Students' errors in solving mathematical story problems based on Polya's solution steps

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DOI: https://doi.org/10.31980/pme.v3i1.1779

Submission Track:
Received: 10-01-2024 | Final Revision: 14-02-2024 | Available Online: 28-02-2024

How to Cite:
Aeni, T. N. (2024). Students' errors in solving mathematical story problems based on Polya's solution steps. *Jurnal Inovasi Pembelajaran Matematika: PowerMathEdu (PME)*, *3*(1), 113-126.

Abstract
When given math problems in the form of story problems, many students make mistakes when solving them. This study aims to determine the location of student's mistakes in solving math story problems based on Polya solving steps. This type of research used in this research is descriptive research with a qualitative approach. The subjects of this study were 3 students from class X in Neglasari Village, Kadungora District, Garut Regency. Data collection procedures through interview tests and field notes. The stages of data analysis are data reduction, data presentation and conclusion drawing. Based on the results of the study, it showed that the errors of students at the stage of understanding the problem were 26%, errors at the planning stage of the completion plan were 7%, errors at the stage of completing the plan were 26%, and errors at the re-checking stage were 36%, These errors included not writing or being wrong in writing down what is known and asked, being unable to make mathematical models, being wrong in calculations, not writing conclutions and not checking answers.
Keywords: Errors Analysis; Mathematical Story Question; Polya Solving Steps

Abstrak
Pada saat diberikan persoalan matematika dalam bentuk soal cerita, banyak siswa yang melakukan kesalahan pada saat menyelesaikannya. Penelitian ini bertujuan untuk mengetahui letak kesalahan siswa dalam menyelesaikan soal cerita matematika berdasarkan langkah penyelesaian Polya. Jenis penelitian yang digunakan dalam penelitian ini adalah penelitian deskriptif dengan pendekatan kualitatif. Subjek penelitian ini adalah 3 orang siswa dari kelas X yang ada di Desa Neglasari Kecamatan Kadungora Kabupaten Garut. Prosedur pengumpulan data melalui tes, wawancara, dan catatan lapangan. Tahap-tahap analisis data adalah reduksi data, penyajian data, dan penarikan kesimpulan. Berdasarkan hasil penelitian menunjukkan kesalahan siswa pada tahap memahami masalah sebesar 26%, kesalahan pada tahap merencanakan rencana penyelesaian sebesar 7%, kesalahan pada tahap menyelesaikan rencana sebesar 26%, kesalahan pada tahap memeriksa kembali sebesar 39%. Kesalahan-kesalahan tersebut meliputi: tidak menuliskan atau keliru dalam menuliskan apa yang diketahui dan ditanyakan, tidak mampu membuat model matematika, keliru dalam perhitungan, tidak menulis kesimpulan, dan tidak memeriksa kembali jawaban.
Kata Kunci: Analisis Kesalahan; Soal Cerita Matematika; Langkah penyelesaian Polya

Introduction

Mathematics is a subject that needs to be learned by students, because in everyday life students are always in touch with the application of mathematics. According to Ariani (2016) mathematics is a thinking tool used to learn something in a logical and systematic way. Therefore, efforts are needed to improve the quality of mathematics education.

One of the basic skills that students must have in learning mathematics is problem-solving skills. As stated by Branca (in Putra, Thahiram, Ganiati, & Nuryana, 2018) that problem-solving skills must be mastered by every student because they are basic skills and the heart of mathematics.

According to Effendi (2012) by having problem-solving skills, students will be accustomed to facing problems, whether related to mathematics, other studies or problems in daily activities. This means that every student is required to have good problem-solving skills so that they can solve various problems in their lives.

Mathematics problem-solving questions are generally in the form of story problems. According to Hartini (in Yuwono, Supanggih, & Ferdiani, 2018) story problems are a type of question that presents mathematical problems where the problems are related to problems in students' daily lives. By providing mathematical problems in the form of stories, it can provide knowledge for students to be able to solve mathematical problems and can provide an idea of the relationship between these problems and students' daily lives (Handayani, 2017).

According to Khasanah & Sutama (2015) there are three aspects in solving problems in the form of story problems, namely language, prerequisite, and application aspects. In the language aspect, there is the ability to read to interpret the problem and the ability to reason to find out the meaning of the problem given. The prerequisite aspect is the ability to change the problem in the question into a mathematical sentence and determine the plan to be used and the application aspect is the ability to calculate correctly when using the formula.

But in fact, when given a mathematical problem in the form of a story problem, many students find it difficult. According to Huda & Kencana (2013) the difficulties often experienced by students when working on story problems are understanding the problem given, interpreting the problem into a mathematical sentence and making an analogy.

This is shown from an interview conducted by Paola, Doren & Farida (2019) with a mathematics teacher that in working on story problems, students experience difficulties so that they tend to make mistakes, and students also often complain to teachers when given story problems because there are many readings so that students feel bored when reading the questions. Likewise with the results of research conducted by Rofi'ah, Ansori, & Mawaddah (2019) regarding student errors in solving mathematical story problems are:

(1) errors in understanding the problem, as many as 20.65% of students did not include complete data that was known and asked; (2) errors in the planning step, as many as 26.18% of students were incomplete and made mistakes in writing the formula so that it caused errors in the next step; (3) errors in the planning completion step, as many as 26.39% of students made errors in arithmetic operations; (4) errors in the rechecking step, as many as 26.74% of students drew the wrong conclusions due to errors in the previous step and it was also found that several students did not write conclusions. From the results of previous studies, it can be seen that students tend to make mistakes when solving problems in story form, however, in this study, researchers analyzed students' errors in solving story problems in a pandemic situation where students were learning online.

According to Malau (in Umam, 2014) students' errors in solving story problems are caused by students' lack of understanding of previous material, lack of understanding of the problem, errors in using formulas and calculations, and misconceptions. This means that students' understanding of previous material is very necessary because in learning mathematics from one material to another, they are interconnected.

Thus, to be able to overcome these errors, error analysis is needed (Hidayah, 2016). Error analysis is an examination of an error or mistake experienced by students when working on questions (Rahmania & Rahmawati, 2016). According to Umam (2014) by conducting error analysis, teachers can see students' weaknesses in solving the problems given.

Analyzing errors is very important to do, because if students' errors are known, it will certainly be easier to find solutions so that it can improve students' mastery of the material. (Katon & Arigiyati, 2015). So, this study aims to determine the location of students' errors in solving story problems. To be able to analyze the location of the error, special steps are needed in solving problem-solving problems, one of which is by using Polya's solution steps. According to Polya (in Nuryah, Ferdianto, & Supriyadi, 2020) the steps in problem solving include: 1) understanding the problem; 2) planning problem solving; 3) implementing the solution plan; 4) re-checking the solution obtained.

Method

The type of research used in this study is descriptive research with a qualitative approach. In this study, the types of errors and percentages of each type of error made by students in solving mathematical story problems based on Polya's solution steps on the subject of the Three Variable Linear Equation System (SPLTV) were analyzed. The subjects of this study were high school students in grade X in Neglasari Village, Kadungora District, Garut Regency. Where from all the grade X students, 3 students were taken as research subjects. The subject selection technique in this study used the Purposive Sampling

technique, the researcher chose subjects whose learning achievements were classified as high, medium, and low. This research was conducted on Saturday, January 2, 2021 in Neglasari Village, Kadungora District, Garut Regency. The data collection technique from this study was in the form of a written test of 2 questions, interviews and field notes. The data analysis techniques used were data reduction, data presentation, and drawing conclusions.

Result

The researcher has 3 subjects, namely: (1) S1, namely students who have high mathematics learning achievements, (2) S2, namely students who have moderate mathematics learning achievements, and (3) S3, namely students who have low mathematics learning achievements. The following are the results of the job analysis of the 3 subjects in story question number 1.

1. Highly capable students

Figure 1. Answer to the first question S1

Based on Figure 1, the test results of high-ability students, it can be concluded that high-ability students when completing question number 1 were able to solve the given problem and get the requested results correctly, but not in accordance with Polya's 4 steps of solving. Where in the question the students already understand the problem, but do not write down what is known and asked, then the students do not write down the final

conclusion, and the students do not recheck their answers. This can be seen from the results of interviews with high-ability students below:

P: "From question number 1, what is known and asked?"
S1: "what is known is that Nana bought 3 kg of apples, 3 kg of oranges and 1 kg of rambutans for Rp. 141,000.00 then Tata bought 2 kg of apples, 4 kg of oranges and 2 kg of rambutans for Rp. 174,000.00 while Huta bought 3 kg of apples, 2 kg of oranges and 2 kg of rambutans for Rp. 171,000.00, then what is asked is if you have to buy 2 kg of apples, 2 kg of oranges and 2 kg of rambutans how much do you have to pay?"
P: "why not write it in the answer?"
S1: "because it's too long sis"
P: "so what is the final conclusion of question number 1?"
S1: "so Haru has to pay Rp. 114,000.00"
P: "why not write the conclusion?"
S1: "I forgot, bro"
P: "Did you check the answers again after you finished working?"
S1: "No, bro"
P: "Why?"
S1: "Not usual, bro"

Based on the results of the conversation that has been conducted by the researcher with students, it can be concluded that students have understood the problems given but students do not write down what is known and asked because students feel that writing what is known and asked is too long, students also do not write down the final conclusion of what is asked because they forget and students do not check their answers again because students are not used to checking their answers.

Based on what the researcher observed during the study, high-ability students read the questions repeatedly, then students saw the examples given by the teacher and started working on the questions, students looked focused on working on the questions, did not glance left and right, and took pictures, students did not seem to have a problem with question number 1.

2. Students with moderate abilities

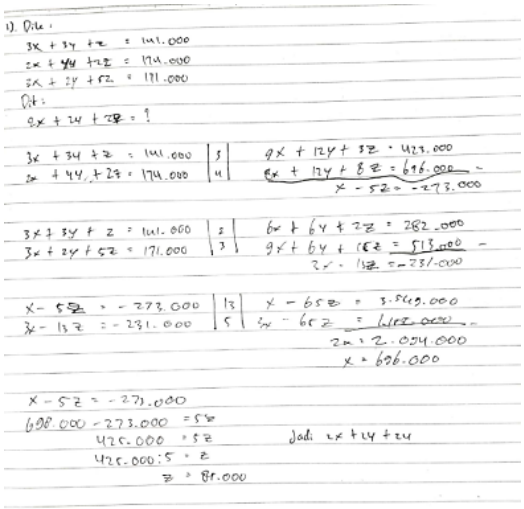

Figure 2. Answer to the first question S2

Based on Figure 2, the test results of students with moderate abilities, it can be concluded that students with moderate abilities when solving question number 1 are already able to understand the problem given but the solution is not in accordance with Polya's 4 steps of solving, when writing what is known and asked, students write their mathematical model directly, then students make mistakes at the stage of completing the solution plan, where in the question the student made a mistake in the calculation so that the student could not solve the problem and the student also made mistakes at the stage of rechecking because they did not recheck their answers. This is shown from the results of interviews conducted by researchers with students with moderate abilities below:

P: "From question number 1, what is known and asked?"
S2: "it is known that 3x+3y+z=141,000, 3x+4y+2z=174,000, 3x+2y+5z=171,000, what is asked is 2x+2y+2z"
P: "if that is the name of the mathematical model, so before that you have to write down what is known and asked first, make an example, then make the model"
S2: "oh yeah sis, I thought that was it"
P: "number 1 why wasn't the work completed?"
S2: "because I was confused sis, the results of x and z were too big, it seems like I made a mistake in the calculation so I didn't continue and I didn't correct it because I was afraid of not being able to do it in time"
P: "did you find it difficult when calculating?"
S2: "yeah sis, I wasn't focused so I kept calculating wrongly"

Based on the results of the conversation, it can be concluded that students with moderate abilities have understood the problems given but students are wrong in writing what is known and asked because students are not used to it, students also make mistakes at the stage of completing the plan because they are not focused so they make mistakes in the calculations, students also do not check their answers again because students are in a hurry.

Based on what the researcher observed during the study, students with moderate abilities read question number 1 repeatedly, looked at examples, but students seemed unfocused in working on it, students often glanced left and right and asked their friends, students took pictures, but students looked troubled and often careless in calculations so they often changed their answers, students seemed unsure of their answers.

3. Low ability students

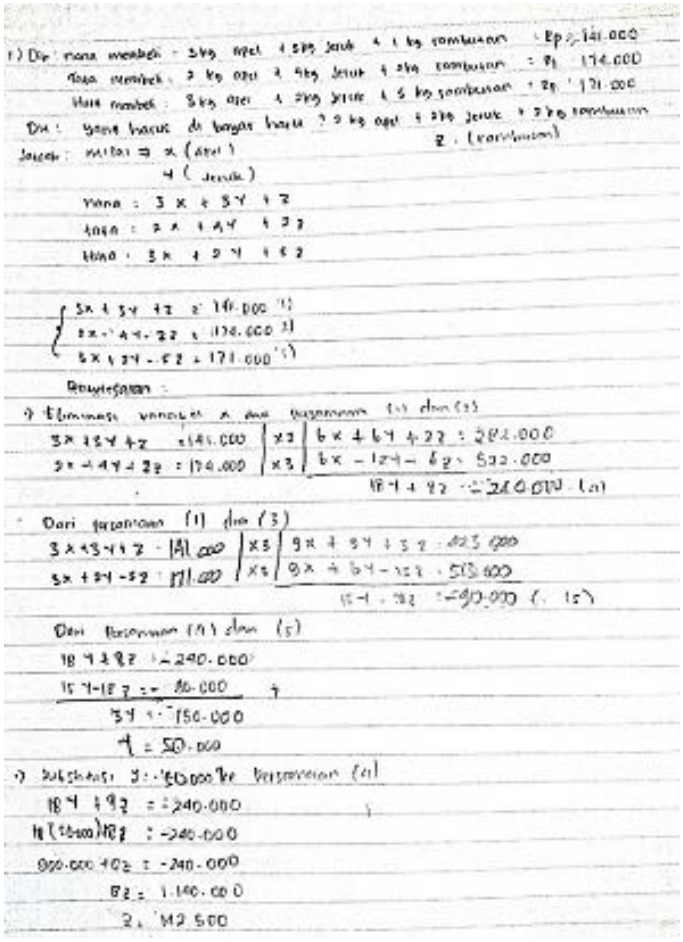

Figure 3. Answer to the first question S3

Based on Figure 3, the test results of low-ability students, it can be concluded that in the first question, low-ability students were able to understand the problem and make a solution plan but made a mistake at the stage of completing the plan and the students did not check their answers again. This is shown from the results of interviews conducted by researchers with low-ability students below:

P: "This is number 1, why did the sign change when it was eliminated?"

S3: "Oh yeah, sorry I wasn't focused"

P: "Why didn't you finish the work?"

S3: "Because I wasn't sure about the results, so I didn't continue"

P: "Why didn't you check it again?"

S3: "Yes, I was in a hurry."

Based on the results of the conversation, it can be concluded that low-ability students already understand what is known and asked but students make mistakes at the stage of completing the plan because they are not focused and not sure, students also do not check their answers again because students are in a hurry so students prefer not to continue their work

Based on what the researcher observed during the study, low-ability students when given questions, students only read the questions briefly, then students start working on question number 1 by following the example, but students look confused and have problems, students look unfocused and often silent, students do not take pictures.

The following are the results of the job analysis of the 3 subjects on story question number 2.

1. Highly capable students

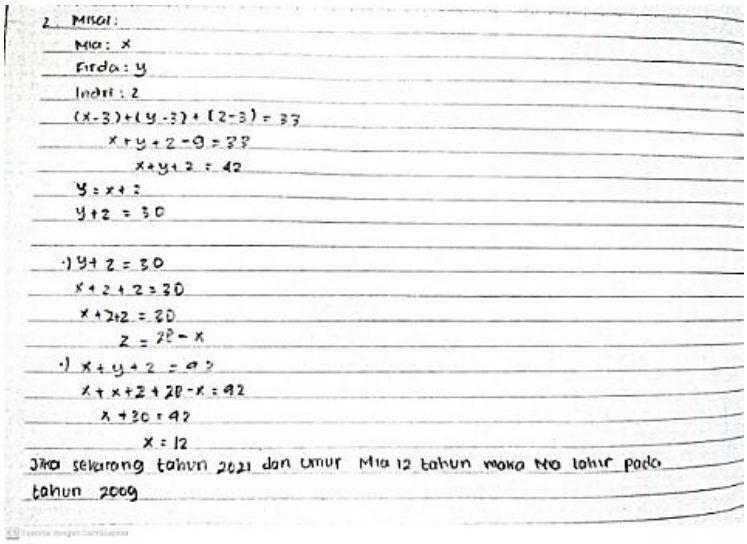

Figure 4. Answer to the first question S2

Based on Figure 4, the test results of high-ability students, it can be concluded that high-ability students when completing question number 2 were able to solve the given problem, but not in accordance with Polya's 4 steps of solving. Where in the second question, students were able to understand the problem, but did not write down what they knew and asked, and did not recheck the answers. This is shown from the results of interviews conducted by researchers with low-ability students below:

P: "Why aren't the known and asked questions written down?"
S1: "Because it's too long, bro"
P: "Are there any difficulties in understanding question number 2?"
S1: "Yes, bro, because the question is a little different from the example, so it takes quite a long time to understand"
P: "Did you check the answer again after you finished?"
S1: "No, bro, because you felt it was correct"

Based on the results of the conversation, it can be concluded that students do not write down what is known and asked because it is too long so that students feel lazy to write it down and then students do not check their answers again because students feel that what they have done is correct.

Based on what the researcher observed during the study, high-ability students when working on question number 2 focused on working on it but looked a little problematic

because the questions given were slightly different from the examples so that students spent a lot of time reading the questions repeatedly.

2. Students with moderate abilities

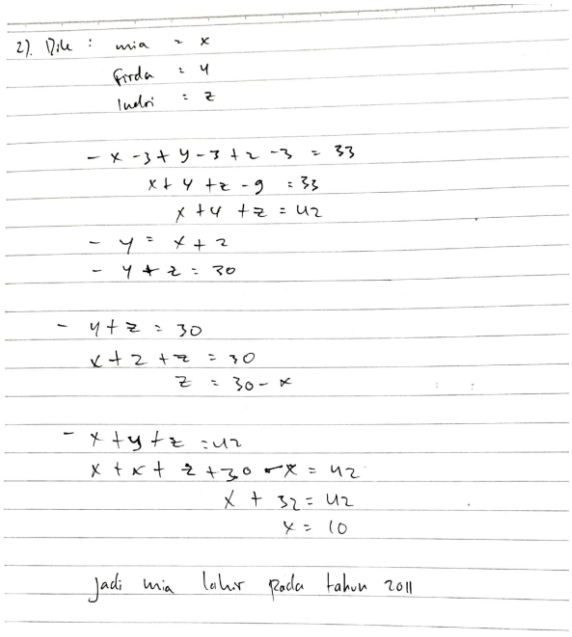

Figure 5. Answer to the second question S2

Based on Figure 5, the test results of students with moderate abilities, it can be concluded that students with moderate abilities when completing question number 2 are able to understand the problem given but the solution is not in accordance with Polya's 4 steps of solving, when writing what is known and asked, students write their mathematical model directly, then students make mistakes at the stage of completing the solution plan, where in the question the student made a mistake in the calculation so that the student could not solve the problem and the student also made mistakes at the stage of checking again because he did not check his answer again. This is shown from the results of interviews conducted by researchers with students with moderate abilities below:

P: "Number 2, why is the model directly known?"
S2: "Yes, I thought it was written in the known and asked"
P: "Why is this still 30? Shouldn't it be reduced by 2?"
S2: "Oh, yes, wrong"
P: "Did you check the final result again?"
S2: "No, I thought it was correct"

Based on the results of the conversation, it can be concluded that students with moderate abilities have understood the problems given but students are wrong in writing what is known and asked because students are not used to it, students also make mistakes at the stage of completing the plan because they are not focused so they are wrong in calculating, students also do not check their answers again because students feel that their work is correct.

Based on what the researcher observed during the study, students with moderate abilities read question number 2 repeatedly, but students did not seem focused in working on it, students often glanced left and right and asked their friends, students took pictures, and students looked sure of the answer to number 2.

3. Low ability students

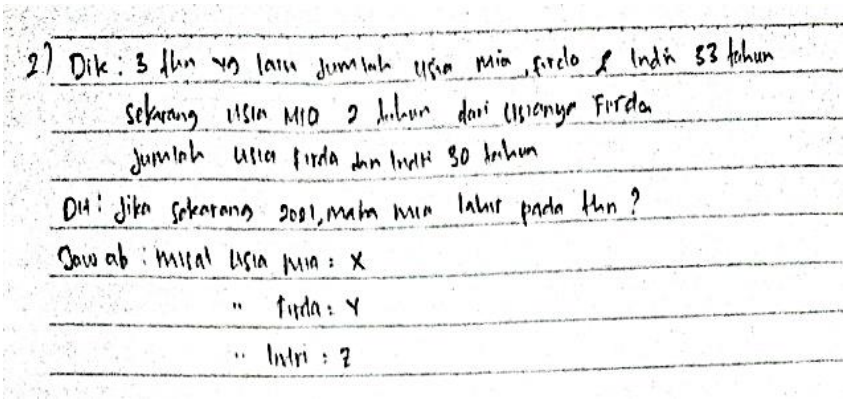

Figure 6. Answer to the second question S3

Based on Figure 6, the test results of low-ability students, it can be concluded that low-ability students when completing question number 2 were able to understand the problem but students were unable to make a solution plan, so students were also unable to complete the solution plan and recheck. The following are the results of interviews with low-ability students.

P: "Have you ever seen this problem before?"
S3: "No"
P: "Why didn't you finish the work?"
S3: "Yes, because I was confused because it was different from the example"

Based on the results of the conversation, it can be concluded that low-ability students have understood the problems given but are unable to make a solution plan because they feel confused because the questions given are different from the examples, meaning that students do not understand the concept of SPLTV, so students also make mistakes at the stage of completing the plan and checking again.

Based on what the researcher observed during the study, low-ability students took a moment to read question number 2, students were not focused, students looked troubled and students did not have the desire to try to do it.

Table 1. Recapitulation of student errors

Subject	Percentage			
	T1	T2	T3	T4
S-1	13%	0%	0%	13%
S-2	13%	0%	13%	13%
S3	0%	7%	13%	13%
Total	26%	7%	26%	39%

Description:

S1 : Highly capable students

S2 : Moderate capable students
S3 : Low capable students
T1 : Stage of understanding the problem
T2 : The completion planning stage
T3 : Stage of completing the plan
T4 : Recheck stage

Discussion

Based on the test results that have been presented, high-ability students have been able to solve the problems given but not in accordance with Polya's solution steps, students have understood the problem but did not write down what is known and asked, then students also did not check their answers again, this happens because students are not used to solving story problems systematically. This is in contrast to the results of research conducted by Nurhasanah (2019) which states that high-ability students are able to work on story problems completely and systematically. Meanwhile, students with moderate abilities are able to understand the problems given but are wrong in writing down what is known and asked, students immediately write mathematical models on what is known and asked, then students also make mistakes at the stage of completing the plan because students are careless in their calculations, this is in line with research conducted by Rusmawati, Utami, & Senjayawati (2018) that the cause of students making mistakes when solving story problems is that students are not careful in the steps of the work and assume that some steps do not need to be written in full. And also when given a different question with the example of a student with medium ability feeling confused, the student also does not check the answer again, this is because the student is in a hurry to do it and the student is also not used to working on questions systematically. While students with low ability already understand the problem given, but cannot plan a solution plan, meaning that students with low ability still do not understand the concept of SPLTV, this is in line with research conducted by Rofi'ah, Ansori, & Mawaddah (2019) which states that several student errors were found not writing the formula, this is due to the lack of student knowledge of the related prerequisite material. This results in students being unable to proceed to the next stage.

Conclusion

Based on the research that has been conducted and the research results obtained, it can be concluded that the types and causes of errors made by students in solving mathematical story problems based on Polya's solution steps are as follows: 1) errors at

the stage of understanding the problem of 26%, the cause is that students are not used to working systematically; 2) errors at the stage of planning the solution of 9%, the cause is that students do not understand the concept of SPLTV, so that when given a problem that is different from the example, students feel confused; 3) errors at the stage of completing the plan, the cause is that students are in a hurry to work so that they make mistakes in the calculations; 4) errors at the stage of checking again of 35%, the cause is that students are not used to checking their answers and feel that what they are doing is correct.

Based on the results of the research conducted, the researcher's suggestion is that teachers should provide more frequent math practice questions, especially math story questions, so that students' abilities in solving a problem can be known, and also pay more attention to the procedure for working on story problems because few students work on story problems without using the right procedure. Suggestions for other researchers who will conduct similar research, that the results of this study are expected to provide input on the types of student errors in solving story problems.

Conflict of Interest

The authors declare that no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely by the authors.

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