ANALOGY PROBLEM POSING FOR ELEMENTARY SCHOOL STUDENTS ON WORD PROBLEMS

Septina Risma Yunita¹, Mohammad Faizal Amir²
¹,²Universitas Muhammadiyah Sidoarjo
Email: septinarismayunita.umsida@gmail.com, faizal.amir@umsida.ac.id

Abstract
This study aims to determine the analogy characteristics of elementary school students in proposing word problems. Analogical reasoning is a complex process that involves retrieving structured knowledge from long-term memory, representing and manipulating role-filling ties in working memory, identifying elements that play appropriate roles, generating new conclusions, and learning abstract schemes. The characteristics of analogy are categorized into four: (1) reformulation, rearrangement of information by changing the order of numbers but still paying attention to the order of mathematical operations. (2) reconstruction, Students rearrange information in the initial problem so that the problem appears different but is identical to the initial problem. (3) reproduction, the resulting product creates a new problem that is different by changing the structure of the initial problem. (4) imitation, changing the structure of the given problem by expanding the goal statement so that the initial problem becomes a step of the solution process of the new problem. Students' failure in making problem posing is included in non-reformulation, where students cannot make problem posing on word problems according to the problem structure.

Keywords: Characteristics, analogies, elementary school students, mathematics, problem posing

Penelitian ini bertujuan untuk mengetahui karakteristik analogi siswa sekolah dasar dalam mengajukan word problems. Penalaran analogi adalah proses kompleks yang melibatkan pengambilan pengetahuan terstruktur dari memori jangka panjang, merepresentasikan dan memanipulasi ikatan pengisi peran dalam memori kerja, mengidentifikasi elemen yang memainkan peran yang sesuai, menghasilkan kesimpulan baru, dan mempelajari skema abstrak. Karakteristik analogi dikategorikan menjadi empat, yaitu (1) reformulasi, penataan ulang informasi dengan mengubah urutan angka tetapi tetap memperhatikan urutan operasi hitung matematika. (2) rekonstruksi, siswa mengatur ulang informasi dalam masalah awal sehingga masalah tampak berbeda, akan tetapi sebenarnya identik dengan masalah awal. (3) reproduksi, produk yang dihasilkan membuat masalah baru yang berbeda dengan mengubah struktur masalah awal. (4) imitasi, mengubah struktur masalah yang diberikan dengan memperluas pernyataan tujuan sedemikian rupa sehingga masalah awal menjadi langkah proses solusi dari masalah baru. Kegagalan siswa dalam membuat pengajuan masalah termasuk dalam non-reformulasi, dimana siswa tidak dapat membuat pengajuan masalah pada word problems sesuai dengan struktur masalah.

Kata kunci: Karakteristik, analogi, siswa sekolah dasar, matematika, pengajuan masalah

Received: March 30, 2023 / Accepted: April 17, 2023 / Published Online: April 30, 2023
INTRODUCTION

Students generally learn math by solving problems given by teachers or obtained from books. But in addition to problem-solving, problem posing, where students create their own problems, has also been identified as an important activity in mathematics education (Kojima et al., 2013). Using problem posing as an instructional objective to have students respond to various problem posing prompts (Stoyanova, 2005). Problem posing as a process where, based on experience, students construct personal interpretations of concrete situations and formulate them as meaningful mathematical problems (Baumanns & Rott, 2022a). A mathematics learning approach that seeks to engage students in more authentic experiences with inquiry in mathematics should provide students with opportunities to explore, make conjectures, and pose meaningful problems (Singer et al., 2015).

Analogical reasoning is widely recognized as a feature of human intelligence, and thus its development is a critical topic. Analogical reasoning allows one to make connections between the transfer of solutions from a known problem to a new problem for which the solution is unknown (Kristayulita et al., 2018). Analogical reasoning is a complex process involving retrieving structured knowledge from long-term memory, representing and manipulating role-filling ties in working memory, identifying corresponding elements, generating new inferences, and learning abstract schemas (Holyoak, 2012).

Problem posing refers to both the creation of new problems and the reformulation of given problems. In the first case, problem posing is a divergent task with several possible answers. Problem posing as the generation of new problems and reformulation of given problems. These activities can occur before, during, or after the problem-solving process (Baumanns & Rott, 2022b). A reasoner must see the similarity of the relational structure between the known problem (source problem) and the new problem (target problem) and the alignment structure between the two problems to be found (Gentner et al., 2016). Papadopoulos et al. (2022) expanded the definition of problem posing into five categories: only generating new problems, only reformulating given problems, both generating and reformulating problems, asking questions, and modeling. Problem posing in this study refers to the first category, namely the construction of problems that demand solutions.

Word problems are math exercises in which important background information related to the problem is presented as text written in natural language rather than in mathematical notation (Mandal & Naskar, 2019). Relevant knowledge for solving word problems consists of three aspects: understanding the problem, the solution procedure, and the comprehensive mental representations available from different problem categories beyond individual problem representations and solution procedures (Scheiter et al., 2010). Word problems have been included to achieve several goals, the most important of which is to offer practice for everyday situations in applied problem-solving and mathematical modeling, where students will need what they have learned in school. They also serve
other purposes, namely motivating students to learn mathematics, training students to think creatively and develop problem-solving abilities, as well as assisting the development of new mathematical concepts and skills (Verschaffel et al., 2020).

Elementary school students have difficulty solving simple analogy problems even before age 9 (Gray & Holyoak, 2021). Analogy problems consist of source problems and target problems. The source problem has the characteristics of being given before the target problem in the form of easy and medium problems. It can help solve the target problem or as initial knowledge of the target problem. While the target problem has the characteristics of a modified or expanded source problem, the structure of the target problem is related to the structure of the source problem and in the form of a complex problem (Kristayulita et al., 2017).

Learners have difficulty in problem posing, especially when formulating an appropriate problem-solution structure (Kojima et al., 2013). There are two ways to problem posing: (1) it is impossible to complete problem-solving tasks without asking new questions; for example, when solving problems, we ask questions such as 'what if' or 'what will happen if'. Thus asking questions is part of every problem-solving process, (2) problem posing is related to problem-solving because the mathematical activity of posing problems deepens students’ understanding of mathematical content and their understanding of the problem-solving process (Palmér & van Bommel, 2020).

The problem of elementary school students in solving word problems lies in the ability to understand the structure of mathematical problems contained in the text of the problem. Difficulty understanding the problem’s structure is the cause of errors in choosing a solution strategy (Bernardo, 1999). When people try to understand word problems, they try to align semantic relationships that cannot or should not be aligned with the mathematical structure of the problem. As a result, they conclude (incorrectly) that mathematically isomorphic base problems and target word problems are different in their mathematical structure (Gentner et al., 2016).

Analogical reasoning is essential in elementary school students’ thinking in proposing word problems. The analogy is a form of similarity or similarity of properties. Orgill and Bodner (2006) state that analogy is a comparison between two elements that are not similar or completely different, which is used to introduce the transfer of a system of relationships between elements in the familiar source of analogy to unfamiliar target elements. Problem posing is generally applied to three quite distinct forms of mathematical cognitive activity: (a) pre-solution posing, where one generates an original problem from a presented stimulus situation; (b) within-solution posing, where one reformulates the problem as it is being solved; and (c) post-solution posing, where one modifies the goal or conditions of an already solved problem to generate a new problem (Silver & Cai, 1996). Problem posing involves formulating new problems and reformulating given situations. Students may create new problems when they solve complex problems. They might reformulate to reduce the size of
the numbers involved or investigate a particular case of a given situation to understand the problem better (Mallart et al., 2018).

According to previous research, students through reproduction learning can facilitate the adaptation of ideas embedded in the solution structure of an example into students' problem posing. For example, reproduction allows students to reuse the ideas used to structure the solution to an example (Kojima et al., 2013). These studies discuss analogy but not characteristics, so research is needed regarding the characteristics in proposing word problems by elementary school students.

This research describes analogy problems as a characteristic of word problems by elementary school students. The urgency of the problem in-word problems by elementary school students is that students can feel the structure of the problem by creating their problems through analogy. This study aims to investigate the analogical reasoning of elementary school students in problem posing and self-made problem-solving. This research can provide an idea to apply problem posing to make the learning process more meaningful. To benefit from learning with problem posing, students must be involved in constructing appropriate and effective problems (Kojima et al., 2013).

METHODS

Research Design

This research uses a qualitative approach, which is a study that examines the quality of relationships, activities, situations, or various materials. This means that qualitative research emphasizes holistic descriptions, which can explain in detail what activities or situations are taking place rather than comparing the effects of certain treatments, or explaining people's attitudes or behavior (Fadli, 2021).

Research Subject

The prospective subjects of this study were grade V students of SDN Bulusidokare. The selection of research subjects used a purposive sampling technique. The purposive sampling technique takes research subjects who fall into the criteria under the research needs and are determined to be research subjects. Subjects were taken with the provisions (1) students can answer the source problem correctly, (2) Students can propose word problems correctly, (3) the answer to the target problem must be correct.

Instruments and Research Indicators

This research instrument is in the form of written tests and interview guidelines that function as research tools. The written test was used as written data of students' strategies in proposing word problems. The interview test was used to determine the strategies students used in proposing word problems. The written test consisted of 1 arithmetic problem, adapted from Kojima et al. (2013) by
adjusting the arithmetic material in grade V elementary school. The interview guideline contains questions about the difficulties experienced by students in problem posing and problem-solving.

Table 1. Word problems submission test

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rina has 5 baskets of oranges. Each basket contains 8 oranges. Then she bought another 14 oranges.</td>
</tr>
<tr>
<td>If all the oranges are distributed to 6 of her friends, how many oranges will each person receive?</td>
</tr>
</tbody>
</table>

This research will describe the characteristics of analogy elementary school students in word problems. The characteristics in this study are theoretically built from four characteristics of Kojima et al. (2013) and Stoyanova's (2005) strategy descriptors consisting of reformulation, reconstruction, and imitation. Hence, the characteristics of problem posing consist of reconstruction, reformulation, reproduction, and imitation.

Table 2. Characteristics of analogy by Kojima et al. (2013)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Description</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reformulation</td>
<td>The resulting product is the same or identical to the given problem and differs from the initial problem only in the presentation of information in the problem statement.</td>
<td>- Rearranging information.</td>
</tr>
<tr>
<td>Reconstruction</td>
<td>The resulting product is obtained by modifications to the original problem that change the problem situation but do not create a new solution.</td>
<td>- Changing and modifying the nature of the given problem.</td>
</tr>
<tr>
<td>Reproduction</td>
<td>The resulting product is obtained by modifying the original problem and creating a new solution by changing the nature of the problem.</td>
<td>- Provide different situations and solutions.</td>
</tr>
<tr>
<td>Imitation</td>
<td>The resulting product is derived from indicating problems generated by combining changes in situations and solutions, adding structures relevant to previously encountered or solved problems.</td>
<td>- Expanding the problem structure by changing the objective</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Connecting with previously learned material.</td>
</tr>
</tbody>
</table>
Research Procedure

This research procedure follows data collection steps by giving tests and interviews. The first step is giving tests to all students to get selected subjects according to predetermined criteria. The second step is to ask the chosen subjects to conduct interviews when the subjects solve and propose problems using interview guidelines.

Data Analysis

The data analysis technique used in this research is data analyzed with qualitative data analysis techniques developed by Milles & Huberman (1994). The method used was data reduction, data presentation, and conclusion drawing and verification. The collected data was examined using triangulation techniques. Data validity was ensured by triangulating techniques, namely by comparing data obtained from test results, interviews, and observations (Sudarsono, 2014).

RESULTS AND DISCUSSION

Based on the research results from 19 prospective subjects, 6 subjects can propose and answer problems correctly. Some students have not been able to convert word problems into mathematical calculation operations, students have difficulty in making problem posing on word problems, and students' difficulties in answering problems they create themselves. However, the other 6 students succeeded in answering and posing problems in word problems. Students create word problems that are identical to the source problem by changing objects and numbers but still paying attention to the order of the mathematical operation system. Students tend to create problems by imitating existing problems. Because students' answers use the same problem and solution as the original problem, it can be identified that the characteristics of analogy elementary school students belong to the reformulation category.

Reformulation

Reformulation is students' ability in problem-solving that is almost the same as the initial problem given. The difference in problem posing made only in the presentation of information in the problem statement without changing the situation and solution of the initial problem.
In the test results S1 can solve math problems correctly, S1 can propose word problems according to the instructions in the problem. In the first step, S1 answers the test question correctly according to the instructions, "5x8 = 40 + 14 = 54: 6 = 9 oranges. Then each person receives 9 oranges." The researcher asked whether S1 understood the problem that had been given. S1 said, "understand". S1 also mentioned, "The first time it was difficult to do it. But now it's not hard." In this case, S1 said he could do the problem because he had gotten the same problem before.

In the second step, S1 is asked to propose word problems according to the material given and answer the problems created. In this step, S1 imitate the initial source problem with the object "orange fruit" to "watermelon fruit". The structure of the problem posed by S1 is no different from the initial problem. In proposing word problems, S1 said, "not difficult". S1 has no difficulty in proposing word problems under the problem instructions.

In the third step, S1 was asked to answer the problem, "4x7= 28+2= 30:5= 6 watermelons. Then each person receives 6 watermelons." In S1's answer, there is a similarity in the calculation operation. S1 changes the numbers but maintains the order and type of mathematical operations. S1 test results write in detail and correctly about what is known in the problem, propose and answer word problems.

Non-reformulation

Non-reformulation is students' ability in problem-solving that is almost the same as the initial problem given. Still, the problem posing proposed is not under the problem structure.
In the test results, S2 can solve math problems correctly, but S2 cannot propose word problems according to the instructions in the problem. In the first step, S2 answered the test question correctly according to the instructions, "5x8 = 40 + 14 = 54; 6 = 9 oranges". In the second step, S2 could not create the problem correctly, "Mala has 10 mangoes, each mango contains 5 mangoes" In the problem sentence proposed by S2, it is known that students have not been able to create problem posing according to the problem structure.

The test results of S3 in solving and proposing problems are S3 can solve the problem correctly, S3 can propose problems under the structure of the problem but has not been able to solve the problems it creates itself, "4x6 + 15; 6 = 6.5." In the answer to the word problem submission submitted
S3 has not been able to solve the problem he created himself. "Baho has 10 baskets of apples; each basket contains 6 apples." S3 writes math arithmetic operations with different numbers on his created problems. However, S3’s answer still applies the sequence of mathematical operations under the test question.

Table 3. Characteristics of word problems

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Description</th>
<th>Sub-description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reformulation</td>
<td>The resulting product is the same or identical to the given problem without changing the situation and solution of the original problem.</td>
<td>- Rearrangement of equal or identical information.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Replacing base information with equivalent expressions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Maintaining the order of math arithmetic operations</td>
</tr>
<tr>
<td>Non-reformulation</td>
<td>The products produced are the same or identical to the given problem but have not been able to propose problems according to the problem structure.</td>
<td>- Rearrangement of equal or identical information.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Replacing base information with equivalent expressions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Unable to produce the item in accordance with the provided instructions.</td>
</tr>
</tbody>
</table>

Discussion

The results show that in the research subjects (based on word problems submission), there are students who can submit word problems under the instructions (reformulation) and students who have not been able to pose or answer their problems (non-reformulation). Two characteristics of the problems posed by the participants were analyzed through their diversity and the strategies used to reformulate the solutions of the bases given in the problem posing test. The problems posed were categorized according to analogy characteristics according to the structure of the problem, and the solution was the same or different from the source problem.

First, in reformulation, students propose problems identical to the source problem. Students create problems by changing objects, replacing base information with equivalent expressions, and changing numbers but still paying attention to the order of the mathematical operating system. Students tend to create problems by imitating existing problems according to the transfer of ideas in the example. The specific similarities between the source problem and the target problem that students can identify through analogical reasoning help students solve the target problem (Kristayulita et al., 2018). According to Kojima et al. (2013), a student reproduces problems identical to the examples presented by following the information generation process. The built-in support system provides the learner with
various ideas about problem posing through learning by reproducing examples.

Second, in non-reformulation, students propose problems almost the same as the initial problem. However, students still struggle to propose word problems and answer problems they create themselves. Students can pose word problems by learning ideas from the source problems that have been done. Even if they are given examples that can serve as clues to structure, they cannot directly learn the ideas by looking at the examples (Kojima et al., 2013). Sari & Aripin (2018) stated that the difficulties experienced by students in understanding the commands, doubts, and inability to interpret the word problems contained in the problem. Students also feel confused by the form of the problem given. Lack of concentration when performing calculations results in errors in obtaining results. In problem posing, students need knowledge that allows them to handle the cognitive tasks involved in problem posing. Students must understand what a problem is, recognize its structure, and identify similar structures to create new problems (Mallart et al., 2018). This is because students need knowledge that allows them to get tasks that help students in posing problems.

CONCLUSIONS

Based on the study's results, elementary school students can propose word problems in accordance with the problem structure and can solve problems created by themselves. Meanwhile, some students can propose problems but have been unable to solve the problems they create themselves as well as some students cannot make problem posing under the problem structure but can answer the problem. Understanding through examples helps generate various situations but cannot always provide a structural understanding of the solution. Therefore, by understanding various types of problems, students will be able to understand mathematical situations, improve their ability to create new problems and solve problems.

REFERENCES


