Students’ gesture of naive, routine, and sophisticated behavior oriented on mathematical problem solving

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Abstract. Gesture aims to see students understanding when such understanding is not visible in writing. This research is a qualitative research with descriptive method that aims to examine the gesture of three students whose orientations are different in solving the problem. Based on literature, there are three kind of behavior problem solving, there are naive, routine, and sophisticated. To reveal the gesture of the students of the three behaviors, six issues related to geometry were given to two junior high school students of equal ability. Data collection was done through mathematical problem solving test, recording of student presentation and interview between researcher and student after doing the problem. Based on the result of the research, sophisticated-gesture students tended to show a profound way of thinking. Routine-gesture students were more relaxed and occasionally showed doubt and unconfidence. Naive gesture students did not tended to behave that look thoughtful. These Gestures were shown consistently for each given question.

1. Introduction
Gesture is a behavior that someone does when understanding problems [1]. In other word, it can be interpreted as a gesture to emphasize or help express a person’s thoughts or feelings in solving math problems. Gesture plays a role to help children either to seek or coordinate the understanding of the numbers to others [2]. Gesture serves to connect the physical movement with the words expressed students in understanding a problem [3]. Three gesture functions: first, gesture is used to achieve, retain, and re-focus on problems to be solved; second: gestures reinforce and extend meaning, if speech or language used in unfamiliar problem solving; third: it is possible in some circumstances, gesture is an index of a degree of cognitive uncertainty that may be a vehicle for change of understanding (cognitive change) [4]. It can be concluded that the gesture function can transfer students’ words or writings into physical movements so others can better understand what is being said. Many studies examined students’ gesture because it is considered to provide benefits for teachers to take a treatment in the
learning process, especially when teacher cannot understand student written work. Reynold's study talks about two students who be given mathematical problems on the graphics of function and graph of a bus trip. In this research, He studied a setting of two collaborating students trying to make sense in solving problems on the topic of speed and time. The report presented by Reynold is equipped with prosodic cues such as voice tap, intonation, speech speed, and pause to assist the reader in understanding the gestures made by the two students. The findings of this study are that gesture has several functions in collaborative problem solving in interpreting the given problem: gesture helps in achieving to stay on the same problem, gesture acts as a cognitive intermediate, if there is a change of student's tempo in speaking it indicates that there is cognitive uncertainty, gesture as an index of cognitive understanding. Based on these findings the teacher can identify the problem faced by the student, when the student cannot express the problem with the language, the student can express in the form of gesture. This can give a clear picture to the teacher whether the student understands the problem domain clearly or not. The investigation of the role of gesture in collaborator problem solving is very rapidly growing and has many variations [4]. Reynold's research leaves the question of whether gestures are unique to each individual, or is it possible to identify patterns of gestures that students use on different age, intergroup gestures, and so forth. This question was answered or continued by Harisman. This study examined how the gesture patterns of two students. The results of Harisman's research were some of the gestures shown by female students are: often lowered heads, less confident, shy, often nods when the cognitive understanding moves, directly moves the body toward the interviewer and asks questions if anything not understood. Furthermore, some of the gestures shown by male students are: play hands, keep looking at things, think long when questions can not be answered, stay calm when transfer of cognitive understanding. The conclusion from Harisman's research is that there was a significant difference in the gesture shown by male and female students. This study was new in one student sample and still at the stage of description [5]. For further research it is necessary to see the consistency of student gesture between gender differences. Is this pattern always the same or every individual has a different and unique gesture in showing their understanding of the given problem. This gesture pattern is obtained from interviewing each item over and over again. The weakness of this research is the use of only one subject of research. For the development of this research, it can be expanded to involve more than one research subjects. The results of this study can help teachers in diagnosing how gesture female students and gesture male students at the time understand the problem, change the cognitive understanding, when not understanding the problem. Noto [1] also answered the question left by Reynold's research [4], Noto [1] examines how gestures of two people who have age differences in mathematical reasoning. Based on the results of the study Noto [1] that age is not the main factor affecting the gesture that appears when the problem is rendered given. In this case the gesture shown by the more mature students did not show first reach, maintain, and focus on the problem to be solved. Gesture (movement) in students who are more mature also do not strengthen and expand the meaning, if the words of students or language used in problem solving is not familiar to younger students. A more mature student gesture also does not affect cognitive uncertainty for younger students when making mathematical reasoning. Especially in the case of Noto's research [1] it turns out that teaching experience is the dominant factor for gestures that are shown as more understanding of the problem, able to clarify and expand meaning, and can influence other students' brown changes. For further research it is advisable to take more samples to see the consistency of the statement. In this study focused on how the gesture of three students of different behavior in solving mathematical problems. Behavior refers to Muir's behavior categorizes behaviors in three categories, completing the research that has been done by Schoenfeld [6, 7]. If Schoenfeld has categorized student behavior when solving mathematical problems in two categories: expert and novice problem solvers, Muir categorizes students' mathematical problem-solving behavior into three categories: naive, routine, and sophisticated. Naive behavior is oriented towards problem-solving behavior that is only related to manipulating the numbers that exist in the problem. Routine problem-solving behaviors are oriented toward structured behavior, and sophisticated problem-solving that can generate their own strategies when faced with a mathematical problem. The implication of Muir's research results [6] is "the categorization of this behavior has an impact on learning mathematical
problem solving". This study tries to see how the gesture of students behave naively, routinely, and sophisticated in solving mathematical problems, with research questions:

- What kind of gesture is shown by students behaving naive, routine, and sophisticated in solving mathematical problems?
- To what extent the gesture is consistent with the given problem?

The problem given in this research is the problem related to the topic of geometry. Geometry topics were selected from Junior high school teacher which considered to be a difficult topic for students to understand.

2. Method

The study uses descriptive study approach to see the gesture of three junior high school students who behave naive, routine, and sophisticated. The grouping of students is based on the rubric of problem-solving behavior described by Muir [6].

Table 1. Problem solving behavioral rubric.

| Factor (Aspect) | Indicator | Naive | Routine | Sophisticated |
|----------------|-----------|-------|---------|---------------|
| Knowledge ownership | The application of Polya's heuristic steps in mathematical problem solving | Made a mistake on all four Problem solving steps | No attempt to verify the solution (Make a mistake on some Problem solving steps) | A high score on each Problem solving step |
| | The use of prior knowledge for mathematical problem solving | Cannot use previously resolved issues | Can identify a similar problem, but not on a mathematical structure | Identify similar problems according to their mathematical structure |
| | How to use in mathematical problem solving | Often use the same way to solve all problems because of the limitations of knowledge possessed | Focus on one way with the knowledge you have to solve a particular problem. Verbal communication is usually obvious | Identify other ways of solving problems because of wider knowledge |
| | Written and verbal communication in mathematical problem solving | Written and verbal communication is inadequate | Written and verbal communication is sufficient | Written and verbal communication is sufficient |
| Self-Control | Metacognitive thinking in mathematical problem solving | Metacognitive thinking does not appear, either in written or verbal communication | Metacognitive thinking appears verbally | Metacognitive thinking is evident in written and verbal responses |
| Confidence | Confidence in the way of implementing strategies in mathematical problem solving | Doing the exact same strategy because of lack of confidence in your ability to solve the problem solving strategy | Implementing the strategy in a systematic way | Produce own strategy because it has a high confidence in the use of problem-solving strategies |
| | Confidence in the variety of strategies used in mathematical problem solving | Rely on one or two strategies | Rely on more than two strategies, but cannot move to another strategy when one strategy cannot work | Desiring to use a combination of strategies |
| Affective | Confidence in solving mathematical problems | Confidence in solving mathematical problems in line with the speed of answers acquainted | Frequently express in confidence in solving mathematical problems | Showing confidence in solving mathematical problems |
Table 1 shows the grouping of students is based on the rubric of problem-solving behavior described by Muir [6]. Naive behavior is oriented towards problem-solving behavior that is only related to manipulating the numbers that exist in the problem. Routine problem-solving behaviors are oriented toward structured behavior, and sophisticated problem-solving that can generate their own strategies when faced with a mathematical problem.

Students were given tests and subsequently interviewed to see the categories of such behavior. Three junior high school students were Alvaro, who was indicated as students behaving sophisticated in solving problems, Anissa who was indicated as a routine problem solver, and Fikri who was indicated as a naive problem solver. The grouping of students has been done systematically on other writings. In this paper we will analyze video interviews from the three students to see the gesture to the three junior high school students in each of the categories of problem-solving behaviors.

2.1. Participants
Participants in this study were three students behaved naive, routine and sophisticated that have been grouped previously in other posts.

2.2. Task
Descriptions of two problems of seven given problems.

Table 2. Descriptions of two problems on geometry material.

| No. | Problems on geometry material |
|-----|------------------------------|
| 1.  | Pak Hok Guan Paralon Shop owner wants to tie paralon pipes with rope, each 6 paralons bond. He confused paralon binding (r = 10 cm). Is it a rectangular or triangular model? Because the rope used is limited to binding paralon, Pak Hok Guan expects the use of the rope can be more efficient. Help Pak Hok Guan solve the problem. Which paralon bundles are most efficient. |
| 2.  | Here are the cube nets numbered 1 through 6. What is the largest number of three numbers on the sides that together form a vertex of the cube. |

As table 2, the given problem has been conceived and designed with all the problem solving strategies such as guessing and checking, drawing, listing, table creation, working backward, looking at patterns, and using logical reasons, solving simple problems and creating questions.

2.3. Procedure
Students were given tests and then interviewed. Afterwards students were grouped into three behavioral Problem solvers proposed Muir [6]. This had been done on writings and other studies. Alvaro had been categorized in sophisticated problem-solving behavior, Anissa had been categorized into routine problem-solving behavior, and Fikri had been categorized on the behavior of naive problem solvers. In this study, It was seen how the gesture of three students who had three categories of different behaviors.

2.4. Data analysis
The collection of student presentation recording and interviews between the researcher and the students after working on the questions in all three categories of behavior were analyzed. The recording of video
during the presentation process and interviews in the form of questions that explore their understanding of the problem was given to see the gesture used by the subject of research. The results of the interviews were described clearly in this paper. Based on the results of the research, it could be determined how the pattern of gesture in the three students of different categories of behavior in answer to the seven problems given. In addition to conversations with students, it was also displayed procedure cues such as sound pressure, intonation, speech speed, and pause may be helpful in understanding the gestures provided by both students. Interviews were conducted for each question to see the consistency of the gesture shown by the two students.

3. Results and discussion

Here, information about how the video recordings of students behave naive, routine, and sophisticated in solving mathematical problems for one problem was presented. The consistency of gesture could be seen in the seven problems given. Procedural prerequisites such as sound pressure, intonation, speech speed, and pause may be helpful in understanding the gesture provided by both students.

Table 3. Episode 1: Oral presentation on the two issues for students behaving sophisticated.

| Time          | Conversation                                                                 | Alfaro’s Gesture (Sophisticated)          |
|---------------|------------------------------------------------------------------------------|------------------------------------------|
| 00:10sec-00:27sec | Interviewer: where does this formula come from? There are 6, and 20: where does these come from? Alvaro: 6 comes from circles, 20 is the diameter | Visible gesture: closed eyes and looked seriously thinking about feedback |
| 00:59sec-01:10sec | Interviewer: where is 4 come from where? Alvaro: that's 4 called as...ohhh... from the arc, ooh, from the angle? | Gesture closed the eyes of the written work by pointing to the sheet of paper |
| 02:10sec-02:27sec | Interviewer: how can it be 180, how the magnitude is this angle?, the total magnitude angles of triangle is 180 degrees Alvaro: No, true 180 is a big corner, it's going to be straight, so be it this one | Seriously pay attention to his written work while interviewer think with closed eyes |

Table 4. Episode 2: oral presentations on two issues for students behave routinely.

| Time          | Conversation                                                                                                                                                                                                 | Anissa’s Gesture (Routine)                                                     |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| 00:12sec-00:25sec | Interviewer: The most efficient is the triangle, because the paralon is stacked, is it a rectangle also stacked, isn’t it? Anissa: hehehe (laughing) but it stacked upwards rather than laterally Interviewer: so to determine the most efficient in using rope, you see the shape of the layer, should not we look first what to look for? Anissa: hehehehe, Not like that anyway. | The gesture is relaxed and comfortable when listening and providing feedback |
| 00:39sec-00:47sec | Interviewer: why don’t you use the same formula to look for a square layer Anissa: Mmm, if you use the same formula the result will be the same | Seen often playing both hands, looks like a lack of focus on providing feedback |
### Table 4. Cont.

| Time       | Conversation                                                                 | Anissa’s Gesture (Routine) |
|------------|------------------------------------------------------------------------------|---------------------------|
| 00:49sec- 00:57sec | Interviewer: how could it be the same, can this formula be used for all? Do you know exactly what formula is it? Anissa: The circumference formula for circle, Any sort of paralonal stack, no matter how many paralon's so, which n it's a lot of paralon, want to form triangle and square right? Anissa: oh yes, you are right, it means that this formula can be used also for all situation, means that this result will be the same as this one? | The focus is torn between playing the hand of cleaning the nails and listening to the interviewer's questions; Seen wiping his eyes several times as he looked confused. |

### Table 5. Episode 3: oral presentation on two issues for students behaving indifferently.

| Time       | Conversation                                                                 | Fikri’s Gesture (naive) |
|------------|------------------------------------------------------------------------------|-------------------------|
| 01:05sec- 01:14sec | Interviewer: why did you use this formula? why the formula n × d Fikri: I do not know | His gesture looks confused and only plays lips, and looks like no thought of feedback |
| 01:43sec- 01:50sec | Interviewer: okay, n × d which length of rope? Fikri: I forgot again Interviewer: there is 6 × 20, which rope do you try to solve? Which string do you search? Fikri: everything | His gesture looks hesitant between going to point the text sheet and holding the chin when it will give feedback |

### 4. Conclusions
Based on the above description, it can be concluded that gesture of sophisticated students tend to show a deep way of thinking. Students behave routine are more relaxed and occasionally show doubt and confidence. Naive students tend not to show gestures that look thoughtful. Gestures are shown always consistent for each given question.

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