Student's Mathematical Communication Skill Based on The Assimilation and Accommodation Framework

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ABSTRACT

The objective of this study was to describe the mathematical communication skill of junior high school students to solve mathematical problem using an assimilation and accomodation framework. This study use qualitative research method. The research data were obtained by giving a mathematical problem to 7th grade students of SMPN 40 Padang, West Sumatera. Methods use for data collection, were test, think aloud and interview. Data that had been collected were analyzed using an assimilation and accommodation framework. Based on data analysis, it was found that were three forms of student's mathematical communication skill, namely (1) pseudo mathematical communication skill, (2) Inappropriate pseudo mathematical communication skill, and (3) imitation mathematical communication skill.

1. INTRODUCTION.

Mathematics is a universal symbolic language that allows human to think, record and communicate their ideas. With these symbols it allows the realization of more accurate and precise communication. As it is known that mathematics has a variety of formulas used to calculate or measure. A formula if it is written in verbal language requires long sentences and many words, and it enables to have misinformation and misunderstanding.

Learning mathematics really needs communication. Communication in learning mathematics has its own characteristics due to the uses of many symbols. Students and teachers have challenges to be able to understand and communicate each symbol being used. The skill to understand and communicate using symbols and mathematical ideas is called mathematical communication skill. Therefore, teachers should pay their attention to student's mathematical communication skill because knowledge is constructed through communication. According to the theory of social construction, mathematical knowledge is constructed through social interaction. As stated by Schell (2001, p. 2) "Mathematical knowledge is social construction that is validated over time, by a community of mathematicians". It supported by NCTM (2000) which states that "communication can support students' learning of new mathematic concepts because they act in situations, describe, use objects, provide verbal reports and explanations, use diagrams, write, and use mathematic symbols".

Although mathematical communication skill is very important in learning mathematics, many research results suggest that student's mathematical communication skill is low (Sholihah, 2017; Hasibuan et al., 2017; Waluya et al., 2017; Alhaddad et al., 2015).

Almost all researches that have been conducted only states about efforts to improve student's mathematical communication skill. There is no study that looked for why student's mathematical communication skill is low. So in this study, researchers tried to get data on why student's mathematical communication skill is low. The objective of this study was to describe student's mathematical communication skill based on the assimilation and accommodation framework.

The assimilation and accommodation framework is closely related to the student's knowledge scheme. Scheme is cognitive structure or mental structure possessed by student (Skemp, 1982). A person's schema is formed through the process of assimilation and accommodation. Neisser (in Arbib, 1990, 46) states that the construction of a schema is the fruit of assimilation and accommodation. Assimilation and accommodation is a process that occurs when a person (student) interacts with a particular environment or object. Piaget (in Kaasila et al., 2009) states that assimilation involves the interpretation of events in terms of existing cognitive structures. Furthermore, he states that accommodation increases knowledge by modifying structure to account for new experience. So, in this study researchers will look at the structure of student's schema when solving mathematical problem. How is the studen's schema when the assimilation or accommodation process are associated with their mathematical communication skill when solving the mathematical problem.

2. RESEARCH METHOD

This study used qualitative methods because in this study, researchers did not test hypotheses but described what the research subjects encountered in solving mathematical problems seen from the mathematical communication skill of each student. The class used as the research subject was class VII.3 of SMP Negeri 40 Padang. The selection of research subjects for interviews was based on several considerations including students who were considered were able to provide information related to the purpose of the study. The stages of data collection were as follows. Twenty-eight students were given written mathematical communication skill test (KKMT). Based on the results of the written test, students were grouped into three, namely groups that had high, medium and low KKMT. Determination of student grouping into three categories was done by standard deviations according to Arikunto's opinion (2015: 299) with the grouping rules as follows.

Table 1. Student Skill Grouping

No	Group	Score Limit
1	High	$x \geq \bar{x} + SD$
2	Medium	$\bar{x} - SD < x < \bar{x} + SD$
3	Low	$x \leq \bar{x} - SD$

Of the three groups, 6 (six) students were selected to be interviewed. In qualitative research, there are no specific rules about the number of subjects that must be studied, but we should pay attention to the adequacy of the information obtained (Creswell, 2012). Therefore, two students of each groups were taken as research subjects which were considered capable to provide an overview of the thinking process in solving a mathematical problem based on the assimilation and accommodation framework.

3. RESULT AND DISCUSSION

The data of this study were presented according to the ways of collecting data, namely data on student's mathematical communication skill collected by test and data on the student's thinking process based on assimilation and accomodation framework. Data on student's mathematical communication skill were obtained by processing data of test result of mathematical communication skill using the mathematical communication skill rubric. From the results of data analysis, students grouping on three levels of student's mathematical communication skill were as shown in the following Table 2.

Table 2. Data on Mathematical Communication Skill

No.	Group	Criteria	Total	Percentage(%)
1	High	$x \geq 37,88$	8	28.57
2	Medium	$21,40 < x < 37,88$	15	53.57
3	Low	$x \leq 21,40$	5	17.86

Data on student's thinking process were obtained by conducting interview based on results of students work in solving mathematical problems. Two students represented each group, so that there were six students selected to be interviewed with the encoding of S1, S2, S3, S4, S5 and S6 as shown in Table 3.

Table 3. Interviewed Subject Code and Group

No.	Code Subject	Group
1	S1	High
2	S2	High
3	S3	Medium
4	S4	Medium
5	S5	Low
6	S6	Low

Of the 6 subjects who were interviewed, 3 students were selected to present the results of the interview, namely S2, S3, and S6. The selection was carried out by considering students who had the most complete and clearest data on the thought process. The Following is the description of the interview results of the research subjects :

1. Subject S2

Based on the answer of written test of S2 as a whole, S2 had good written mathematical communication skill. S2 was able to solve the given problem correctly and able to write the appropriate symbols. But when it was confirmed, there was student's explanation which did not fit the concept, even though the answer that S2 wrote was correct, as shown in Figure 1.
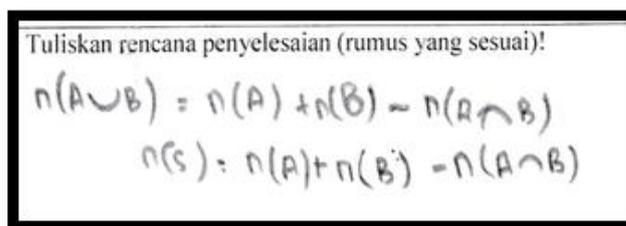
Figure 1. The Answer of Mathematical Communication Test of S2

At the step of planning completion, the S2 was able to write a plan or formula to solve the given problem correctly. S2 had a scheme of operations to combine two sets and about the universe set. However, after further reviewing it turned out that S2 was unable to explain it. The formulas and symbols that S2 wrote were correct, but when it is explored further the S2 cannot explain the formula he wrote. S2 understand that n (A∪B) and n (S) as two different things.

When interviewed, S2 was asked to explain the meaning of the formula he wrote. S2 encountered an assimilation process when explaining the point of n (A∪B) and n (S), but the explanation was not quite right. S2 was only able to write the formula correctly, but when confirmed S2 was not able to explain the meaning of his writing correctly because S2 did not fully understand the operations and universe sets. It was indicated by the following passage:

P : "Please explain the formula you have written here !" (while pointing down the students).
S2 : " n A union B = n A added by n B minud i n A intersection B $n(A \cup B) = n(A) + n(B) - N(A \cap B)$
P : what is " $n(A \cup B)$? ". (while pointing the students)
S2 : In the question there are students like mathematics and there are students like natural science and also there are students like both of them, so the all students are... Ma'am ?

P   : All students ?
S2   : Yes all students are intersection Ma'am. P   : Is this union or intersection ?
S2   : In the note is union, Ma'am
P   : So what is this (while pointing the answer for student from second row) ? Which formula used ?
S2   : "Both of them".
P   : "Both of them ?.What is the different ?".
S2   : "($n(S)$) is S same with n A added by nB minus n A intersect B ($n(S) = n(A) + n(B) - n(A \cap B)$)"
P   : "Formula $(A \cup B)$ and $n(S)$ is same, so what do $(A \cup B)$ dan $n(S)$ mean same or different ?
S2   : "May be different, Ma'am".

At a glance, written mathematical communication skill possessed by the S2 was good, he was able to write mathematical symbols properly and correctly. When it was confirmed what he wrote, it was found that S2 did not really understand what he wrote. Subanji and Nusantara (2015) introduced the term of true pseudo thinking process, which means the process of thinking of someone seems right but after being confirmed it was actually wrong or inappropriate. Based on the terms used by Subanji and Nusantara (2015) and based on the findings of the interview results it can be concluded that S2 written mathematical communication skill was categorized as having pseudo mathematical written communication skill.

2. Subject S3
Based on the answer of written test of S3 as a whole, it was known that the written mathematical communication skill possessed by the S3 was not good enough. S3 had not been able to write the right symbol to state what was known and asked on the question. The formula he wrote was also not fit with the proper concept. However, the value he substitude was correct, so the results obtained were correct. When confirmed, it turned out that S3 believesd that the symbol he wrote was correct. S3 did not realize that there was something wrong with the answer. This can be shown in Figure 2.
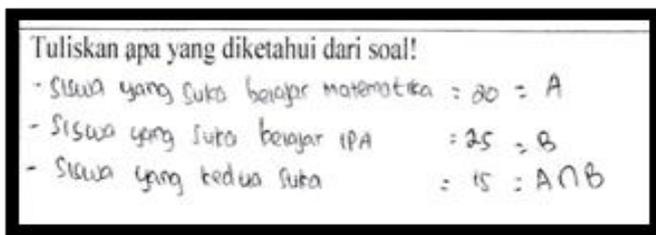
Figure 2. The Answer of Mathematical Communication Test of S3

S3 encountered an assimilation process when explaining the meaning of symbol A. He said that symbol A showed the number of students who like math. S3 was sure the symbol A was very appropriate to be used to express the intent he wanted. As a matter of fact, S3 usesd symbol A to show a set of students who like math and symbol n (A) to show the number of members of set A. When explaining the meaning of an intersection symbol ($\cap$), S3 experienced the accommodation process. Initially , S3 claimed oblivious , after thinking for a moment S3 could explain the purpose of the intersection, but it was still halting and the explanation was not correct. S3 was not able to communicate ideas and knowledge with appropriate symbols. The set of symbols and members

was written by inappropriate symbols because when carrying out the assimilation and accommodation process, S3 used an inappropriate scheme. S3 thought that many members of set A were simply indicated by the symbol A. It was not in accordance with the scientific concept of the set. It was indicated by the following passage:

P   : "please explain, what is your reason to write this as known!" (while pointing the student answer)
S3   : "because in the question it is stated there are 20students who like mathematics, so I make that students who like mathematics are the same as ($=$) 20 atau A".
P   : " what does A mean ? ".
S3   : "A is member of its set."
P   : "Why A?".
S3   : "Because it is easier ".
P   : "So, what is this ? . (While pointing student is answer) S3: "Here, there are 25 students who like natural science, so I make students who like natural science are the same as ($=$) 25, so the member a set group is B (while looking and pointing question).
P   : "So what is this ?". (While pointing the student answer).
S3   : "Here 15 students like to learn both of them so I make the student who like both of them 15. I make A intersection B $((A \cap B))$".
P   : "Why is A intersection B?".
S3   : "Because he likes mathematics, and natural science. So A is intersection A irisan B $((A \cap B))$".
P   : "What is intersection ($\cap$)?".
S3   : With low voice and holding head and smiling, " Mmm I don't remember it Ma'am.
P   : "Why?".
S3   : (After thinking for a moment) "Intersection ($\cap$) is group A in...." (thinking while turning to right), " member of A in member B ....." (thinking again while turning left)), "Member A exist in member B ".

Based on the explanation of interview result with S3, it can be seen that S3 had a schema of knowledge about set and intersection operation, but he did not precisely use symbols to express members of a set and symbols for many members of the set. S3 was very sure of the symbol for the number of members for a set, but what he believed to be true was not suitable with the formal concept. This condition showed that S3 carried out an assimilation process about the symbols of the number of members of a set in an unsuitable scheme. This means that S3 did not respond to the problem according to the scheme as it is in accordance with scientific concept. Then it can be said that S3 had inappropriate mathematical communication skill.

3. Subject S5
Based on the answers of written test of the S5 as a whole, it was known that the written mathematical communication skill of the S5 was not good. A lot of S5's answers were a lot wrong, ranging from symbol writing, formula determination until writing final conclusions. When confirmed, S5 was also unable to explain it properly. The following by one of the S5 answer which was considered to be able to describe the scheme that the S5 had clearly :
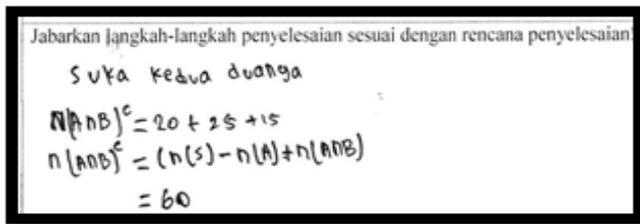
Figure 3. The Answer of Mathematical Communication
Test of S5

S5 experienced the accommodation process when asked to explain the answers he wrote   at the stage of solving the problem according to the completion plan. When asked to explain the meaning of the symbol 〖n (A∩B)〗 ^ C, S5 read   the symbol in an incorrect term. S5 read it according to what he saw . The symbol "∩" that should be read "intersection ", S5 saw it like the letter n, then the symbol "C" that should be read "complement", S5 saw   it just like the letter c as   usual. When asked to explain the meaning of these symbols, the S5 could not respond immediately. The S5 took   a long time to think about the answer, and finally the S5 could not   explain the meaning of the symbol. It was assumed that S5 had   an imitation scheme, because when solving problem, S5 just guessed   and imitated   what the teacher had   recorded or probably   from his friend's work. S5 did   not have enough knowledge to resolve the problem. The symbols he wrote might be symbols he had seen, but he did not understand the purpose of the symbol. It was indicated by the following interview passage:

P   : "Please explain the steps that you do?".
S5   : "n A n B c".
P   : "What does C mean?"
S5   : "the symbol".
P   : "What is the symbol used   for ?".
S5   : "For ....". (Student stays quite long enough while thinking)
P   : "Mmm?. "Let's continue for this what does it mean ? $20 + 25 + 15$ how can you get it ". (While pointing to the student)
S5   : "From question".
P   : It is "Known from question ? Why you add it ?
S5   : "..........".(Student stays quite long enough while looking question and answer) "who like both of them".
P   : "What about below this, what does it mean (while pointing
P   :   What does C mean?"
P   : What does C mean?""because in the question it is stated there are 20students who like mathematics, so I make that students who like mathematics are the same as $(=)$ 20 atau A".
P   : " what does A mean ? ".
P   : "Mmm?. "Let's continue for this what does it mean ? $20 + 25 + 15$ how can you get it ". (While pointing to the student)
S5   : "From question".
P   : It is "Known from question ? Why you add it ?
S5   : "..........".(Student stays quite long enough while looking question and answer) "who like both of them".
P   : "What about below this, what does it mean (while pointing the student answer)
S5   : "same as above".

P   : "And this ?". (While pointing the student)
S5   : "The total members minus the number of members and members who like both of them".
P   : Please explain what do you mean ! What is the relation between proceeding row ?
S5   : "The number ".
P   : "The number ?. So $n(S)$ means 20?"
S5   : "Yes".
P   : "Why is this substracted while this one is added, medium must be added ?
S5   : "That is wrong, Ma'am. First the numbers are added, all numbers are added, so that become 60"
P   : "So you make the score first, and then the formula?"
S5   : (nodding).

From the results of the work and interviews, it can be understood that   S5 did   not have enough knowledge scheme about the set. S5 only recognized symbols about the set but he cannot explain the meaning of these symbols. It can be seen that, S5 only imitate or rewrite   the symbols he had ever seen. S5 writes n (A∩B) ^ c = n (S) -n (A) + n (A∩B), as the followings,
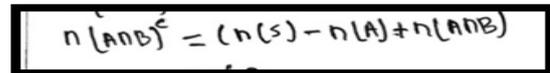
The S5 could not   explain whatever he has written   can be interpreted that the scheme of S5 knowledge about sets was false or   imitation. It means   that the S5 have imitation written mathematical communication skill.

4. CONCLUSION

Based on the result of data analysis, it was found that there were three types of   student's mathematical communication skill based on the assimilation and accommodation framework. Firstly, pseudo mathematical communication skill , student experienced an assimilation process with a quasi (pseudo) scheme. Student's written   mathematical communication skill seem   right, but actually he didn't   understand. Secondly, the student's written mathematical communication skill was not appropriate. Student experienced   an assimilation process with an inappropriate scheme. Student believed that the answers written were correct, but actually the answers were   not in accordance with the mathematical concept. Thirdly,   Imitation mathematical communication skill. Students experienced the accommodation process with imitation schemes. Students only imitated the forms of symbols that they had seen without knowing what the symbols mean. In accordance with the conclusions above, it can be concluded that the level of student communication skill was largely determined by the condition of the student scheme at that time. In other words, student communication skill can be improved by improving the quality of students' cognitive structures. Teachers can design learning that can facilitate students to construct their cognitive structures better.

Acknowledgements

REFERENCES

Alhaddad. I., Kusumah,Y.S., Sabandar, J., &Dahlan, J.A. (2015). Enhancing Students' Communication Skills ThroughTreffinger Teaching Model. Journal Mathematics Education. 6(1), 31-39.

Arbib, A.M. (1990). A Piagetian Perspective on Mathematical Construction. Syntesis. 84(1), 43-58.

Freeman, B., Higgins, K.N., & Horney, M. (2016). How Students Communicate Mathematical Ideas: An Examination of Multimodal Writing Using Digital Technologies. Contemporary Educational Technology, 7(4), 281-313.

Hasibuan, I.S., &Amry, Z. (2017). Differences Of Students Mathematical communication Ability Between Problems Based Learning, Realistic Mathematical Education And Inquiri Learning In SMP Negeri 1 Labuhan. IOSR Journal of Research & Method in Education. 7(6), 54-60.

Kaasila, R & Pehkonen, E & Hellinen, A. (2009). Finnish pre-service teachers' and upper secondary students' understanding of division and reasoning strategies used. Education Studies Mathematics. (pp: 247–261). Springer Science + Business Media B.V.

Netti, S. Nusantara, T., Subanji, Abadyo, Anwar, L. (2016). The Failure to Construct Proof Based on Assimilation and Accommodation Framework from Piaget. International Education Studies. 9(12).

Paridjo & Waluya, B (2017). Analysis Mathematical Communication Skills Students In The Matter Algebra Based NCTM. IOSR Journal of Mathematics. Vol 13(1).

Skemp, R. (1982). The Psychology of Learning Mathematic. Great Britain. Harell Watson & Vinely Ltd.

Subanji & Nusantara, T. 2016.Thinking Process of Pseudo Construction in Mathematics Concepts. International Education studies. 9 (2) 17-31.

Hodges, F. M. (2003). The promised planet: Alliances and struggles of the gerontocracy in American television science fiction of the 1960s. The Aging Male, 6(3), 175-182.