issues involving geometrical mathematics, which accounts for about 69.44% or 25 of 36 students.

This study corroborates the findings of other research (Ilmiyah et al., 2018; Islamiyah et al., 2018; Yusuf & Fitriani, 2020), which indicate that students make errors in the stages of comprehension, transformation, and process skills. It is also relevant to the results of the study by Alhassora, Abu, and Abdullah (2017) that most students are able to do the reading and encoding stages but they face difficulties in doing the next stage. However, it is worth noting that the researcher's findings on student work in this study were better than the findings of prior studies because there were no students who made the types of reading and encoding errors observed in previous studies. This also illustrates that, according to the study's findings, the cause of student difficulty is not the question itself but rather the interaction between the problem solver and the question (Clements & Ellerton, 1996). Furthermore, the findings of this study are verified by the findings of Cipta et al. (2020), who conclude that there is a clear association between students' errors and their difficulties in problem-solving. This study's results correspond with those of Dewi and Kartini (2021), who discovered that the type of transformation has a high proportion of errors, as well as those of Islamiyah et al. (2018) and Hariyani and Aldita (2020), who discovered that the type of understanding has a high proportion of errors as well.

These findings serve as the foundation for researchers to recommend that students intensify their efforts to comprehend language offered in contextual situations and translate them into mathematical models. This recommendation is very reasonable and should be considered to be incorporated in the educational process. A particular emphasis should be placed, according to the researcher, on improving students' grasp of geometric ideas and how to

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apply them to situations that are relevant to their life in the classroom (Silo, Herman, & Jupri, 2021). This recommendation was also conveyed by Son, Darhim, and Fatimah (2021), who argued that conceptual and procedural flaws should be the primary focus of the investigation. Moreover, the high rate of misunderstandings and transformation errors discovered in the study sheds light on the critical role of language in constructing mathematical notions (Clements & Ellerton, 1996; Supartinah & Hidayat, 2021). Thus, the results of student error analysis utilizing Newman's criteria provide guidelines for instructing students on using effective learning strategies (Karnasih, 2015), so the teacher needs to anticipate (Bahir & Mampouw, 2020) or to scaffolding (Cipta et al., 2020; Raharti & Yunianta, 2020; Rahayuningsih & Qohar, 2014), in which case it is possible to construct a hypothetical learning trajectory (Silo et al., 2021). What is astonishing is that student errors like this are included in a critical note on the international mathematics education research agenda, which can be seen here (Clements & Ellerton, 1996). This emphasizes the significance of this research to be conducted.

Identity of Factors and the Error Model

Table 2 demonstrates the relationship between the error model and the causal factors experienced by students in each of the three categories of errors identified by examining their answers.

Table 2. Results of identification of error types, models, and factors.

Type	Error Model	Causative Factors	Code
Comprehension	Students did not submit all required information.	Students have difficulty reading or incorporating keywords into sentences.	C1
Transformation	(1) No mathematical models are created by students.	(1) Students lack an understanding of how to create mathematical models.	T1
	(2) Students make errors when constructing sentences.	(2) Students have not integrated sentences and mathematical models.	T2
Process Skill	(1) Students make incorrect solution method selections.	(1) Students are unfamiliar with the proper approach to the solution.	P1
	(2) Students are incorrect in their application of the method.	(2) Students lose track of the proper method.	P2
	(3) Students make erroneous use of the model's elements.	(3) Students do not comprehend the measures necessary to solve the problem.	P3
	(4) Students execute an arithmetic error.	(4) Students do not comprehend the methods necessary to complete arithmetic operations.	P4

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According to Table 2, the correspondence between the error model and its factors in the kind of process skill appears to be the most numerous discovery, even though the number of students is minor compared to the forms of comprehension and transformation errors. These findings are consistent with the many models and confounding variables that contribute to the inaccuracy of some conclusions (Puspitasari, Yusmin, & Nursangaji, 2015; Safitri, 2017).

When the number of models for other sorts of errors is compared to the number of correspondences, it becomes clear that the process skill error has a more significant chance of capturing student errors. This could be owing to the error model's high volatility. This process skill error model identified at least four to six individuals out of 36 students in the research area. Students who become entangled in this correspondence do so because they have not reached the correct solution. As Clements and Ellerton (1996) noted about the hierarchical level mentioned in Newman's criterion, failure at any level of the sequence of operations preceding it prevents the problem solver from obtaining a satisfying solution. On the other hand, students who can escape from error models based on the type of process skill represent potential students who will solve problems, as shown in Table 1, where no students are included in the encoding type error.

Furthermore, one correspondence on the type of comprehension error was revealed by students who did not complete writing information because they skipped reading or did not notice the use of keywords in sentences because they did not complete reading information. This correspondence between the error model and the identified factor is consistent with the findings of several earlier investigations. Dewi and Kartini's (2021) study revealed that errors arise when students do not pay close attention to the details of the problem they are being asked to solve. Referring to Tables 1 and 2, if only one error model were detected in the comprehension type, affecting a maximum of 12 students, the optimal prescription for learning would be to advise students to read carefully while. On the other hand, there is undoubtedly an effect of the contextual problems provided, namely mathematics and geometry-related difficulties, as confirmed by the findings of the recapitulation of the number of students on the types of transformation errors. Clements and Ellerton (1996) stated that one of the most difficult challenges for educators in improving students' understanding of mathematical texts or their ability to transform is their inability to identify the correct sequence of operations that will solve the given word problem. The findings of this study are consistent with this statement.

The type of transformation error was related to two factors: students did not build mathematical models because they did not know how to do so, and students modeled sentences improperly due to an issue of compatibility between the model and the sentence, respectively. The findings of this study are consistent with the findings of the (Dewi & Kartini, 2021), which revealed that errors were caused by students' inability to carry out the procedures or actions that would be utilized to solve the problems.

Moreover, students have been unable to construct the meaning of words into mathematical models, which may be due to a lack of familiarity

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working on variations of questions, causing them to misunderstand the problems (Bahir & Mampouw, 2020; Zahra, 2019), not fully grasping the concept (Azka & Martila Ruli, 2022), have inaccuracies in their interpretations of solutions and calculations, and do not comprehend the subject matter (Farida, 2015; Silvia et al., 2020). It was also said that when the identification results showed that students did not know how to construct mathematical models, the findings of the Bahir and Mampouw (2020) study revealed that students did not identify the variables in the models.

Correspondences in Identity and Existential Conditions

According to the results of the identification of the error model and its factors, at least seven (C1, T1-T2, P1-P4) correspondences emerge between the elements in the error model domain and the causal factors. Table 3 summarizes the findings of the ontological study-based analysis. Even though all of the occurrences fall within the exact scope of learning activities, Table 3 shows that each correspondence derives from a unique occurrence due to the systematic impact of Newman's analysis methods. In recognition of the fact that comprehension and transformation are dimensions of cognitive processes, Radmehr and Drake (2017, 2018) categorize the indicators relevant to the incident's source into four categories: interpreting (C1), structuring (T1), organizing and abstracting (T2). The result is that although most students can handle contextual problems merely through the activation of low-level cognitive processes, a significant number of them stay locked in the error trap. Such a condition is declared as a student error due to not having acquired higher order thinking skills (Abdullah, Abidin, & Ali, 2015; Alhassora, Abu, & Abdullah, 2017). The origin of this type of student process skill error is a knowledge dimension connected with procedural knowledge, namely knowledge of subject-specific skills and algorithms (P1) and knowledge of subject-specific approaches and methodologies (P3). This is supported by the correspondence with code P2. On the other hand, there is student work that does not consider the function of signs or symbols (code P4), which is included in the factual knowledge dimension (Radmehr & Drake, 2017, 2018) and this is referred to as a procedural error (Raharti & Yunianta, 2020; Son et al., 2021).

Table 3. The findings of ontological studies on the correspondence

Code	The Occurrence's Cause
C1	Solving problems quickly, skimming, and failing to interpret.
T1	Solve problems without comprehending the concept and without referring to the definition.
T2	Learning but not yet organizing or abstracting
P1	Solve problems and think but are not model-flexible
P2	Learning is memorization
P3	Solve problems only based on discussion examples without inquiring why
P4	Bypass the sign function to resolve the issue

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This study also adds to the findings of Dwita and Sugiman (2021). They said that flexibility is influenced by comprehension errors and has an impact on performance involving students' abilities in processing information and information processing skills. Consequently, the phenomenological reduction of this study resulted in a conclusion stating that students' learning processes do not always engage higher-order thinking processes and instead concentrate on the aspects of procedural knowledge during their learning process. In order to determine the compatibility between the learning process and students' thinking levels, as well as the relevance of this synthesis to learning activities that have been carried out at school, further research must be conducted on this synthesis.

Granberg (2016) asserted that it is critical to building conceptual understanding through learning mathematical concepts through "effort" since students operate the dimensions of cognitive processes at a low level and the dimensions of procedural knowledge at a low level when solving problems. The effort is defined as reorganizing the mental relationship between mathematical facts, ideas, and procedures, which is accomplished through the development of mathematical concepts and the attempt to comprehend concepts that are not yet understood.

The effort was made in order to induce a restructuring of a more solid mental link between the two people involved. When students' past knowledge is insufficient to understand or cope with a particular problem, or when students are unable to assimilate new information, reform their prior knowledge, or reinterpret what is new, efforts should be made to help them understand and cope (Alghadari, 2013). This explanation corresponds to the experience of students who have made errors while trying to solve a problem. They should be encouraged to become accustomed to testing the correctness of their mathematical models, performing debugging, and looking back because the comprehension and transformation processes operate earlier than the process skills. It is also because the proportion of comprehension and transformation errors experienced by students in this study is relatively high.

Debugging or simulation is the process of assessing a created program (Azmi & Ummah, 2021), such as a mathematical model. It is one of the stages in computational thinking (Yuntawati, Sanapiah, & Aziz, 2021). While computational thinking is a method of problem-solving (Supiarmo, Mardhiyatirrahmah, et al., 2021; Supiarmo, Turmudi, et al., 2021). This result is crucial because it may be utilized by teachers to plan how the mathematics learning process should be carried out utilizing multiple learning components tailored to the needs of individual students.

CONCLUSION AND SUGGESTION

According to the study, there were no students that had reading and encoding problems. Reading comprehension and transformation errors are relatively common among students. Issues involving mathematics or geometry have the highest proportion of errors, with around 69.44% of all errors in answering contextual problems (25 people out of 36 students).

Even though the number of students who experienced these errors was the most minor, process skill errors resulted in the identity of the error

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model and the most significant number of causal components, namely four out of seven. It is also possible to uncover different sources of events using identity correspondence for ontological investigations. There are seven pairs in total. The dimensions of cognitive processes and procedural knowledge include the sources of events and their consequences. The phenomenological reduction of the seven correspondence identities resulted in a synthesis revealing that students' learning processes were not always centered on higher-order thinking processes but rather on procedural knowledge dimensions. Therefore, as an appropriate suggestion, when students encounter understanding or transformation issues, they must be encouraged to make constructive attempts, and carry out debugging to test problem-solving programs as part of the learning stimulus.

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