

## **Improving Mathematical Communication Ability and Self Regulation Learning Of Junior High Students by Using Reciprocal Teaching**

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### ***Abstract***

This paper presents the findings from a posttest experiment control group design by using reciprocal teaching, conducted in Indonesia University of Education to investigate students' ability in mathematical communication and self regulated learning. Subject of the study were 254 of 9th grade students from three junior high schools of high, medium, and low level in Bojonegoro, East Java. The instruments of the study were an essay mathematical communication test, and a self regulated learning scale. The study found that reciprocal teaching took the best role among school cluster and students' prior mathematics ability on students' mathematical communication ability and self regulated learning as well. The other finding were there was interaction between school cluster and teaching approaches, but was no interaction between students' prior mathematics ability and teaching approaches on mathematical communication ability and self regulated learning. Moreover, there was association between mathematical communication and self regulated learning

**Keywords:** Reciprocal Teaching, Mathematical Communication, Self Regulated Learning

### **Abstrak**

Makalah ini melaporkan temuan dari suatu eksperimen dengan disain tes akhir dan kelompok control yang memberikan reciprocal teaching dan bertujuan mengembangkan kemampuan komunikasi matematis dan kemandirian belajar siswa. Penelitian melibatkan 254 siswa kelas 9 dari tiga SMP yang mewakili sekolah klaster atas, sedang dan bawah di Bojonegoro Jawa Timur. Instrumen penelitian ini adalah tes komunikasi matematis dan satu set skala kemandirian belajar. Penelitian menemukan bahwa pembelajaran reciprocal teaching memberikan peran terbesar dibandingkan dengan klaster sekolah, level kemampuan awal matematika siswa, dan pembelajaran konvensional terhadap pencapaian kemampuan komunikasi matematis dan kemandirian belajar siswa. Temuan lainnya adalah, terdapat interaksi antara pembelajaran dan klaster sekolah, namun tidak terdapat interaksi antara pembelajaran dan kemampuan awal matematika terhadap kemampuan komunikasi matematis dan kemandirian belajar. Selanjutnya, ditemukan pula asosiasi antara kemampuan komunikasi matematis dan kemandirian belajar.

**Kata kunci:** Reciprocal Teaching, Komunikasi Matematis, Kemandirian Belajar

### ***Introduction***

Mathematical communication ability as an essential learning mathematics outcome should be improved on high school students. That statement was in line with the goals of National Education (2004) and school mathematics learning (KTSP, 2006, NCTM, 2004). Those goals among other things were: to communicate mathematically, to use mathematics as a tool for communicating, to make relation among mathematics ideas, to express mathematics idea, and to explain a situation or problem by using symbol, table, diagram, or other media. Further, by referring to some writers' opinions Sumarmo (2000) identified some indicators of mathematical communication ability namely: a) to express a situation, figure, diagram, or a real situation into mathematical language, symbol, idea, or model; b) to explain or clarify mathematical ideas, situation, and relation either oral or written; c) to listen, to discuss, and to write about mathematics; and d) to read written mathematical representation meaningfully.

To develop students' mathematical communication ability, Pugalee (2001) suggested that in learning mathematics students should be encouraged to answer questions accompanied with relevant reason, and to comment a mathematical statement in their own language, so that students became to understand the mathematics concepts and arguments meaningfully.

Brenner (1998), and Palincsar and Brown (1984) suggested reciprocal teaching strategy for improving students' mathematical communication ability. Reciprocal teaching strategy followed constructivism philosophy that students should be encouraged and motivated to explore mathematical ideas, to ask explanation from their friends or teacher about difficult mathematics concepts without hesitating or being ashamed. Further, Palinscar (1986) stated that reciprocal teaching enclosed some learning activities namely: to read a written learning materials carefully, to summarize them, to pose some relevant questions, to construct an explanation and or a prediction. Those activities happened in cooperative learning small group situation, where teacher took a role as fasilitator and helped students by using probing and scaffolding. Similar to Palinsar (1986), Brener (1998) stated that during discussion in a small group, students were motivated and encouraged to propose some questions and opinions and then indirectly the activities would improve mathematical communication ability of the students. Hendriana (2002) by implementing reciprocal

teaching accompany with probing and scaffolding reported that senior high school students interacted actively, pleased to learn, and attained a good grade on mathematical communication ability. Further, Foster and Rotoloni (2008) suggested that learning materials should be written incrementally from a simple form to a more complex one.

There were some variables that potentially influenced the attainment of good grade on mathematics learning, among them was self regulated learning (SRL). Some of writers (Butler, 2002, Corno and Randi, 1999, Hargis, <http://www.smartkidzone.co/>, Paris dan Winograd, 1998, Schunk dan Zimmerman, 1998, Wongsri, Cantwell, dan Archer, 2002), elaborated the meaning of SRL, connected it to other similar terms, examined the effect of SRL on science learning, and proposed suggestion for improving SRL. In those articles SRL was defined in different ways but they had three main similar characteristics namely: to plan a goal, to select strategy, and to monitor cognitive and affective processes happened in solving an academic task. Hargis (<http://www.jhargis.co/>) defined SRL as an attempt to deepen and to manipulate associative network in a certain field, and to monitor the process. The SRL it self was not a mental ability or an academic skill such as reading ability but as self directive process that transformed into a certain mental ability. Bandura (<http://www.jhargis.co/>) suggested three phases in executing SRL such as: (1) self observe and self control, (2) compare our own position to a certain standard, and (3) give self positive or negative response. Similar to Bandura's suggestions, Schunk and Zimmerman (1998) proposed three phases in SRL cyclus namely: to plan learning, to implement the plan, and to evaluate learning outcome.

To analyzed the indicators of mathematical communication ability, of self regulated learning, and of metaphorical thinking approach, it was predicted that the teaching variable had a big role toward the attainment of students' mathematical communication ability and self regulated learning. Moreover, to consider previous mathematics ability as a prerequisite for further mathematics learning it was expected that previous mathematics ability to take an important role on achieving students' ability on further mathematics topics as well.

Those analysis encouraged researcher to conduct an experimental study to investigated the roles of metaphorical thinking approach and students' previous

mathematics ability on students' mathematical communication ability and self regulated learning.

### ***Theoretical Framework***

#### *Mathematical communication*

Basically, mathematics was an important symbol language that should be learned by every high school. Student who learned mathematics should possess communication ability by using mathematical symbols. The importance of possessing mathematical communication ability was in line with the goals of mathematics teaching-learning (Depdiknas, 2004, KTSP Matematika, 2006, NCTM, 1999) among other were: students could communicate ideas by using mathematical symbols, table, diagram, or other media for explaining situation or problems. NCTM (1999) stated that the goals of mathematics learning among others were to improve: ability to communicate mathematically, to use mathematics as a tool for communicating, ability to make connection among mathematical ideas, between mathematical ideas and other intellectual activities. Sumarmo (2000) stated that mathematics had universal attributes that could be understood by person who learned mathematics. Each mathematics symbol had definite meaning and agreed to all people. For examples symbols of whole number 9, of counting operator  $+$ ,  $\times$ ,  $-$ , and algebraic symbols  $\leq$ ,  $\{\dots\}$  were understood by students who learned mathematics.

Further, based on analyzing some writers' statements Sumarmo (2000) summarized the goal of learning mathematics language and symbols was to communicate mathematically so that students were able:

- a. To reflect and to explain their ideas mathematically;
- b. To formulate definition of mathematics concepts and to compile generalization through invention method;
- c. To express a figure, diagram, or a real situation into mathematical language, symbol, idea, or model;
- d. To explain or clarify mathematical ideas, situation, or relation in daily language orally or written;
- e. To read, to clarify, and to examine mathematical presentation meaningfully;
- f. To appreciate the beauty and the power of mathematical notations and used them accurately and precicely.

Pugalee (2001) suggested to improve students' mathematical communication ability students were motivated to give relevant reason on their answer or statements and to remark on other opinions so that students were able to understand mathematics concepts being learned meaningfully.

Further, Kist (Clark, 2005) stated that in general effective communication ability should be possessed by students in all subject matters and not only in mathematics. Likewise, in daily society a person who had good communication ability tended to be able working together and had opportunity to become a successful person.

### ***Self Regulated Learning***

There were some components of teaching-learning process which had important role on improving students' mathematics ability, among others was self regulated learning (SRL). Bandura (Hargies, <http://www.jhargis.co/>, Sumarmo, 2004) defined the term SRL as a human personality and an ability to observe his or her own behavior. Then he suggested three phases in conducting SRL those were: To observe and to monitor his or her self; to compare his or her position with a certain standard, and to give either positive or negative self response. The strategy of SRL involved some activities such as: self evaluation, to manage and to transform, to determine goals and planning, to collect information, to note and to monitor, to drive a consequence, to think of and to repeat, to seek social assistance, and to review some notes. Hargis (<http://www.jhargis.co/>) defined SRL as an attempt to deepen and to manipulate associative network in a certain field, and to monitor the process. The SRL it self was not a mental ability or an academic skill such as reading ability but as self directive process that transformed into a certain mental ability. Then, Hargies (<http://www.jhargis.co/>) reported that students who performed high SRL obtained a good grade in science. Likewise, Yang (Hargis, <http://www.jhargis.co/>, Sumarmo, 2004) found that students with high SRL: tended to learn better in their own control, were able to control, to evaluate, and to manage their learning effectively, to save their time in solving their tasks, and to manage their time efficiently. Similar to Bandura's definition Schunk and Zimmerman (1998, Sumarmo, 2004, Woolfolk, 2007) defined SRL as a learning process that affected by his or her thinking, feeling, strategy, and behavior which oriented to attainment of his or her goals. Schunk and Zimmerman (1998, Sumarmo, 2004) stated three main phases in a siklus of SRL those

were: to plan learning, to monitor learning progress, and to evaluate learning outcome completely. Then, Woolfolk (2007) identified some factors that affected SRL namely: knowledge, motivation, and self-discipline. To possess high SRL, students should be acquainted with their selves, subject that would be learned, tasks, learning strategies, and application of the subject to be learned. Usually, students with high SRL performed high learning motivation, high interest on solving their tasks and high self discipline, aware why they should learn and they selected and solved their tasks based on their own control and not caused of external control. Corno (Woolfolk, 2007) proposed that motivation denoted the existence of commitment and self discipline indicated the existence of learning continuity, and both of them guaranteed that their activities proceeded continuously up to obtain the better grade.

Lowry (ERIC Digest No 93,1989-00-00) summarized some suggestions for facilitating development of SRL namely:

- a. Help students to identified the beginning of a learning project, then help them to examine and to compile a relevant report.
- b. Encourage students to consider that knowledge and the truth as a contextual phenomenon, to consider the frame work of value as a social construct, and to aware that they were able to work individually or coepratively.
- c. Create a patnership environment, by using strategy and evaluation criterium of negoziation.
- d. Be a learning manager except for information
- e. Help students to compile their needs suitable with their learning objectives.
- f. Encourage students to compile their objectives that could be obtained through various ways and offer them some successfully performances
- g. Profide samples of successfully works
- h. Be sure that they aware of their determined objectives, learning strategy, and evaluation standard
- i. Train the students to search, to derive conclusion, to develop and to self evaluate
- j. Act as a counselor in seeking a source learning
- k. Help students to fit the source and their need, and help them to develop positive attitude and feeling.
- l. Appreciate kinds of students personality and learning style.
- m. Use field experience as an adult learning experience

- n. Develop a high quality learning guide
- o. Encourage students to think critically
- p. Create an open environment and mutually believe for developing better performance.
- q. Help students to prevent ethics code for avoiding manipulation action.

Darr and Jonathan (2004) and Montalvo and Maria (2004) expressed that students with good SRL would maximize their opportunity and abilities in learning. They not only could control their meta cognition but also they could improve their SRL. Then, Montalvo and Maria (2004) identified the characteristics of students with high SRL namely: they believed that learning was proactive process, they could motivate themselves, and they used various strategies to obtain the learning outcomes that they wished. Pintrich (Rhee and Pintrich, 2004) proposed there were four kinds of strategies for improving SRL those were: self regulated thinking strategy that included to monitor, to control, and to manage self thinking, self regulated motivation and feeling which covered to monitor, to control, and to manage motivation, emotion, and feeling, self regulated behavior strategy that enclosed to monitor, to control, and to manage behavior, ; self regulated contextual strategy that enclosed to monitor, to control, and to manage context and environment.

### ***Reciprocal Teaching***

Reciprocal teaching was a teaching approach that students were trained to understand a text and to explain it to other member of their group. Palinscar (1986) stated that reciprocal teaching was a series of learning activities included to read learning materials, to draw a conclusion, to pose questions, to explain and to compile a prediction. Learning process conducted in a cooperative learning group and a member acted as a leader of discussion, and teacher acted as a facilitator and tutor by using scaffolding. He suggested four strategies those were: summarization, membuat question generation, clarification, and prediction.

Hendriana (2002) implemented reciprocal teaching accompanied with probing and scaffolding, reported that students interacted more active, performed to be please in learning, and obtained a good grade on learning. Foster and Rotoloni (2008) suggested that teacher should provide effective learning materials, the tasks were





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No	Statement	SDA	DA	A	SA
1.	I do my mathematics task because I love it.				
2.	When I face a difficulty on mathematics tasks, I wait for teacher's help.				
3.	The resolution of learning target help me to manage learning strategy				
4.	To know self position toward the target make me worry				
5.	I am proud of participating on various activities.				

***Findings and Discussion***

Table 1 showed that the higher school cluster and the grades of students' prior mathematics ability (PMA) so the higher the grades of students' mathematical communication ability (MCA) ability as well. These findings pointed out that school cluster and PMA took place good roles on attaining mathematical communication ability (MCA). However, regarded entirely class, and low and medium school cluster and PMA levels the grade of MCA of students taught by reciprocal teaching were better than the grade of MCA of students taught by conventional teaching. While on MCA there was no difference of the grade of students taught by reciprocal teaching and the grade of students taught by conventional teaching. Moreover, there were no different grade of MCA between students with low and of medium PMA taught by reciprocal teaching and of students with medium PMA and high PMA taught by conventional teaching.

Further analysis, by using two path analysis ANOVA study found that there was no interaction between teaching approaches and school cluster, and between teaching approaches and PMA on attaining MCA (Figure 1, and Figure 2).

Table 1.  
Students' Mathematical Communication Ability based on  
Teaching Approach, School Level, and Prior Mathematics Ability

School cluster	Students' PMA	Students' Mathematical Communication Ability						Total		
		Reciprocal Teaching			Conventional					
		Mean	SD	n	Mean	SD	n	Mean	SD	N
High	High	19.91	2.17	11	19.85	1.68	13	19.88	1.87	24
	Medium	19.55	2.20	22	17.70	2.30	20	18.67	2.41	42
	Low	16.70	1.16	10	16.64	1.57	11	16.67	1.35	21
	Sub Total	<b>18.98</b>	<b>2.33</b>	<b>43</b>	<b>18.07</b>	<b>2.29</b>	<b>44</b>	<b>18.52</b>	<b>2.34</b>	<b>87</b>
Medium	High	19.43	2.76	7	16.00	1.77	8	17.60	2.82	15
	Medium	16.62	2.11	21	13.80	1.79	20	15.24	2.41	41
	Low	14.21	1.05	14	11.13	1.41	15	12.62	1.99	29
	Sub Total	<b>16.29</b>	<b>2.62</b>	<b>42</b>	<b>13.28</b>	<b>2.41</b>	<b>43</b>	<b>14.76</b>	<b>2.92</b>	<b>85</b>
Low	High	17.75	0.96	4	13.75	1.71	4	15.75	2.49	8
	Medium	16.39	2.30	18	11.88	1.82	16	14.26	3.08	34
	Low	13.32	1.73	22	11.44	2.53	18	12.48	2.30	40
	Sub Total	<b>14.98</b>	<b>2.57</b>	<b>44</b>	<b>11.87</b>	<b>2.23</b>	<b>38</b>	<b>13.54</b>	<b>2.86</b>	<b>82</b>
Total	High	19.36	2.28	22	17.64	2.96	25	18.32	2.88	47
	Medium	17.61	2.62	61	14.64	3.12	56	16.19	3.22	117
	Low	14.33	1.93	46	12.64	3.04	44	13.50	2.66	90
	Sub Total	<b>16.74</b>	<b>3.00</b>	<b>129</b>	<b>14.54</b>	<b>3.53</b>	<b>125</b>	<b>15.65</b>	<b>3.44</b>	<b>254</b>

Note: Ideal score is 23

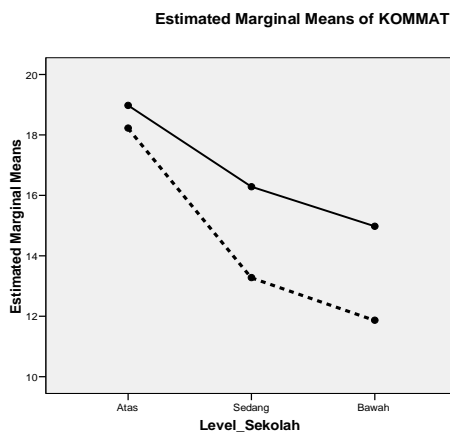


Figure 1. Interaction between School Cluster and Teaching approach on Mathematical Communication Ability

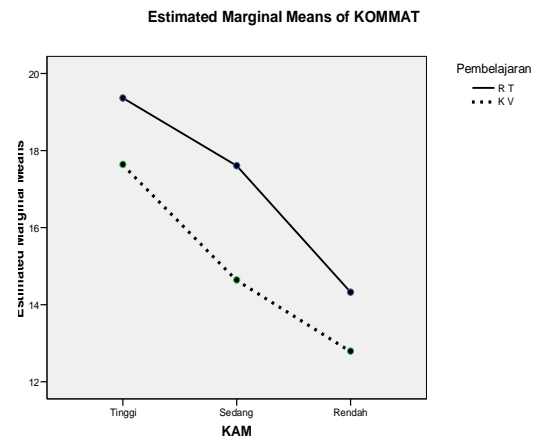


Figure 2. Interaction between PMA and Teaching approach on Self Regulated Learning

Similar to the findings of students' MCA, Table 2 showed that the higher the school cluster and students' PMA there were found the higher the grades of students' SRL. Those findings pointed out that school level and PMA level took roles on attaining students' SRL. However, regarded entirely, in each school cluster, and each PMA level, students' SRL of reciprocal teaching were always higher than those of conventional teaching. Those findings showed that reciprocal teaching took place the

best role compared to the roles of school level, students' PMA, and conventional teaching on attaining students' SRL.

Table 2  
Students' Self Regulated Learning based on  
Teaching Approach, School Level, and Prior Mathematics Ability

School cluster	Students' PMA	Teaching Approach						Total		
		Reciprocal Teaching			Conventional					
		Mean	SD	n	Mean	SD	N	Mean	SD	N
High	High	183.5	16.5	11	158.3	23.6	13	169.8	23.9	24
	Medium	165.6	21.4	22	149.0	16.3	20	157.7	20.7	42
	Low	157.5	25.4	10	147.0	16.7	11	152.0	21.4	21
	Sub Total	<b>168.3</b>	<b>22.9</b>	<b>43</b>	<b>151.2</b>	<b>18.9</b>	<b>44</b>	<b>159.7</b>	<b>22.6</b>	<b>87</b>
Mediocre	High	180.4	28.6	7	151.0	22.9	8	164.7	29.0	15
	Medium	163.2	22.0	21	147.2	22.7	20	155.4	23.5	41
	Low	154.9	21.8	14	131.4	23.9	15	142.8	25.5	29
	Sub Total	<b>163.3</b>	<b>24.1</b>	<b>42</b>	<b>142.4</b>	<b>24.1</b>	<b>43</b>	<b>152.7</b>	<b>26.1</b>	<b>85</b>
Low	High	176.5	20.0	4	137.5	11.2	4	157.0	25.7	8
	Medium	156.1	21.8	18	134.1	13.7	16	145.8	21.3	34
	Low	151.1	15.3	22	132.2	19.5	18	142.6	19.6	40
	Sub Total	<b>155.5</b>	<b>19.5</b>	<b>44</b>	<b>133.6</b>	<b>16.2</b>	<b>38</b>	<b>145.3</b>	<b>21.1</b>	<b>82</b>
Total	High	181.2	20.7	22	152.6	22.4	25	165.8	25.8	47
	Medium	162.0	21.7	61	144.1	19.0	56	153.4	22.3	117
	Low	153.7	19.6	46	135.6	21.1	44	144.8	22.2	90

Note: Ideal score is 242

The superiority of reciprocal teaching than conventional teaching was also pointed by the finding that the grades of students' SRL of low (155.5) and medium school cluster (163.3) taught by reciprocal teaching were higher than the grade of students' SRL of medium (142.4) and high school cluster (151.2) taught by conventional teaching. Such superiority were also pointed out by the findings that the grades of students' SRL of low PMA (153.7) and medium PMA (162.0) taught by reciprocal teaching were higher than the grades of students' SRL of medium PMA (144.1) and of high PMA (152.6) taught by conventional teaching. By using ANAVA study found there were no interaction between teaching approaches and school cluster, and PMA level on the attaining students' SRL (Figure 3, Figure 4).

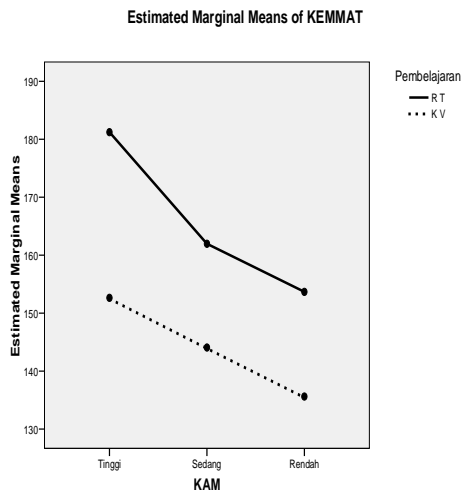


Figure 3. Interaction between teaching approach and PMA on MCA

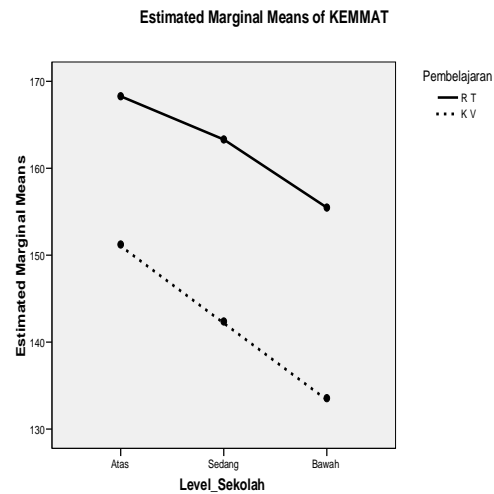


Figure 4. Interaction between teaching approach and school level on MCA

Further analysis by using  $\chi^2$  test in contingency table (Table 3) it was found contingency coefficient  $C = 0,545$  and it means that there was association between mathematical communication (MC) and self regulated learning (SRL).

Table 3. Association between Mathematical Communication (MC) and Self Regulated Learning (SRL)

Mathematical Communication \ Self Regulated Learning	Self Regulated Learning			Total
	Low	Medium	High	
Low	23	27	0	50
Medium	32	90	3	125
High	8	63	8	79
Total	63	180	11	254

In addition to the superiority of reciprocal teaching than conventional teaching on the attaining of students' mathematical communication ability and self regulated learning, from observation during reciprocal teaching study found a reflection of students' activities as follow. When reciprocal teaching was introduced for the first time, students of low and medium school levels were confused because they usually accepted only teacher's explanation but now they had to represent mathematics concepts in his own language, to pose questions, and to explain their ideas. However students of high school level were able to adapt those situation directly. Later on, in the next weeks students of all school levels were able to adapt reciprocal teaching

situation and their tasks, they unafraid to express their opinion, to solve the tasks, to pose questions, to explain, to clarify, and to propose arguments and reasoning. Even though, students of conventional teaching had no difficulties to follow the conventional lesson, but they pose some difficulties when they had to express their opinion, to solved the tasks, to pose questions, to explain, to clarify, and to propose arguments and reasoning.

### ***Conclusion***

Based on the findings and discussion, the study drew some conclusion as follow. Compare to conventional teaching, school cluster, and prior mathematics ability, the reciprocal teaching strategy took the best role to the attainment of students' mathematical communication ability and self regulated learning as well. The study also concluded there was no interaction between teaching approaches and school level and between teaching approaches and prior mathematics ability on students' mathematical communication ability and self regulated learning. Other conclusion was that there was association between mathematical communication ability and self regulated learning.

Concerning students' activities during the lesson, it was concluded that students of reciprocal teaching performed more active in discussion, they also were unafraid and unashamed to express their ideas, to pose questions, to explain, to clarify, and to propose arguments and reasoning. More over, they were more capable in compiling mathematics model, and they more systematic in solving mathematical communication problem than those of students taught by conventional teaching.

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