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JIGSAW TYPE OF COOPERATIVE LEARNING AS A MEANS OF IMPROVING HIGH SCHOOL-STUDENTS' MATHEMATICAL COMMUNICATION ABILITY

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ABSTRACT: *The mathematical communication is the basic ability which must be possessed by mathematics practitioners and users during teaching-learning process and assessing mathematics. By using Jigsaw technique as a part of cooperative learning, this technique considers students to work interdependently in a group of four to six but at the same time have individual responsibility. Every group is responsible for the mastery of the learning material. The aim of this research, however, was to examine the quality of mathematical communication ability between students who were treated with cooperative learning model and those with conventional model. The population of this study were second grade students of SMUN Banyumas in the academic year 2005/2006. Two classes were taken as sample, each of them had thirty students. Data were collected by means of communication ability test that had satistactory face and content validity and had reliability of 0.5335 (high reliability). Based on analisys result using t-test, it was concluded that the cooperative learning model gave better result to the students communication ability than the conventional one.*
KEY WORDS: *jigsaw, cooperative learning model, conventional learning model, mathematical communication ability.*

INTRODUCTION

Many scientists predict that the current speed of technology advancement during this millennium era is still unable to reveal the whole isolated mathematical facts. That is why those who have to deal with mathematics will need more communication and information. Lindquist, the President of the National Council of Teacher of Mathematics (NCTM), 1992-1994, states that we will need mathematrical

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communication if we want to fully achieve the social goal such as mathematics literacy, life-long learning and mathematics for all (NCTM, 1996a:1). The mathematical communication ability, as recommended by NCTM, includes such aspects as representing and discourse, reading, writing, discussing and assessing (NCTM, 1996a).

In relation with today's goal and expectation of mathematics learning which, according to UNESCO (United Nations for Economic, Social and Cultural Organization), is supported by four elements namely *learning to know, learning to do, learning to be* and *learning to live together (in peace and harmony),* it is essential that learning model which address the four elements be created (UNESCO, 1991).

With regard to the above consideration, the problem is how teacher should improve the quality of the teaching-learning process to achieve the student's ideal ability in communication. This, of course, should be done by finding the suitable learning model. This is the topic, whereas the writers want to deal with in the research.

Knowing that normal learning practice still rely on teacher as the source person, the writers consider that giving reading materials will have maximum effect if it is given in the form of learning.

With those stated above in mind, the problem of the research can be formulated as follows: (1) Is there any difference in terms of mathematical communication ability between students who are taught using Jigsaw type of cooperative learning and those taught using conventional model?; (2) What do students and teacher do during Jigsaw type of cooperative learning?; (3) What is the quality of the students' cooperative skill in Jigsaw type of cooperative learning?; and (4) How is the student's interest in Jigsaw type of cooperative learning in mathematics class?

LITERATURE REVIEW:
A. MATHEMATICAL COMMUNICATION

Mathematical communication is the ability to communicate in the forms of: (1) reflecting concrete objects, picture, or mathematical ideas; (2) creating situational mode orally, in written, using concrete objects, graph and algebra; (3) using the ability to read, write, and analyze to interpret and assess mathematical ideas, symbol, terms and information; and (4) responding to a problem using sound argument (NCTM, 1996b; and Wahyudin, 2000).

The mathematical communication is the basic ability which must be possessed by mathematics practitioners and users during teaching-learning process and assessing mathematics. Peressini & Bassett (in NCTM, 1996a:157) argue that without mathematical communication, we will have a little information, data and facts about student's comprehension in doing mathematical process and application. This implies that mathematical communication helps teacher to understand his student's ability in interpreting and expressing their understanding (Tarigan, 1980; Hardjawidjaja, 1988; and Pudawari, 1997).

A research which needs to be mentioned in this context is one conducted by Mulyadiana (2000) who concluded that an improvement in communication ability occurs after students of *Madrasah Aliyah* (Islamic High School) were given reading material in the form of pictures, diagrams, graphs and tables.

B. Jigsaw Type of Cooperative Learning

Cooperative learning is a very popular today. Slaving (in Lasmawan, 1997:10) says that cooperative learning is a learning model in which students learn and work in small heterogenous groups of four to six collaboratively. While Sunal & Hans (in Juliati, 2000:30) state that cooperative learning is a learning strategy which is designed to encourage students to work together during the learning process.

Jigsaw technique was developed by Aronson as a part of cooperative learning (in Slaving, 1995; Lasmawan, 1997; and Juliati, 2000). In this technique, students work interdependently in a group of four to six but at the same time have individual responsibility. Every group is responsible for the mastery of the learning material.

R.E. Slavin (1995:122-124) outlines the procedure of using Jigsaw technique: (1) Groups are given different problems to be solved; (2) Each group study the problem; (3) Representatives of each group meet in an expert group to discuss the solution of the problem in about thirty minutes; and (4) The representatives return to their group to disseminate.

Research Method and Technique

The research method and technique can be illustrated as follows. *First,* **Research Design.** The research is experimental one with the following design:

A : T X T
A : T T

"A" is the sampling which is done randomly on class basis; "T" is the pre and post-test, and "X" is the treatment, the Jigsaw technique.

Second, **Population and Sample.** Kusumajaya stated that "*high school students have a relatively similar characteristics in terms of their dependence in learning*" (in Hardjawidjaja, 1988). The population of this research is the second year students of SMA (*Sekolah Menengah Atas* or Senior High School) in Baturaden, Banyumas, Central Java, Indonesia. Out of that population a class is randomly taken as experiment group and another class as control group taught using conventional technique.

Third, **Instrument.** The research has used the steps as follows: (1) Validity. The formula used to calculate the validity coefficient of every test item is that of Product Moment Correlation:

$$r_{xy} = \frac{n\sum XY - \left(\sum X\right)\left(\sum Y\right)}{\sqrt{\left\{n\sum X^2 - \left(\sum X\right)^2\right\}\left\{n\sum Y^2 - \left(\sum Y\right)^2\right\}}}$$

n : the number of testees
x : item score
y : total score

The result is then t-tested using the following formula:

$$t = r_{xy} = \sqrt{\frac{N-2}{1-r_{xy}^{\;2}}} \backslash$$

t : differing power
r_{xy} : correlation coefficient
N : the number of the students

Based on the above calculation, the t_{table} is 2.42 with the degree of significance of 99% and N 40.

Table 1
Item Validity

Item number	r_{xy}	t_{count}	Remarks
1	0.43	2.94	Valid
2	0.72	6.40	Valid
3	0.34	2.27	Valid
4	0.73	6.58	Valid
5	0.74	6.78	Valid

Having used the validity, next step (2) is Analysis of Test Reliability. To calculate the reliability, the writers use Alpha formula as follows:

$$r_{11} = \left(\frac{n}{n-1}\right)\left(1 - \frac{\sum S_i^2}{S_t^2}\right)$$

R_{11} : reliability coefficient
N : number of items
"S_1^2 : the number of score variance of every item
S_t^2 : the variance of the total score

It is found that r is 0.5335 and after t_{test} the t_{count} is 3.89 for N equals 40 and the degree of significance of 99%, so t_{table} is 2.42. This means that t_{count} is higher or that the test is very reliable.

Having used the analysis of test reliability, next step (3) is Analysis of Difficulty Level. In this research, the researchers stipulate that a testee is said to have made a correct answer if he/she gets a minimum score of 2 out of 4 for every test item. This is based on the holistic scoring rubrics which says that level 2, 3 and 4 of the students' answer is regarded correct. The criteria used to determine the level of difficulty can be seen in the following table:

Table 2
Difficulty Index

Item	Difficulty Index	Category
1	74	Easy
2	44	Medium
3	70	Medium
4	55	Medium
5	56	Medium

Having used an analysis of difficulty level, next step (4) is Analysis of Discriminating Power. To determine the differing power of each test item, the researchers use half dividing which gives upper group (27%) and lower group (27%). The formula used to calculate it is that designed by Karno To (1996:15) as follows:

$$DP = \frac{S_A - S_B}{I_A} x100\%$$

DP : differing power
S_A : the score sum of the upper group of the item processed
S_B : the score sum of the lower group of the item processed
I_A : the ideal score of the item processed

The intervals with their corresponding categories are:

Negative – 10% : very bad
10% - 19% : bad
20% - 29% : fair
30% - 49% : good
50% - up : very good

The result of the calculation of the differing power can be seen in the following table:

Table 3
Difficulty Index

Item	Differing Power	Category
1	39	good
2	48	good
3	50	good
4	36	good
5	24	fair

Data Analysis

Statistical calculation used is the $t_{test,}$ that is to test two means. Prior to the test, the normality and homogeneity of the data have to be identified first.

First, **Normality test**. This is done using X^2 test with the help of the following table:

Table 4
X^2 test

Class Interval	Class Limit	Z Class Limit	Z table width	E	O	$\frac{(O-E)^2}{}$

Testing Criteria: If $X^2{}_{count}$ is smaller than $X^2{}_{table}$, it means that the data is distributed normally.

Second, **Homogeneity test**. This is calculated using the F statistics, namely:

$$F_{count} = \frac{S^2{}_{big}}{S^2{}_{small}}$$

With $S_i^2 = \dfrac{(n-1)(S_1+S_2)}{n_1+n_2-2}$; and $F_{table} = F_{(\alpha)(dk1,dk2)}$.

Hypothesis is accepted if F_{count} is smaller than $F_{table.}$

Third, after it is known that data is distributed normally and homogenously, it is followed by t_{test} of which the formula is following here (in Sudjana, 1996:239).

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\dfrac{(n_1-1)S_i^2 + (n_2-1)S_2^2}{n_1+n_2+2}\left(\dfrac{1}{n_1}+\dfrac{1}{n_2}\right)}}$$

$\overline{X_1}$ = the mean of the first sample

$\overline{X_2}$ = the mean of the second sample

S_1^2 = the variance of the first sample

S_2^2 = the variance of the second sample

n_1 = the number of data of the first sample

n_2 = the number of data of the second sample

If the data obtained is distributed normally but not homogenously, the statistic test used to t_{test} with:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{S_i^2}{n_1} + \frac{S_2^2}{n_2}}}$$

If the data is neither distributed normally nor homogeneously, the test uses that of Mann-Whitney (in Subino, 1987) as follows:

First, finding the percentage of students' interest. The percentage of alternative answer = *alternative answers* x 100% number of sample.

Second, in finding the percentage of teacher and students' activity in the learning process, the instrument's reliability is determined by two observers and the data obtained is analyzed using:

$$R \left(1 - \frac{A-B}{A+B}\right) X 100\% \quad \text{(Borich, 1994:385)}$$

Third, in finding the percentage of the frequency of the students' cooperative skill during learning process, the instrument reliability is decided by observers and the data is then analyzed using:

$$R \left(1 - \frac{A-B}{A+B}\right) X 100\% \quad \text{(Borich, 1994:385)}$$

A : the frequency of behaviour as noticed by observer of high frequency
B : the frequency of behaviour as noticed by observer of low frequency

RESULTS:
A. MATHEMATICAL COMMUNICATION ABILITY

The mathematical communication ability is taken from the mean of summative test score for experiment class, while that of control class is taken from the mean of summative test score on the topic related to communication ability, namely that of *chance.*

Table 5
The Mean of Standard Deviation of Mathematical Communication Ability

Table 6
Normality and Homogeneity Test

Class	X^2_{count}	dk	$X^2_{table}(a = 0.0)$	Category
Experiment	4.17	3	1.3	normal
Control	2.69	3	1.3	normal

This shows that the two compared have the same variance in their mathematical communication ability. This is because F_{count} is 1.25, which is smaller that F_{table}, which is 2.29 ($F_{count<}$ F_{table}).

To find the difference between the two means of the two class, the writers used t_{test} with the following hypothesis formula:

Ho : There is not any difference in the students' mathematical communication ability between the experiment and control class.
Hi : There is difference in the mathematical communication ability between the experiment and control class.

T_{test} shows that there is significant difference in mathematical communication ability between students in the experiment class and those in control class with α being 0.01. From the calculation of t, it is found that t_{count} is 9.60, while t_{table} is 2.65. This means that there is difference in mathematical communication ability between students in the experiment and control group in the topic of *chance.*

B. OBSERVATION RESULT

There are three the results of observation in the research. *First,* **Students' and teacher's activities**. The students' and teacher's activities during the learning process is expressed in percentage. The observation was done by two observers and to two groups of students and teachers alternatively every two minutes. One was used to write the record on the ready made observation sheet. The observation went on until the end of the learning process. The purpose of using two observers is to get data on the reliability, the result of which is presented in the following table:

Table 7
The Means of Reliability Coefficient of Student-Teachers' Activity

Observation subject	Reliability Coefficient (%)					Means of Reliability (%)
	LP1	LP2	LP3	LP4	LP5	
Student	86.33	83.33	79.50	79.00	83.00	82.23
Teacher	73.83	79.00	76.50	73.83	79.50	76.53

From table 7, it can be seen that the reliability coefficient as recorded by both observers is 82.33% for students' activity and 76.53% for that of teacher's. Therefore the observer's observation to the student-teacher activity during the Jigsaw mode of learning can be classified as constant (Borich, 1994).

Second, **Student's cooperative skill**. Student's cooperative skill during the learning process can be seen in the following table. The observation was done by two observers and to two groups of students and teachers alternatively every two minutes. One was used to write the record on the ready made observation sheet. The observation went on until the end of the learning process. In recording their observation, the observers were permitted to write more than one category of cooperative skill.

Table 8
The Means of Reliability Coefficient

Reliability Coefficient					Means of Reliability Coefficient
LP1	LP2	LP3	LP4	LP4	
85.33	87.33	92.00	86.00	85.00	87.13

From table 9, it can be seen that the reliability coefficient as recorded by both observers is 82.33% for students' activity and 76.53% for that of teacher's. Therefore the observer's observation to the student-teacher activity during the Jigsaw mode of learning can be classified as constant (Borich, 1994).

Table 9
Frequency and Percentage of Student's Interest in Jigsaw Technique

ITEM	AGREE		DISAGREE		NO IDEA	
	F	%	F	%	F	%
1	18	60.00	4	13.33	8	26.67
2	10	33.33	18	60.00	2	6.67
3	26	86.67	1	3.33	3	10.00
4	25	83.33	2	6.67	3	10.00
5	3	10.00	25	83.33	2	6.67
6	17	56.67	10	33.33	3	10.00
7	18	60.00	5	16.67	7	23.33
8	27	90.00	1	3.33	2	6.67
9	26	86.67	2	6.67	2	6.67
10	26	86.67	1	3.33	3	10.00
11	28	93.33	1	3.33	1	3.33
12	28	93.33	0	0.00	2	6.67

Third, **Student's interest in Jigsaw technique.** To find this out, a questionnaire was given to each student. There were required to choose one out of three options provided (agree, disagree, no idea) and give their reason for the choice. The result is as seen in table 9.

To item number one of the questionnaire 60% of the students express that they enjoy being taught mathematics using Jigsaw technique, because they have to find problems related to material which they will learn in the next meeting.

Conclusion

Based on the research and discussion, it can be concluded as follows:

First, Mathematical communication ability of students who learn using Jigsaw type of cooperative learning is better than those using conventional model of learning.

Second, the students' main activities during the learning process using the Jigsaw technique are listening to teacher's or peers' explanation, making necessary note, studying the student's work sheet, discussing with their peers; while those of the teachers include monitoring students' activities, guiding and motivating.

Third, the main cooperative skills during the learning process are be on duty, respecting others, checking for accuracy and actively listening.

Fourth, Students give positive response to the use of Jigsaw technique because it makes their learning more dynamic, effective and efficient. Besides, it teaches them a sense of responsibility for the tasks assigned to them, self confidence and improving their sense of solidarity.

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