Students' errors in solving probability problems viewed by learning style

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Abstract. The students’ error in this study is an error made by students in solving probability problems. This study aims to describe students’ errors in probability problems viewed by learning styles. The learning style is a person’s main potential in thinking and processing activities to find out information. To explain this problem, first, we developed and validated three probability test items. Then, 26 students were given one set of tests and continued with the giving one set of learning style questionnaire. Next, six students were selected as representatives of each learning style group with the purposive sampling technique. The interview was conducted to ascertain the types of students’ errors. Finally, the data were analyzed based on Newman’s theory. The results showed that the types of errors made by the visual group consisting of misunderstanding the problem, being wrong in writing the final answer, and being wrong in carrying out problem-solving procedures. The types of errors made by the auditory group involve an error in carrying out problem-solving procedures, not knowing the concept to solve the test, and not understanding problems. The types of errors made by the kinesthetic group include misunderstanding problems and not knowing concepts to solve the test. This finding suggests that the types of students’ errors for the visual group consist of comprehension, encoding, and process skills; for the auditory group consist of process skills and transformation; for the kinesthetic group consist of comprehension and transformation.

1. Introduction
Mathematics is one of the sciences needed and studied at all levels of education. In the curriculum of education unit level, one of the mathematical topics studied at the junior high school level is the probability. According to [1], one of the purposes of studying the topic of probability is students will be able to compute the probabilities of simple and complex events. Probability is an important topic for students because it is directly related to their daily lives. The application of probabilities in everyday life includes the problem of weather forecasts, the selection of clothing combinations with different colors, and the election of the student council president in school.

Based on the observation that had done in one of the junior high schools in Indonesia, we found that some students had difficulty in learning the topic of probability. These difficulties were shown by many students who did not respond to stimulus questions submitted by the teacher. Besides, some students are unable to solve the probability problems that have been given by the teacher. The students said that they had difficulty understanding the topic of probability. It is just that they do not know how to express these difficulties. So that, the teacher who teaches has difficulty in overcoming this problem.
Analysis of student answers is one alternative that can help teachers solve their problems. This is supported by [2] that by analyzing student answer errors, educators are expected to be able to use appropriate ways to improve their learning activities. In this case, the analysis of students' answers is expected to help teachers improve the learning activities in the classroom. Besides, by analyzing students’ answers, the teacher will also get many advantages such as getting information about the types of errors that are often made by students, getting information about difficult topics, and knowing how to overcome students' learning difficulties.

There are many causes of students’ errors in solving mathematical problems. One of the causes is their difficulty in interpreting the problem. This is supported by [3,4,5], that some of the difficulties faced by students include difficulties in understanding problems, determining appropriate resolution strategies, translating problems into mathematical forms, and performing procedures correctly. That is in accordance with [6] that the cause of students' errors in solving mathematical problems is the lack of mastery of the language of mathematics, error in interpreting or applying formulas, miscalculations, lack of rigor, haste in solving problems, and forgetting concepts.

The study about students’ errors in solving probability problems is not a new topic. The similar problem had carried out by [7] by analyzing students’ errors in solving mathematical problems in the topic of probability based on high order thinking and giving scaffolding. However, the study was carried out using Polya's problem-solving stages, which is in our opinion these stages were still very common. So, we tried to analyze this problem using Newman's theory viewed by student learning styles, to reveal the types of specific student's errors.

Newman Error Analysis (NEA) is one alternative that is used to analyze the type of student errors. According to [8], NEA model has a hierarchy that can categorize the types of errors based on the level of a student's problem-solving. NEA was introduced in Australia in 1980 by Clements. The reason for the introduction of NEA is to help teachers deal with students who have difficulty in solving mathematical problems. NEA provides a framework for uncovering reasons of student difficulties and processes to help teachers find why misunderstandings occur. Therefore, the teacher can develop effective strategies to help them. [9,10,11].

The types of errors according to NEA consist of (1) reading, that is, if students cannot read keywords or symbols in the problem, so that they will not be able to continue the problem solving process; (2) comprehension, that is, students have been able to read all the words in the problem, but do not understand it comprehensively, so that they cannot continue the further process in solving it; (3) transformation, that students have understood the question in the problem but cannot identify the operation, or sequence of operations, needed to solve the problem; (4) process skills, that students can identify the right operation, or sequence of operations, but cannot carry out operating procedures accurately and correctly; and (5) encoding, that is, students cannot express the final solution correctly [12,13,14].

The understanding of Newman's theory in mathematics learning will succeed if accompanied by an understanding of student learning styles. According to [15], learning styles are a combination of a person's ability to absorb and regulate and process information. Whereas [16] defines learning styles as a combination of cognitive characteristics, affective and psychological factors that influence individuals to interact and respond to their learning environment. Teachers who understand their students' learning styles are expected to be able to prepare and design suitable learning models. So that it can help students focus more in learning activities, and ultimately will increase success in education [17,18].

Students’ learning style consists of visual, auditory, and kinesthetic, commonly known as VAK. The characteristic of these learning styles are the visual students learn through what they see, the auditory students learn through what they hear, and the kinesthetic students learn through movement and touch [15]. This is similar to what is suggested by [19] that visual students will be better if they learn to use media visualization of information through images, films, diagrams, charts, and other visual images. Auditory students will be better if they learn to use information that involves hearing and discuss ideas. Meanwhile, kinesthetic students will be better if they learn to use something the involve physical activity. According to [15] each student has all three learning styles, although most of them have a tendency on one of the learning styles only. So, in this study, we were interested in revealing the types of student errors viewed by learning styles.
2. Experimental Method

This case study was a part of a qualitative study that aimed to describe the types of students’ errors in solving probability problems seen from learning style. This study conducted in a type of boarding school in Indonesia where was all students were male. The subjects were the 9th graders (14-15-years-old) that had learned probability topic in mathematics. Todo so, first, we developed and validated three probability test items based on the characteristics of probability topic for junior high school (see Table 1). The scoring rubric was adjusted to the difficulty level of the given items. Then, 26 students were given one set of tests and continued with the giving one set of learning style questionnaire (see appendix 1.1, 1.2). The learning style questionnaires were used to group students into their respective learning style. Six students were selected as participants who represented each learning style group. The selection of participants as subjects used the purposive sampling technique based on criteria: (1) their answer errors represent all students’ errors, (2) they have medium mathematical abilities, and (3) they can express ideas or opinions clearly. The interview was conducted to ascertain types of students’ errors. Finally, the data were analyzed based on the Newman theory, which consists of errors in reading, comprehension, transformation, process skills, and encoding.

Table 1. The test on probability topic

| No. | Items of the test                                                                 | Score |
|-----|----------------------------------------------------------------------------------|-------|
| 1   | From the results of field research, the probability of the Suka Maju villagers to be sick in one month was 0.015. What is the probability of the Suka Maju villagers to be healthy in a month? | 3     |
| 2   | A dice was thrown in 300 times. Determine the frequency of expectations appearing: | 4     |
|     | a. dice 3                                                                        |       |
|     | b. dice is not 3                                                                 |       |
| 3   | A bag containing 10 red balls and 4 yellow balls. A ball is taken randomly from the bag. Determine the probability that the ball was red or yellow! | 4     |

3. Results and Discussion

Twenty-six students were grouped based on their type of learning styles, consisted of nine students in each visual and auditory group, and eight students for the kinesthetic group. Then the test results of six students selected as participants from the three groups are shown in Table 2.

Table 2. The test results

| No | Subjects | Learning styles | Items of the test | Total score |
|----|----------|----------------|-------------------|-------------|
|    |          |                | 1     | 2    | 3    |       |
| 1  | S-1      | Visual 1       | 1     | 4    | 4    | 9     |
| 2  | S-2      | Visual 2       | 1     | 4    | 3    | 8     |
| 3  | S-3      | Auditory 1     | 3     | 3    | 3    | 9     |
| 4  | S-4      | Auditory 2     | 3     | 2    | 0    | 5     |
| 5  | S-5      | Kinesthetic 1  | 3     | 4    | 2    | 9     |
| 6  | S-6      | Kinesthetic 2  | 3     | 3    | 4    | 10    |

Based on Table 2, we got information that kinesthetic groups had the highest score compared to the other two groups, and the visual group was the group that scored the second highest in solving probability problems.

For the visual group, several answer errors had discovered. The errors had found in the answer on item 1 and item 3 for two subjects. The answer errors on item 1, can be seen in Figure 1.
Based on Figure 1 and the result of the interview, we found that S-1 had not comprehensively understood the mathematical symbols. On his answer sheet, he wrote “n (A) = 0.015” for the probability of an even, whereas the correct answer is “P (A) = 0.015”, not n(A). In addition, he also made errors in the subtraction operation. For the S-2, he made errors in determining the final answer. He wrote “1 - 0.015 = 9.985”, whereas the correct answer is 0.985. Based on Newman’s theory, both subjects made errors in comprehension and encoding.

In the visual group, we also found other types of errors. This is we found in answer S-2 on item 3, which is shown in Figure 2.

From Figure 2 we found that S-2 did not solve the problem as it asked. He did not determine the probability of the combination of taking a red ball or a yellow ball and only solved the problem until the stage of determining the probability of each ball. Based on the results of the interview, we found that he forgot to finish the answer to the end. The results of the interview that corroborated these findings were shown in the following transcript.

R: What do you understand relating to item 2?
S-2: What I understand from the problem is the probability of getting the red ball or the yellow ball.
R: and then?
S-2: I determine the probability for each ball and then I write it.
R: Ok, do you still remember the formula for the probability to two events?
S-2: Yes, of course.
R: Does the problem include probability of two events?
S-2: Oh, yeah. But my answer was wrong because I was too rushed to finish it. I have forgotten this.

In this case, based on Newman’s theory, S-2 made an error in process skills. He understood the asked problem, but the rush caused his answer to be wrong.

On the auditory group, we found some answer errors on item 2 for both subjects and item 3 for S-3. The answer errors of the auditory group can be seen in Figure 3.
Figure 3. Auditory Group’s Answers on Item 2

Figure 3 shows S-3 and S-4 have made the same errors in writing the information about the problem. Based on the interview, S-3 did not memorize the solving procedure. He also made procedurally error on item 2. He had written the frequency of expectation for dice is not 3 is “250 + 50 = 300 = 250”. According to him, he has difficulty in formulating his answer. So that, he just wrote what he knew. Next, on the S-4’s answer, it can be seen that item 2 was not solved until completed. Based on the interview, S-4 did not know the procedure to complete it. So that, he could not complete his answer. In this case, based on Newman’s theory S-3 made an error in process skills and S-4 made an error in transformation.

In the kinesthetic group, several errors had been found, on item 3 for S-5 and item 2 for S-6. The S-5’s answer can be seen, in Figure 4.

Figure 4. S-5’s answer in the kinesthetic group on item 3

From Figure 4 we can be seen that S-5 had been made errors in his answer. The answer error can be seen on the part the asked on the problem. On his answer sheet, he had written about “what is the probability of both colors?”. While the correct answer is “what is the probability of getting a red ball or a yellow ball?” Next, from the results of the interview, it was obtained that S-5 made an error in the understanding what was asked from the problem. He did not yet understand the probability of compound events. This error has impacted a failure to reached the correct solution of the asked problem. Based on Newman theory, S-5 made an error in comprehension.

The type of error made by S-6 in item 2 is the same as that done by S-3 in the auditory group. He made an error in write the correct procedure. The error his made is shown in Figure 5.

Figure 5. S-6’s answer in the kinesthetic group on item 2

Based on the results, we found that there were several types of similar errors made by visual, auditory and kinesthetic groups. However, the problems were different. In general, the types of errors
made by most students of the three groups of learning styles are comprehension, process skills, and transformation.

4. Conclusion
Based on the results described in the previous section, we make the three following conclusions. First, the types of errors made by the visual group are comprehension, encoding and process skills. They are shown by errors in the understanding problem for comprehension, in writing down the final answers for encoding, and in being rushed to solve problems for process skills. Second, the types of errors made by the auditory group are process skills and transformation. They are shown by errors in writing the solutions for process skills and not knowing concepts to solve the problems for transformation. Third, the types of errors made by the kinesthetic group are comprehension and transformation. They are shown by errors in understanding the problem comprehensively for comprehension and not knowing the concept to solve problems for transformation.

Our study applies only to the special case at a type of boarding school where is all students are male. For further studies, it is recommended to study this problem at public schools where students are diverse.

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Appendix 1.1

Learning Style Questionnaire
University of California, Merced
Student Advising and Learning Center

Reactions: For each statement, check the box that best describes you

| No. | Statements                                                                 | Often | Sometimes | Seldom |
|-----|---------------------------------------------------------------------------|-------|-----------|--------|
| 1.  | I can remember best by listening to a lecture that includes information, explanations and discussions |       |           |        |
| 2.  | I prefer to see information written on the board and supplemented by visual aids and assigned readings |       |           |        |
| 3.  | I like to write things down or take notes for visual review               |       |           |        |
| 4.  | I prefer to use posters, models, or actual practice and other activities in class |       |           |        |
| 5.  | I require explanations of diagrams, graphs, or visual directions          |       |           |        |
| 6.  | I enjoy working with my hands or making things                           |       |           |        |
| 7.  | I am skillful with and enjoy developing making graphs and charts         |       |           |        |
| 8.  | I can tell if sounds match when presented with pairs of sounds.          |       |           |        |
| 9.  | I can remember best by writing things down several times.                |       |           |        |
| 10. | I can easily understand and follow directions on a map                    |       |           |        |
| 11. | I do best in academic subjects by listening to lectures and tapes.       |       |           |        |
| 12. | I play with coins or keys in my pocket                                  |       |           |        |
| 13. | I learn to spell better by repeating words out loud than by writing the words on paper.|       |           |        |
| 14. | I can understand a news article better by reading about it in the newspaper or online rather than by listening to a report about it on the radio or internet |       |           |        |
| 15. | I chew gum, smoke or snack while studying                                |       |           |        |
| No. | Question                                                                 | Visual | Pts. | Auditory | Pts. | Tactile | Pts. |
|-----|--------------------------------------------------------------------------|--------|------|----------|------|---------|------|
| 2   | I think the best way to remember something is to picture it in my mind.  |        |      |          |      |         |      |
| 17  | I learn the spelling of words by “finger spelling” them.                |        |      |          |      |         |      |
| 18  | I would rather listen to a good lecture or speech than read about the same material. |        |      |          |      |         |      |
| 19  | I am good at working and solving jigsaw puzzles and mazes.              |        |      |          |      |         |      |
| 20  | I grip objects in my hands during learning periods                     |        |      |          |      |         |      |
| 21  | I prefer listening to the news on the radio or online rather than reading about it in a newspaper or on the internet. |        |      |          |      |         |      |
| 22  | I prefer obtaining information about an interesting subject by reading about it. |        |      |          |      |         |      |
| 23  | I feel very comfortable touching others hugging, handshaking, etc.     |        |      |          |      |         |      |
| 24  | I follow oral directions better than written ones                      |        |      |          |      |         |      |

Source: Adapted from "Student Advising and Learning Center, University of California, Merced". https://learning.ucmerced.edu/sites/learning.ucmerced.edu/files/page/documents/learningstylequestionnaire.pdf accessed on 25 February 2018.

Appendix 1.2

Learning Style Questionnaire
University of California, Merced
Student Advising and Learning Center

Scoring:
Complete the table below by assigning the following point values for each question:
Often = 5 points  Sometimes = 3 points  Seldom = 1 point
Then, add the points in each column to obtain your learning preference score under each heading.

| Visual | Pts. | Auditory | Pts. | Tactile | Pts. |
|--------|------|----------|------|---------|------|
| No.    |      | No.      |      | No.     |      |
| 2      | 1    | 4        |      |         |      |
| 3      | 5    | 6        |      |         |      |
| 7      | 8    | 9        |      |         |      |
| 10     | 11   | 12       |      |         |      |
| 14     | 13   | 15       |      |         |      |
| 16     | 18   | 17       |      |         |      |
| 19     | 21   | 20       |      |         |      |
| 22     | 24   | 23       |      |         |      |

Visual Preference Score: | Auditory Preference Score: | Tactile Preference Score:

If you are a VISUAL learner: Make use of all available study materials such as charts, maps, filmstrips, notes, and videos. Write out everything for frequent and efficient review. Practice visualizing or pictures words and concepts in your mind. Adding meaningful symbols, colors, and graphics to notes also provide visual cues. Try to visualize how information appears on a page. In study groups or discussions, focus on how people look when they speak.

If you are an AUDITORY learner: Try using tapes to supplement other study materials. For example, tape lectures to help fill in gaps in your notes or covert lecture notes to auditory tapes—but do listen and take notes, and review your notes frequently. Sit in the lecture hall or classroom where you can hear well (most often this is near the front). After you have read something, summarize it and recite it aloud. Talk to other students about class material. You may also benefit from group study sessions where members review class material.
If you are a TACTILE learner: Try tracing words as you say them. Facts that must be learned should be written several times. Keep a supply of scratch paper on hand for this purpose. Taking and keeping lecture notes is very important. It may also help you to make study sheets, and to associate class material with real-world applications and occurrences. For some classes, practice role-playing. Highlighting, underlining, labeling information, and writing add movement to learning. Participation in study groups or tutoring others provide additional ways to become an active learner. Science courses also offer manipulative aids to demonstrate chemical reactions. The more you do, the more you learn.

A note about learning preferences: Although it is important to know your learning strengths as a foundation for the development of personal study habits, realize that not all college courses and instruction will lend themselves to your strengths. Attempt to adapt learning tasks using the suggestions above. You may also take this as an opportunity to improve and educate yourself to learn in different ways. Indeed, some of the most successful professionals approach problem solving and decision making from many different perspectives!

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