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How good are the students practicing the Collaborative Problem-Solving Skills in Mathematics-Based Task? (A Case of Indonesia)

Abstract

This study aims to assess the collaborative problem-solving skills of junior high school students on the subject of mathematics using the teaching approach of collaborative problem-solving. The student's skill in collaborative-problem solving will be the main focus of this study due to this skill is one of the important required skill regarding the Indonesian 2013 curriculum demands. In addition, collaboration-problem solving skill is a mandatory skill that must be given to students in facing global competition.

Collaborative problem-solving skills are one of the 21st century skills that not only prioritize knowledge of cognition but must also be together with social attitudes that will make success in a work group. This research was conducted at SMP Negeri 2 Telaga, State Junior High School in Gorontalo Province, Indonesia and was carried out in the academic year 2020/2021.

The research method used was a survey with a quantitative approach. The instruments used in data collection were tests. The results showed that the student's skills were still relatively moderate in using collaborative problem-solving skills, namely building and managing mutual understanding with the value of 11,682, taking action approaches or strategies to solve problems (10,219), and building and managing team organizations with 12,854.

Keywords: assessment, collaborative, problem solving, mathematics, student.

Introduction

Student achievement in mathematics is still one of the problems in mathematics education in Indonesia (Prahmana, 2017; Yurniwati & Hanum, 2017). This is a classical problem that has not been resolved until today (Reys, et al., 2009). At the international level, the mathematics achievement of Indonesian students is still below compared to that of other countries (Aini, 2013; PISA, 2013; Sari, 2015). The results of an assessment conducted by TIMSS in 2015 placed Indonesia in rank 44 out of 49 countries (Nizam, 2016). In addition, the results of a survey by the Programme for International Student Assessment (PISA) in 2018, which was published in March 2019, indicated that, in the mathematics category, Indonesian students occupied rank 7 from the bottom (73) with an average score of 379. It was a decrease in achievement, in which Indonesia was ranked 63rd in 2015.

The low student achievement in mathematics can be caused by various factors. One of them is that many students still consider mathematics a very difficult subject (Sinay & Nahornick, 2016). As a result, most of them are not enthusiastic and confident enough in learning mathematics. In addition, the factors of methods and approaches applied by the mathematics teachers to teach their students also affect students' learning outcomes (Nurhayati, 2014).

Mathematics has an important role. It is a basic science of knowledge that is widely used in various fields of life (Rosa & Orey, 2011). Through the mathematics subject, it is hoped that students can develop critical, creative, systematic, logical, careful, effective, and efficient thinking skills in solving problems. This competence is highly needed so that students can have the ability to acquire, manage, and use the information to survive in ever-changing, uncertain, and competitive conditions (Haciomeroglu, 2006; Hill et al., 2016).

The National Council of Teachers of Mathematics suggested that the implementation of effective mathematics learning must (1) involve students in completing and discussing tasks that encourage reasoning and problem solving and allowing various input and solving strategies, (2) involve students in making connections between mathematical representations for a deep understanding of mathematical concepts and various procedures for problem-solving, (3) facilitate discussion among students to build mathematical understanding by analyzing and comparing various approaches and arguments proposed by students, (4) provide meaningful questions to assess the progress of students' reasoning, and (5) utilize the results of students' thinking to assess their progress towards mathematics understanding and to adapt ways of teaching on an ongoing basis that support and develop students' learning styles (Lindquist et al., 2017; Lomibao, 2016; Nolan et al., 2015).

In general, the goal of learning mathematics is to construct the problem-solving skills that are expected to be acquired by students after learning math-

ematics. The problem-based collaborative learning strategies are superior to conventional strategies in terms of developing students' mathematical problem--solving abilities, mathematical communication skills, and confidence in learning mathematics (Norton, 2018). For that reason, the implementation of problem--based collaborative strategies in mathematics learning needs to be carried out more so that students have adequate problem-solving skills and mathematical communication skills (Degner & Fi, 2012; Hoover et al., 2016).

Literature review

Collaborative Problem-Solving

Collaborative Problem-Solving Skills are an essential and necessary skill in preparing students to become a qualified and successful workforce in a career (Fiore et al., 2015; Griffin, 2017). In its implementation in learning, collaborative problem-solving skills require interaction between students and each other in solving problems to achieve common goals (Graesser & Foltz, 2013). The ability to collaborate for problem-solving is crucial to be developed so that students can work together in different groups as a provision to face the globalization era of the 21st century (Levy & Murnane, 2013; Liu et al., 2012). Collaborative problem--solving skills are collaborative interactions between students to achieve common goals (Chinn et al., 2000; Graesser et al., 2018).

In Indonesia, the Ministry of Education has integrated collaborative problem--solving skills in the implemented curriculum in learning activities in response to the importance of mastery of 21st-century skills. The improvement of the 2013 curriculum has developed several objectives, which are: 1) Strengthening student--centered learning patterns; 2) Strengthening interactive learning patterns (teacher-student-community-natural environment interactive, sources / other media); 3) Strengthening network learning patterns (students can gain knowledge from anyone and from anywhere contact and obtain via the internet); 4) Strengthening active-seeking learning (active seeking student learning is further strengthened by the scientific learning approach); 5) Strengthening individual and group learning patterns (collaborating); 6) Strengthening multimedia--based learning; 7) Strengthening mass-classical based learning patterns while still paying attention to the development of the special potential of each student; 8) Strengthening the plural science learning patterns; and 9) Strengthening critical learning patterns (Ministry of Education and Culture Regulation, 2014).

The teacher should teach the students by using the right strategies in learning activities so that students can have the ability to collaborate in problem--solving (Umar et al., 2018). The implementation of this strategy has been carrying out practicum activities during the learning process (Häkkinen et al., 2016). Students who can collaborate in solving problems should master three compo-

nents of collaborative abilities. The three components are to: 1) Demonstrate the ability to work effectively and respect team diversity; 2) Show flexibility and willingness to accept other people's opinions in achieving common goals; 3) Carry out joint responsibility in collaborative work because they are required to appreciate the contribution of each team member (Trilling & Fadel, 2009). The importance of mastering collaborative problem-solving abilities for students made PISA start including it as an indicator in assessing student abilities in 2015. The CPS assessment in the PISA Program 2015 focused on cognitive and social skills related to problem-solving in collaborative scenarios (PISA, 2015). The indicators were building and maintaining shared understanding, taking appropriate action to solve problems, and building and maintaining group organizations.

Learning Mathematics with Collaborative Problem-Solving

In general, the students learn Mathematics because it helps them solve problems. Observation reveals that some students do not spend time identifying the problem, which makes it more challenging for them to create, execute, and analyze the effectiveness of a solution plan (Silbey, 2016). In the schools, many Mathematics educators have struggled to improve students' performance in Mathematics. Based on the cognitive load and problem-based theory, many conventional instructional formats are less than effective because little consideration is given to the concept of Collaborative Problem-Solving capacity (Tarmizi & Bayat, 2012).

According to Pólya (2004) there are four principles of problem solving: (1) understand the problem: students are often stymied in their efforts to solve problems simply because they don't understand it fully, or even in part; (2) devise a plan: the skill at choosing an appropriate strategy is best learned by solving many problems; (3) carry out the plan: using care and patience, persist with the plan you have chosen. If it continues to not work, discard it and choose another; (4) look back: take the time to reflect and look back at what you have done, what worked, and what didn't. The four stages of Pólya's cycle are neglected or missing in the work of low-achieving students, who would more typically rush into answering problems without planning systematically, neglecting to use key strategies, and finishing when they found an answer without stopping to consider whether the answer was reasonable (Boaler, 2008).

In the teaching practices, as many teachers, they often find themselves reverting back to teaching how they were taught rather than adapting and changing their practice. This is common in mathematics where procedural teaching and rote learning are often inherent. In many countries, schools are often wanting a 'programme' to follow rather than upskilling teachers' mathematical content knowledge and pedagogical content knowledge. However, the „ideal" Curriculum document is wanting to engage students in mathematical thinking as they solve problems and model situations in a range of meaningful contexts. The

teacher wants the students to create models and representations, justify and verify their thinking as they work with others and look for patterns and generalizations. This is nigh on impossible if the teacher only teaches mathematics using textbooks and worksheets. The best maths teachers have always encouraged their students to do more than learn by rote, because Mathematics is different from other subjects as it inculcates application of certain logical sequences that result in the culmination of a desirable solution to a problem. Contextually, to the change of mind-set of students in math classes, teachers have no choice but to incorporate rigour in their classes, which were once considered to be dead classes. Introducing mathematics to students in a context that is meaningful or perhaps linked to other subjects is one way of doing this (Cellis, 1993; Mirza & Hussain, 2014; Peterson, 2019).

By using Collaborative Problem Solving, teachers can facilitate students' learning through the Standards for Mathematical Practice and the act of productive persistence. The impact of teaching Mathematics through Collaborative Problem Solving method are: (1) empowers students to reflect on their own thinking and learning, (2) enables teachers to analyze student thinking for instructional implications, (3) aligns with the Common Core Standards for Mathematical Practice and Productive Persistence, as well as can be used in K–12 classrooms. Collaborative Problem Solving involves and engages every student in class. It also embraces the third Common Core Standard for Mathematical Practice (Graham et al., 1999; O'Brien, 2005; Zevenbergen et al., 2003).

Method

The population of this study was all grade XI students at SMP Negeri 2 Telaga, Gorontalo, Indonesia in the 2020/2021 academic year. Furthermore, samples were selected by employing purposive sampling. The total of samples in this study was 98 students. Those students were taught using collaborative problem--solving (CPS) by giving them mathematics assignments. The instrument applied in this study was a test of mathematical ability by measuring three aspects of the CPS adopted from the 2015 PISA, namely (1) building and maintaining shared understanding, (2) taking appropriate actions to solve problems, and (3) building and maintaining a team organization.

Result

The results of the pretest to determine students' initial abilities before being given the treatment showed that the average pretest scores of students' abilities in solving mathematical problems for three aspects of the CPS were 8.086

with maximum score is 10 for Aspect 1, 8.063 for Aspect 2, and 8.066 for Aspect 3. After being given treatment, the average posttest score of students' abilities in solving mathematical problems collaboratively was 13.343 for Aspect 1, 13.360 for Aspect 2, and 13.610 for Aspect 3.

By utilizing SPSS v. 20, the researchers carried out a data normality test using the Kolmogorov-Smirnov test at the significance level (α) of 0.05. The hypotheses for the normality test were as follows. H^0: Data is normally distributed and H^1: Data is not normally distributed. Furthermore, the criteria for testing the hypothesis were based on *p*-value (significance).

The results of the normality test of the students' ability scores for three aspects of the CPS before being given the treatment can be seen in Table 1.

Table 1
The Results of the Normality Test on Students' Pretest Scores for Three Aspects of the CPS

The Aspects of the CPS	Kolmogorov-Smirnov		Conclusion	Note
	Stat.	Sig.		
1	0.116	0.136	H^0 is accepted.	Normal
2	0.142	0.082	H^0 is accepted.	Normal
3	0.158	0.127	H^0 is accepted.	Normal

Source: author's results.

The significance values of students' abilities for three aspects of the CPS, according to the score gained from the Kolmogorov-Smirnov test, were greater than 0.05. These results indicated that H^0 was accepted. In other words, the distribution of data on students' ability scores for three aspects of the CPS before being given the mathematical assignment treatment was normally distributed.

The results of the normality test of the students' ability scores for three aspects of the CPS after being given the treatment can be seen in Table 2.

Table 2
The Results of the Normality Test on Students' Posttest Scores for Three Aspects of the CPS

The Aspects of the CPS	Kolmogorov-Smirnov		Resume	Note
	Stat.	Sig.		
1	0.148	0.096	H^0 is accepted.	Normal
2	0.165	0.082	H^0 is accepted.	Normal
3	0.136	0.027	H^0 is accepted.	Normal

Source: author's results.

Based on the results of the data normality test on students' ability in three aspects of the CPS (Table 2) after being given the treatment using the CPS method, in the Kolmogorov-Smirnov column, the significance value varied and all of three examined aspects were greater than the value of α (0.05). Therefore, the distribution of data on students' ability scores for three aspects of the CPS after being given the mathematical assignment treatment was normally distributed.

To find out whether the data for three aspects of the CPS have homogeneous variances or not, the variance homogeneity test was carried out. The test was conducted by using Levene's statistical test with a significance level of 5% with the following hypotheses.

$H^0 : \sigma^2 = \int_2^2$, the variance of data concerning students' abilities on three aspects of the CPS is homogeneous.

$H^1 : \sigma^2 = \int_2^2$, the variance of data concerning students' abilities on three aspects of the CPS is not homogeneous.

Hypothesis testing was carried out based on *p*-value (significance value or sig. value) with the following criteria.

If sig is ≤ 〈 with 〈 = 0.05, H^0 is rejected.

If sig is ≥ 〈 with 〈 = 0.05, H^0 is accepted.

The results of the homogeneity test on the scores of students' mathematical problem-solving abilities for the three aspects of the CPS before being given treatment can be seen in Table 3.

Table 3
Results of the Homogeneity Test on Students' Pretest Scores

The Aspects of the CPS	Homogeneity of Variance		Resume	Note
	Lenene's Stat.	Sig.		
1	0.096	0.758	H^0 is accepted.	Homogeneous
2	0.165	0.082	H^0 is accepted.	Homogeneous
3	0.136	0.027	H^0 is accepted.	Homogeneous

Source: author's results.

Based on Table 3 in the column of homogeneity of variance, the sig value of students' mathematical problem-solving abilities for the three aspects of the CPS was greater than α (0.05). Therefore, the variance of the pretest scores of students' mathematical problem-solving abilities was homogeneous.

After being given the treatment using a learning process with the results of the homogeneity test on the scores of students' mathematical problem-solving abilities for the three aspects of the CPS can be seen in Table 4 below.

Table 4
Results of the Homogeneity Test on Students' Posttest Scores

The Aspects of the CPS	Homogeneity of Variance		Resume	Note
	Lenene's Stat.	Sig.		
1	0.216	0.644	H^0 is accepted.	Homogeneous
2	0.165	0.082	H^0 is accepted.	Homogeneous
3	0.136	0.027	H^0 is accepted.	Homogeneous

Source: author's results.

In the table above, it can be seen that, in the column of Homogeneity of Variance, the sig value was greater than α (0.05). Therefore, the variance of the post-test score of students' mathematical problem-solving abilities was homogeneous.

Average Difference Testing

Data on students' abilities for three aspects of the CPS before being given the treatment were normally distributed and homogeneous. Therefore, to find out whether the average scores of students' abilities for three aspects of the CPS were equal before being given the treatment, the average difference test was carried out using the T-test. This statistical testing was conducted using SPSS v. 20 software with T-test (compare means independent samples t-test) at the significance level (α) of 0.05. For the rule of decision making, if the *p*-value (sig) was < α, then H^0 was rejected.

$$H^0 : \mu e = \mu k$$

$$H^1 : \mu e > \mu k$$

The results of the T-test on the students' CPS ability scores before being given treatment are presented in the following table

Table 5
The Results of the Mean Difference Testing on the Pretest Scores

t	Sig.	Conclusion	Note
0.042	0.965	H^0 is accepted.	There is no difference.

Source: author's results.

From the results of the T-test, the obtained sig value for students' CPS ability was greater than α (0.05). Therefore, before being given the experiment to students, they had the same initial ability for the three aspects of the CPS.

Based on the results of the normality test and the homogeneity test on the data concerning students' ability in three aspects of the CPS after being given the treatment, it was found that the posttest data on students' CPS ability scores in both classes were normally distributed and homogeneous. Therefore, to determine whether students' CPS ability was similar, the researchers carried out the average difference testing using the T-test. The results of the T-test on the posttest scores of students' CPS abilities were presented in the following table.

Table 6
The Results of the Mean Difference Testing on the Posttest Scores

t	Sig.	Conclusion	Note
2.1840	0.039	H^0 is rejected.	There is a difference.

Source: author's results.

Based on the data presented in the table above, it can be seen that the sig value was smaller than α (0.05). Therefore, H0 was rejected.

This meant that the mathematical problem-solving abilities of students who were given treatment with a collaborative problem-solving (CPS) learning method were better than that of students who were given the treatment with the conventional learning method.

Discussion

This study aimed at measuring students' ability in solving collaborative problems for three aspects of the CPS in mathematics. In addition, this study was also to find out the presence of an increase in students' problem-solving abilities by collaborating with other students in mathematical subjects both before and after being given the collaborative problem-solving learning model as the treatment (Griffin, 2017; von Davier & Halpin, 2013). Before being given treatment, students were given a pretest to determine their initial abilities in three aspects of the CPS, namely (1) building and maintaining shared understanding, (2) taking appropriate actions to solve problems, and (3) building and maintaining a team organization (OECD, 2013).

After being given the treatment, students were given a posttest to determine the increase in their ability in those three aspects of the CPS. The results of the normality test and homogeneity test on the data concerning students' scores on the mathematical representation ability before being given the treatment showed that the population was normally distributed and homogeneous.

Furthermore, from the results of the T-test at the significance level (α) of 0.05 on the scores of students' mathematical representation ability before being given the treatment, it was found that there was no difference in the initial students' ability for three aspects of the CPS. This means that, before being given the treatment, students had equivalent abilities for three aspects of the CPS.

After being given the treatment, the average score of students' abilities for the three aspects of the CPS obtained from the collaborative problem-solving learning method was higher than that from the conventional learning method (Luckin et al., 2017; Nokes-Malach et al., 2015).

The average score of students' abilities for three aspects of the CPS after being given the treatment using the collaborative problem-solving learning method was 11.567. The scores of students' abilities for three aspects of the CPS were 11.628 for Aspect 1 (building and maintaining shared understanding), 10.219 for Aspect 2 (taking appropriate actions to solve problems), and 12.854 for Aspect 3 (building and maintaining a team organization).

After students were given the treatment, their abilities for three aspects of the CPS increased. This increase was higher after giving the collaborative problem--solving learning method than the conventional method (Hesse et al., 2015). In other words, the collaborative problem-solving learning method can increase students' CPS abilities.

Conclusions

The study results indicated that the ability of students who got the collaborative problem-solving learning method was better than that of those who got a conventional learning method. In conclusion, this study proves that the collaborative problem-solving learning method can improve students' mathematical representation abilities.

The results of this study also showed that, from the three aspects of the CPS, students' CPS ability in the aspects of building and maintaining a team organization had the highest score, namely 12.854. Meanwhile, the lowest score was in the aspect of taking appropriate actions to solve problems, namely 10.219. The aspect of building and maintaining mutual understanding had a score of 11.628, which was categorized as a fairly good ability, meaning that students had a sufficient ability in solving problems collaboratively based on the treatment given to measure students' CPS abilities through assigning tasks on the mathematics subject.

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Jak dobrze uczniowie opanowują umiejętność wspólnego rozwiązywania problemów w zadaniach matematycznych (przypadek Indonezji)

Streszczenie

Celem artykułu jest ocena umiejętności wspólnego rozwiązywania problemów uczniów gimnazjów z przedmiotu matematyka z zastosowaniem metody dydaktycznej wspólnego rozwiązywania problemów. Umiejętność ta jest jedną z ważniejszych w odniesieniu do wymagań indonezyjskiego programu nauczania przedmiotu z 2013 roku. Jest ona traktowana jako kluczowa umiejętność w obliczu wymogów globalnej konkurencyjności.

Umiejętność wspólnego rozwiązywania problemów jest jednym z głównych wyzwań XXI wieku – na pierwszym miejscu stawia wiedzę, musi ona jednak harmonizować z nabytymi dyspozycjami społecznymi, które zapewnią sukces w grupie roboczej. Badanie przeprowadzono w SMP NEGERI 2 Telaga, gimnazjum państwowym w prowincji Gorontalo w Indonezji w roku szkolnym 2020/2021.

W badaniu zastosowano podejście ilościowe z wykorzystaniem testów. Wyniki pokazały, że umiejętności uczniów były umiarkowane w zakresie wspólnego rozwiązywania problemów, a mianowicie: budowanie i zarządzanie relacjami wzajemności i zrozumienia osiągnęło wartość 11 682, podejmowanie działań lub strategii w celu rozwiązywania problemów było na poziomie 10 219, a budowania zespołu i zarządzania nimi na poziomie 12 864 odpowiedzi.

Słowa kluczowe: ocena, współpraca, rozwiązywanie problemów, matematyka, uczeń.