Source Problem Answered False in Analogical Reasoning: Why Students Do It?

Kristayulita[1], Toto Nusantara[2], Abdur Rahman As'ari[2] and Cholis Sa'dijah[2]
[1]*Jurusan Tadris Matematika, Universitas Islam Negeri Mataram, Jln Pendidikan No.35 Mataram, Nusa Tenggara Barat, Indonesia*
[2]*Department of Mathematics, University of Malang, Jln Semarang 5 Malang, Jawa Timur, Indonesia*

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Abstract: The purpose of this study was to describe thinking processes students' in answer source problem is false and answer target problem is true. Two analogical problems, the students will solve two problems using the same procedure and have two possible answers are both is true or false. Using qualitative design approach, the study was conducted at Universitas Negeri Malang, Indonesia. The instrument used probability problems topic in conjunction with independent events. The findings of this study showed that the presence of misconceptions and errors occur in solving the problem source. Factor time can affect and there is a time lag in solving-problem of both analogical problems. Furthermore, target problem is answered correctly because the student has time to reflect on the answer to the source problem and the student improves working memory to recall the previous learning experience.

1 INTRODUCTION

Analogical reasoning is an essential ability of human cognition since analogies can be used to explain many aspects of cognitive creativity, productivity, and adaptivity. In addition, analogical reasoning is central to the learning of abstract, procedural, and mathematical ideas (Magdas 2015). Magdas (2015) adds that analogical reasoning can develop potential such as the skill of discovering similar things that are already known for new situations, skills to apply something already known for something new, and generalizability skills.

English (2004) said that solving the analogical problem can improve students' mathematical conceptual knowledge. This is reinforced by Amir-Mofidi, Amiripour, and Bijan-Zadeh (2012), by facilitating students via analogical reasoning can help students to connect new mathematical knowledge to existing knowledge, learn more about math, and math concepts in long-term memory. Alexander and Buehl (2004) found evidence that there is a relationship between analytical reasoning abilities and students' mathematical abilities in their research.

If students can do all the stages in analogical reasoning, then students can learn math more deeply and the mathematical concept can be stored in long-term memory (Amir-Mofidi, Amiripour, and Bijan-Zadeh, 2012). The analogical reasoning makes the student must find the relationship of source problems with target problems and relate to the relevant mathematical concepts (Pang and Dindyal, 2009). Therefore, students must have a strong understanding of concepts and have the skills to connect old knowledge and new knowledge (May, 2009).

Problem-solving using analogical reasoning can provide many benefits. Bernardo (2001) explains that analogical reasoning can allow students to explore and engage in searching for mathematical information that can lead students to a deeper level of understanding. Analogical reasoning is important because students must make their own discoveries, discoveries made can help students to build an understanding of new information (Bal-Sezerel and Sak 2013). In addition, students should also establish relationships between analogical problems and improve students' ability from routine problem solving to advance troubleshooting.

Chuang and She (2013a) said that analogical reasoning can develop understanding, solve problems, and conduct investigations. In solving the problem students are asked to understand the relationship between target problems and source

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problems so that the student in analogical reasoning is required to investigate activity. Students' ability to investigate analogous similarities differed by the pre-requisites of students (Holyoak, 2012).

The analogical problem consists of source problems and target problems. The existence of source problems and target problems on analogical reasoning requires students to look for similar structural relationships of similar properties so that students can solve the given target problem. So analogical reasoning provides basic cognitive tools so that students can use the new phenomenon approach and transfer the entire context (Richland, Morrison, and Holyoak, 2006). Analogical problems are expected to help students understand in solving mathematical problems. This is because analogical reasoning train students to develop problem-solving skills (Chuang and She 2013b).

English (1999) said that source problem has characteristics: (1) given before the target problem, (2) problem is easy, and (3) can help resolve target problem or as initial knowledge of the target problem. And then target problem has characteristics: (1) source problem that are modified or expanded, (2) the structure of the target problem related to the structure of the source problem, and (3) problem is complex. In this study using analogical problem were the target problem is the source problem of the modified.

The concept of work in solving analogical problem consisting of source problems and target problems are (1) the source problem is done first correctly, (2) then work on the target problem, (3) with students' knowledge, through analogy reasoning will look for similarities between source problems and target problems, and (4) the results of the conclusions summarized as the basis for solving target problems. Assmus, Forster, and Fritzlar (2014) explains there are 4 types of answers to two analogical problems are (1) the source problem and the target problem are answered correctly, (2) the source problem is answered correctly and the target problem is answered incorrectly, (3) the source problem is answered incorrectly and the target problem is answered correctly, and (4) the source problem and the target problem are answered incorrectly.

In this study will be discussed about student cannot solve the given source problem, but the target problem is solved correctly. Further this research focuses on:

1. Why do students answer source problems incorrect and then target problems correct?
2. What causes students to answer the source problem is incorrect while the target problem is correct?

2 METHOD

2.1 Research Design

The first, this study apply the descriptive quantitative for to see percentages of student answer criteria. The second, this study apply the descriptive qualitative approach for to see thinking process of students. Following are the description of the method used in this study. Creswell (2014), such research is a qualitative research. One of the characteristics of qualitative research is that the process of research is always evolving dynamically. All the stages of the research process can change after the researchers enter the field and start collecting data. For example, the individuals studied and the locations visited can also change at any time (Creswell, 2013).

2.2 Research Subject

The subjects are 33 semester V students at Universitas Negeri Malang, Indonesia. All Students have not completed the theory of probability learning in the Mathematical Statistics course.

2.3 Research Instrument

The analogical problem consists of source problems and target problems. Source problems and target problems are related to conjunction with independent two events problems. Source problems and target problems has the same resolution procedure. Analogical problems in this study can be seen in Table 1.

2.4 Research Procedure

Research is done in several stages. Stages include preparation, execution, analysis of results, and interviews.

2.4.1 Preparation

a) Subjects are given instructions to work on the problem individually.
b) Subjects are asked to carefully read the instructions and answer questions about resolving an analogical problem related to

conjunction with independent two events problem.

Table1: Conjunction with independent events problems.

Type	Question
Source Problem	There are 76 books in the Science section of the library, six of which are new. In the History section, there are 120 books, 15 of which are new. The principal randomly picks a book from each of the two sections. What is the probability that the principal picks a new from both sections?
Target Problem	There are 24 schools in District A, eight of which are public school. In District B, there are 32 schools, 12 of which are public school. For each district, a school is randomly chosen to host the district sports fest. What is the probability that a public school is chosen to the host fest in both district?

(Bernardo 2001).

2.4.2 Implementation

a) Subjects are given 45 minutes to work on resource issues related to conjunction with independent two events problem.
b) Response results of source problems were collected.
c) After 45 minutes, subjects were given 45 minutes to work on target problems in conjunction with independent two events.
d) Results of answers to target problems are collected.

2.4.3 Analysis of Results

a) The result of the subject's answers to source problems and target problems analyzed.
b) Categorize the results of the subject's answer analysis of source problems and target problem.

2.4.4 Unstructured Interviews

a) Conduct interviews on subjects who answered source problem are false and answered target problem is true.
b) Describe analogical reasoning schema that occurs on the subject.

3 RESULTS

Based on description quantitative analysis obtained the following research results. There are 33 students who participated in this study. Each student is given two problems that must be done, namely source problems (the first problem) and target problems (the second problem). Source problem given at the beginning was followed by providing a target problem. Source problem is accomplished in for 37 minutes. By an interval of 45 minutes, the student is given the target problem. For target problems, the students work for a period of approximately 15 minutes. From the student's answers, there are several mistakes made by the students.

In aggregate, approximately 69.69% have wrong answers on an analogical problem. The number of students to answer one of the first problems (source problems) was approximately 57.57%, while the second problem (target problems) was approximately 48.48% of the students. There are four criteria students answered are (1) the student who answer source problems and target problems are correct, (2) the student who answers source problems and target problems are wrong, (3) the student who answers source problems is correct and target problems is wrong, and (4) the student answers source problems is wrong and target problem is correct (can be seen in Table 2).

Furthermore, the description of qualitative analysis obtained from the following studies. Researches describe the thinking of student's eligible source problems were answered incorrectly and target problems were answered correctly.

Table 2: Data result of answer analogical problem.

Description	Total students	(%)
Source problems and target problems were answered correctly	10	30.3
Source problems and target problems were answered incorrectly	12	36.36
Source problems were answered incorrectly and target problems were answered correctly.	7	21.21
Source Problems were answered correctly and target problems were answered incorrectly.	4	12.12
Total	33	100

Based on Figure 1 (a) and 1 (b), subject S1 begins by identifying what is known from the source problem. Subject S1 wrote probability taken new

science books $\frac{6}{76}$ and probability taken new history books is $\frac{15}{120}$. Then the subject S1 determines the probability of taking a new book from the science and history section by summing up the probability of new science books and the chances of a new history book acquired $\frac{31}{152}$. S1 subject answers wrong source problem. Next, S1 completes the target problem. Subject S1 do mapping process from target problem to source problem. Furthermore, in the structuring process, subject S1 identifies the problem as it did in resolving the source problem. The subject S1 identifies the target problem by stating that the selected probability of public school in area A is $\frac{8}{24}$ and region B is $\frac{12}{32}$. In the applying process, subject S1 solves the target problem of determining the eligibility of public schools from both regions by multiplying the selected probability of public schools in area A and the selected probability of public school in region B is obtained $\frac{1}{8}$. The target troubleshooting process is not the same as resolving the source problem. In the verifying process, the answer to the target problem is similar to the result of the source problem answer. The answer to the target problem is $\frac{3}{8}$.

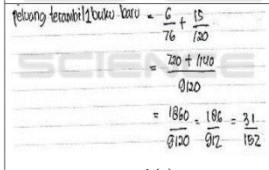
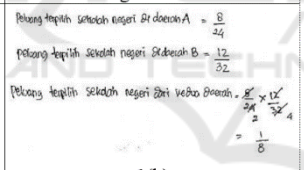
Source answers	Target answers
	
1(a)	1(b)
Probability fetched 1 new book $= \frac{6}{76} + \frac{15}{120}$ $= \frac{720+1140}{9120}$ $= \frac{1860}{9120} = \frac{186}{912} = \frac{31}{152}$	Probability elected public schools in the region A $= \frac{8}{24}$. Probability elected public schools in the region B $= \frac{12}{32}$. Probability elected public schools from both regions $= \frac{8}{24} \times \frac{12}{32} = \frac{1}{8}$.

Figure 1 (a) & 1 (b): Answers to source problems and target problems subject S1.

Subject S2 answered source problems by summing the books of science and the history of 196 books. And then subject S2 determining probabilities of each new science books and new history books acquired $\frac{6}{196}$ and $\frac{15}{196}$. Furthermore, subject S2 determine probability of new books chosen from science and history by summing up probabilities of a new science book and a new book of history, so that it gets $\frac{21}{196}$.

The following is interview expert S2.

I: What do you think about the current look (pointing at the source problem)?

S2: Here the book because ... there are 76 science sections and there are 6 new ... and there is 120 books section of history... then there is the new 15. What being asked is how many probabilities of fetching new book science and history. Well Here I suppose that science n(A) and the history of n(B). Probability science P(A) and a historical probability P(B). It's bookshelves right. It's not a science bookshelf bookcase but also history. But one shelf was a book of science and history... the total of science and historical books on the shows is 196 books. So, the contents of the shelves of science and history books then S2 is mastered how many probabilities right here chose a new book of science and history... It means that we take his place not just science but also science and history with the total number of 196. Because of the requested new book, the probabilities for science is $P(A) = \frac{6}{196}$ and the historical probability is $P(B) = \frac{15}{196}$.

I: What do you know about this matter? (pointing at the target problem)

S2: similar to the previous example (refer to the source problem) ... there are two local schools which are area A and area B. Area A has 24 schools and 8 public schools ... and other, there are 32 schools, there are 12 public schools. The probability of choosing public schools in area A is $P(A) = \frac{8}{24}$ and the probability to choose public schools in area B is $P(B) = \frac{12}{32}$.

I: how many answers about this (pointing at the source problem)?

S2: As the requested probability of drawing a new book of science and history then probability is summed, so $P(A) + P(B) = \frac{6}{196} + \frac{15}{196} = \frac{21}{196}$.

I: how to answer this question? (pointing at the target problem)

S2: because the matter is related to the two events are independent ... then the probabilities are drawn by the public schools of the two regions by multiplying the probability of events A and B that gained $\frac{1}{3} \times \frac{3}{8} = \frac{1}{8}$.

Based on the subject's answer in this study: the first, the subject resolves the source problem via identifying the problem correctly. However, subject recognizes mathematical formulas incorrectly. Then, subject applies mathematical formulas and obtains incorrect results. The second, subject resolves target problem identifying the problem. The subject

recognizes mathematical formulas correctly. The mathematical formula used between the source problem and the target problem is different. Then, the subject applies mathematical formulas and gets the correct results.

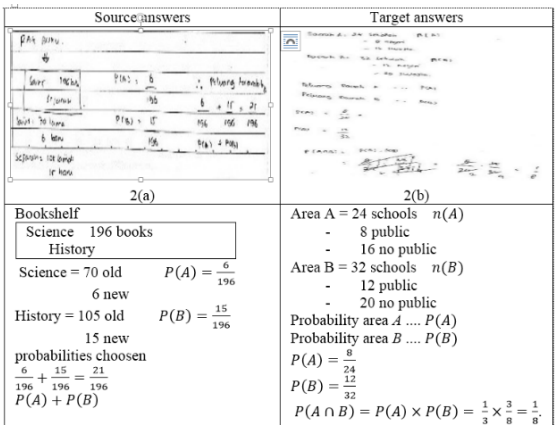


Figure 2: (a) & 2 (b): Answers to source problems and target problems subject S2.

Analogical problem-solving begins by recognizing the similarity between the target problem and the source problem. Then, they mapped the target problem to the source problem. Source troubleshooting steps are mapped one-to-one to troubleshooting steps that begin with the setup, deployment, and verification process. The problem-solving process analogies between the target problem and the source problem using the analogical reasoning stage can be seen in Figure 3.

Description of the encoding in analogical reasoning process of the student in solving-problem the probability of two independent events on Figure 3 can be seen on Table 3.

4 DISCUSSION

Analogical problem consists of source problems and target problems. First, students solve source problems and then solve the target problems. The second, problems are analogy then source problems were answered correctly, it can be ascertained target problems were answered correctly. Pang and Dindyal (2009) students must search for a common connection between source problems and target problems so that students can use mathematical concepts from source problems to solve target problems.

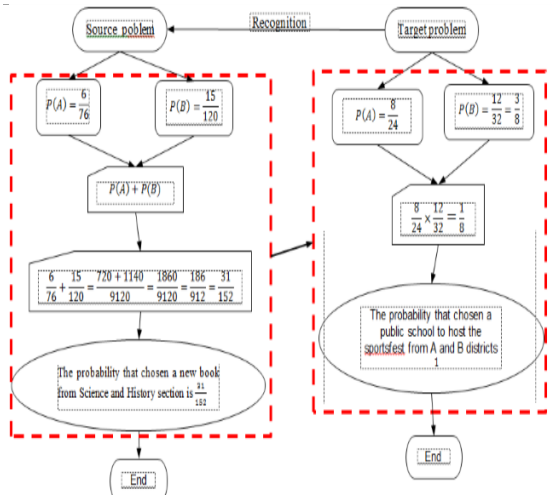


Figure 3: Analogical reasoning process of the student in solving-problem the probability of two independent events.

Table 3: Description of the encoding in analogical reasoning process of the student in solving-problem the probability of two independent events.

Term	Code
Start/End	
Structuring	
Mapping	
Applying	
Verifying	
Process Activity	

But the existing theory does not apply to this case. The student did not solve source problems correctly, but the target problems were resolved correctly. Basically, students understand ways to answer source problems and target problems. However, students do not use the same mathematical concepts to solve an analogical problem. But perceptions of students to problem solving on both analogical problems is the same. The concept and context of the given problem have something in common. So students are expected to transfer the entire context with existing cognitive tools through analogical reasoning(Richland, Holyoak, and Stigler, 2004).

There are two ways in which students solve source problems. First, students summing science and history books, summing new books from science and history and determine probabilities of a new book from science books and history books. The second, students determine probabilities of new science books, students determine probabilities of new history books, and determine probabilities of a new book from science books and history books. The first way, students assume that should add up all the books from the science and history, and new books on

science and history because the books are stored on a shelf in the library. Students misconception in resolving source problems because students do not understand the problem well, the concept is wrong, and the procedure is wrong (Sandhu, 2013; Sarwadi and Shahrill, 2014). While the second way, the students determine each probability chosen new books from science and history section. Then determine probabilities of a new book from the science and history. However, the formula used is wrong in determining probabilities of a new book from science and history section. This can mean that students make mistakes because students understand the problem well, but either incorrect or incorrect formula in writing the operation marks used (Sandhu, 2013; Lin et al., 2012). Furthermore, the mistake made is a transformation error that is an error in using the formula correctly (White, 2005; Saleh, Yuwono, As'ari, 2017).

One of the factors that this happens is structuring. Students can't students cannot perform structuring the source problem correctly, students cannot see key word in the source problem, and students cannot find a relationship between the target problems with the source problem. There are reading errors, comprehension errors, and transformation errors (Saleh, Yuwono, As' ari, et al. 2017). Kristayulita, Nusantara, and As'ari (2018) said that these errors are structuring errors. Ruppert (2013) said that identifying each mathematical object that exists in the source problem with the coding of attributes or characteristics and making conclusions from relationships that are identical between the problem source and the target problem. Furthermore, students are not using mathematical formulas properly for source problem. Mathematical formulas used between source problem and target problem are different. There is skill process errors (Saleh, Yuwono, As'ari, et al. 2017). Kristayulita, Nusantara, and As'ari (2018) said that these errors are applying errors. This is influenced by learning experiences and prior knowledge from students. Novick (1988) said that we are often reminded of similar problems solved earlier and may use the solution procedure from an old problem to solve a new one, such analogical transfer. Besides, time is the other factor. There is an interval of 45 minutes before the students to solve target problems. The length of time students have after solving source problems with time before completing target problems, students can use to reflect the answer to source problems obtained. So, the students try hard to solve target problems correctly.

All students have a presumption that source problem and target problem is analogy. Students solve target problems using the same concepts and procedures by solving source problems. Students use analogy reasoning to solve target problems. Amir-Mofidi, Amiripour, and Bijan-Zadeh (2012) by facilitating students to analogical reasoning can help students to connect new mathematical knowledge to existing knowledge, learn more in-depth math, and math concepts can be stored in long-term memory. So that the student changes, the formula used is no longer the same as solving source problems. However, students use concepts and procedures appropriate to the problem. In addition to the time factor, early knowledge of long-term students stored in long-term memory can be recalled. Source problems are a trigger to call the memory deeper to solve target problems. We hope you find the information in this template useful in the preparation of your submission.

5 CONCLUSIONS

The results show that there are misconceptions and errors made by students in solving source problems. Even if the source problem is answered wrongly with the analogical reasoning students can solve the target problem by paying attention to the previous learning experience. Target problem can be answered correctly due to the time and working memory. Students' prior knowledge stored in long-term memory is recalled by connecting experience in solving the problem source.

Further research needs to look at the level of intelligence of students who do so. In addition, based on student learning styles need to be researched and analysis further. Teachers need to learn by displaying analogical problems aimed at improving students' understanding of the math material being taught.

We hope you find the information in this template useful in the preparation of your submission.

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