JOURNAL OF BALTIC SCIENCE EDUCATION

ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

CLOSING THE SCIENCE PROCESS SKILLS GAP BETWEEN STUDENTS WITH HIGH AND LOW LEVEL ACADEMIC ACHIEVEMENT

Baskoro Adi Prayitno,
Duran Corebima,
Herawati Susilo,
Siti Zubaidah,
Murni Ramli

Abstract. *Science Process Skills (SPSs) are fundamental skills to mastering science. To nurture students' SPS, inquiry based learning and student-center activities may work effectively. This study aims at analyzing: How Inquiry-based Learning and Student Team Achievement Division (INSTAD) affects science process skills compared with inquiry-based learning, Student Teams Achievement Divisions (STAD), and conventional learning method. The participants were 136 grade 7 students from 27 public middle schools in Surakarta, Indonesia. They were divided into 68 students with higher academic (HA) achievement and 68 students with lower academic (LA) achievement. A nonequivalent control group design with pretest and posttest were applied to get data on SPSs using a sort of essay test. The result indicates that: (1) While the outcomes of INSTAD and inquiry-based learning are comparable, they are significantly different compared with the outcomes of STAD and conventional learning. (2) Students in HA group have higher SPS than students in LA groups. (3) INSTAD, on an equal level with inquiry-based learning, significantly increases the students' SPSs. Compared with other three methods, INSTAD was confirmed the most effective in closing the science process skills gaps between students in HA group and LA group.*

Keywords: *inquiry-based learning, INSTAD, STAD, science process skills.*

Baskoro Adi Prayitno
Sebelas Maret University, Indonesia
Duran Corebima, Herawati Susilo, Siti Zubaidah
State University of Malang, Indonesia
Murni Ramli
Sebelas Maret University, Indonesia

Introduction

Science comprises aspects of scientific product, process, and attitude. Products of science include concepts, principles, laws, and theories. Scientific process occurs when science process skills possessed by scientists are performed in conducting scientific works to invent a science product. Science process skills are categorized into basic process skills and integrated skills. Basic science process skills include the skills of observing, inferring, classifying, communicating, measuring, and predicting. Integrated science process skills include the skills of controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting, and formulating models. Scientific attitudes refer to the behavioral natures expected in individuals who intend to become successful scientists, which include honesty, conscientiousness, responsibility, and critical-mindedness (Hamilton & Swortzel, 2007; Hartikainen & Sormunen, 2003; Mei, Kaling, 2007).

To teach science ideally means teaching all three aspects of scientific product, process, and attitude to students. The three aspects will be learned optimally when the learning process is process-oriented. Process-oriented science learning encourages students to practice conducting scientific works and invent scientific products like a real scientist. Through scientific activities, students can improve their science process skills and develop scientific attitudes (Hartikainen & Sormunen, 2003; Karsli & Şahin, 2009; Rambuda & Fraser, 2004).

Science teaching in Indonesia mostly focuses on memorizing science concepts. The success of science teaching is generally measured by how many scientific products (concepts, theories, and laws) are successfully recognized and memorized by students. Students do not get adequate opportunities to develop their science process skills. Students learn in teacher-centered classrooms in which the teacher is the main knowledge resource who retains full control of the classroom and its activities (Prabowo, 2015). Science learning that emphasizes on merely memorizing science products will result in low science process skills and scientific attitudes of the students. By learning science process skills, students will get used to thinking logically and systematically and will be able to solve problems that they frequently face in their daily lives (Orhan, 2008; Mei & Kaling, 2007; Lumbantobing, 2005; Tifi, Natale & Lombardi, 2006).

Many studies show that the science process skills of Indonesian students are remarkably low (Deta, Suparmi, & Widha, 2013; Prabowo, 2015; Rusmiyati & Yulianto, 2009; Ambarsari, Santosa, Maridi, 2013). Data from PISA (Programme for International Student Assessment) indicated that in 2000, Indonesia ranked fourth worst for science process skills among 41 surveyed countries. In 2006, Indonesia ranked 50th of 57 countries and ranked 60th of 65 countries in 2009 (Kurnia, Zulherman, & Fathurohman, 2014).

In addition, the apparent science process skills gaps between students with different academic achievement need to be addressed immediately. Students' academic skills might be classified into high academic (HA) achievement and low academic (LA) achievement (Ozden, 2008; Ozguc & Cavkaytar, 2015). Students' academic achievement vary due to frequent nonlinearity in their age and intelligence (Corebima, 2007). Students' academic achievement is not only determined by their academic ability, but also by many other factors including study duration (Ozden, 2008). Academic achievement gaps between students with HA and LA achievement can be reduced if students with LA achievement are given sufficient time to study tailored to their need and ability (Corebima, 2007). In classrooms, all students have the same period to study, which creates academic achievement gaps. Therefore, a teaching model that can address this issue is greatly needed.

Science process skills can be taught through learning methods that focus on scientific work (Gormally, Brickman, Hallar, & Armstrong, 2009). An appropriate method is the inquiry-based learning. The syntax of inquiry-based learning is developed based on the procedures of scientific method (Douglas & Chiu, 2009; Leech, Howell, & Egger, 2004). Inquiry-based learning has been proven effective in improving students' science process skills (Brotherton & Preece, 1996; Deta et al., 2013; Mei, Kaling, Xinyi, Sing, & Khoon, 2007). To reduce the gaps between the science process skills of HA and LA students, cooperative learning method can be implemented (Corebima, 2007). Cooperative learning has been proven effective to optimize the scaffolding used for HA students to be adapted for teaching LA students through discussion, tutorial, and peer teaching. Optimized scaffolding will move students progressively toward stronger understanding and better learning outcomes (Murray & Arroyo, 2002) so that the skills gaps between HA and LA students can be reduced. In addition, optimized scaffolding gives LA students adequate study time (Bodrova & Leong, 1998). A meta-analysis conducted by Corebima (2007) on students' theses, final projects, and dissertations in Malang State University, Indonesia shows that cooperative learning can successfully reduce the academic achievements gaps between HA and LA students.

Integrating inquiry-based learning and Student Teams Achievement Divisions (abbreviated as INSTAD) is assumed essential to reduce the science process skills gaps between HA and LA students. Implementation of inquiry-based learning without combining it with Student Teams Achievement Division (STAD) is thought to be less effective in reducing the gaps because inquiry-based learning does not facilitate the scaffolding of HA students to be used by LA students as effectively as STAD does. On the contrary, implementation of STAD without inquiry-based learning does not sufficiently support students to practice science process skills, because unlike inquiry-based learning, STAD is not developed to teach science process skills to students. INSTAD, as a combination of inquiry-based learning and STAD, has the characteristics of both strategies. The feature of inquiry-based learning is that it teaches science process skills. STAD has a strong characteristic with scaffolding that has been proven successful in reducing the science process skills gaps between HA and LA students. The INSTAD model is seen as a potential strategy to reduce science process skills gaps between HA and LA students more effectively compared with inquiry-based learning and STAD alone.

Existing studies concerning the application of science process skills mostly discussed a single learning model, such as inquiry-based learning, problem-based learning, or project-based learning (Lu, Hong, & Tseng, 2007; Kusdemir, Yusuf, & Tüysüz, 2013; Probosari, 2015; Siew, Chong, & Lee, 2015). According to Ozden (2008), if a group of students with fairly balanced academic skills is given the exact same learning method and period, the learning outcomes will form a normal distribution curve. The gaps between the learning outcomes of HA and LA students can be reduced if the amount of time provided to LA students to learn is tailored to their needs. The implementation of a single learning model may lead to science process skills gaps between HA and LA students because the period of learning is not different. INSTAD is considered as a potential learning strategy to solve the problems of time through scaffolding and peer-tutoring activities due to its cooperative feature.

Based on the explanation above, it is necessary to conduct a study to determine whether INSTAD can significantly reduce the science process skills gaps between HA and LA students, and more effective than inquiry-based

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

learning, STAD, and conventional learning. INSTAD is developed to reduce the science process skills gap between HA and LA students. The aims of research are to find out: (1) how INSTAD affects science process skills compared with inquiry-based learning, STAD, and conventional learning; (2) what the influence of academic skills on science process skills; and (3) whether INSTAD can close the science process skills gaps between HA and LA students more effectively than inquiry-based learning, STAD, and conventional learning.

Research Methodology

General Background

The research is a quasi-experimental study conducted through nonequivalent control group design. The data were compared using pre-test and post-test. The research samples were treated for a period of six months starting from January to June 2012, and the scientific process skills were measured at the end of the treatment. In order to eliminate the variation of original scientific process skills among research samples, the pre-test scores were used as covariates. The research design is illustrated in Table 1.

Table 1. Research design.

Group	Class	Pre-test	Experimental Variable	Post-test
G1	$Class_1$	SPS	X1YI	SPS
G2	$Class_2$	SPS	X1Y2	SPS
G3	$Class_3$	SPS	X2Y1	SPS
G4	$Class_4$	SPS	X2Y2	SPS
G5	$Class_5$	SPS	X3Y1	SPS
G6	$Class_6$	SPS	X3Y2	SPS
G7	$Class_7$	SPS	X4Y1	SPS
G8	$Class_8$	SPS	X4Y2	SPS

SPS: Science Process Skills, X1: Inquiry-based learning, X2: STAD, X3: INSTAD, X4: Conventional learning, Y1: Higher Academic Achievement Students Y2: Lower Academic Students

Research Sample

The research population was seventh-graders of 27 public middle schools in Surakarta, Indonesia. Eight schools of low and high quality schools had been selected by stratified random sampling method, in which random samples were taken from two groups: higher quality schools (4 schools) and lower quality schools (4 schools). The quality of the schools was determined by the students' average scores of primary schools' national examination. National Examination for all schools in Indonesia is conducted every year. The data of primary school national examination score was taken from the Educational Board of Surakarta Regency with permission from the Board.

The participants in each school were grouped into two categories: higher academic achievement (HA) and lower academic achievement (LA) students. The total number of research samples were 136 students consisting of 68 HA students and 68 LA students. The students were classified according to their academic skills, which were based on their primary schools' national examination scores. The research sample is illustrated in Table 2.

Table 2. Sample distribution.

School	Class	**Σ Students**	**Σ HA**	**Σ LA**	Learning Model	National Examination Score
School A	VII A	36	17	0	Inquiry-based (34 students)	HA: 26,15-27,40 LA: 20,20-21,35
School B	VII C	36	0	17		

School	Class	**Σ Students**	**Σ HA**	**Σ LA**	Learning Model	National Examination Score
School C	VII A	36	17	0	STAD	HA: 25,95-27,25
School D	VII A	37	0	17	(34 students)	LA: 19,20-21,00
School E	VII D	36	17	0	INSTAD	HA: 26,30-28,50
School F	VII D	36	0	17	(34 students)	LA: 20,00-22,40
School G	VII D	36	17	0	Conventional	HA: 25,70-28,00
School H	VII C	35	0	17	(34 students)	LA: 21,30-22,35
Total		288	68	68	136 students	

Note: HA: Higher Academic Achievement Students, LA: Lower Academic Achievement Students

Among eight schools, there was one low quality school which the number of LA students were 17. In order to equate the sample in each school, researcher decided to use 17 as the amount of HA and LA students in each school. All students in each school have been treated together, however data were analyzed from 17 selected students. Prior to the treatments in all selected schools, researcher had discussed the plan of the participating students and role teachers, as well as took permission from the Educational Board of Central Java Province, and Educational Board of Surakarta Regency as the representative of The Ministry of National Education of Republic of Indonesia in the regional level, school management, role teachers, and students.

Instrument and Procedure

The science process skills of the students were measured through essay assessment. Science process skills include basic process skills and integrated skills. Ability to observe, classify, communicate, measure, and predict were used as the indicators of basic process skills mastery. Ability to identify variables, control variables, make operational definitions, form hypotheses, design and conduct experiment, and draw conclusions are the indicators of integrated process skills mastery.

Before beginning the assessment, the validity and reliability index of the assessment were tested. The validity test was conducted through an expert analysis and empirical test. Three experts were involved in testing whether the assessment was appropriate for measuring the science process skills indicators and whether it was consistent with the learning material. After analyzing, the experts stated that the assessment was valid with a validity index of 3.65. An empirical test was conducted following the expert analysis. The assessment was given to 34 grade 8 students of a public middle school in Surakarta, Indonesia as a trial. The result of the empirical test indicated that the assessment was valid with a validity index of 0.43-0.85. The reliability index of the assessment was tested using Cronbach's alpha formula. The result showed that the assessment was highly reliable with a reliability index of 0.83.

Before the research began, cooperating teachers participated in a training to have the proper knowledge of how to implement the learning model consistently. The implementation of the syntax of learning model during the study was controlled by three observers based on observational instruments to check the consistency of model's implementation.

INSTAD and STAD learning model were applied by considering the criteria of grouping method. Groups in each treatment class were divided into six, each with five members. Two or three students of HA achievement were put together with LA students, in order to provide peer scaffolding between HA and LA students. Whilst, in inquiry and conventional learning model, heterogeneous grouping system was applied, in which students were put randomly in each group.

Data Analysis

The data were analyzed using an analysis of covariance with the pre-test scores as covariates. Before conducting the analysis of covariance, a parametric statistical test as a prerequisite to measuring the data normality and the homogeneity of variance were conducted. The data normality was measured using the Kolmogorov–Smirnov test. The result of the test indicated that the pre-test data was 0.085 and the post-test was 0.203, higher than alpha level of 0.05. This means that the data sample did not deviate from the normal distribution. The homogeneity of variance was tested using Levene's test and it showed that the homogeneity of variance was 0.304, higher than

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

0.05 alpha level or it means the research data was homogenous. The differences in the average value of the variable were measured using the Least Significant Difference (LSD) test. The statistical calculations were measured using SPSS version 16.0 with a significance level of 0.05.

Results of Research

The new learning model called INSTAD is developed through several steps and procedures. Inquiry-based learning is integrated to STAD group works. The repetition phase of inquiry-based learning is used to strengthen the procedures of the STAD model. This phase is placed before individual assignment and group recognition. The outline of INSTAD procedures are: (1) phase I: problem orientation, (2) phase 2: inquiry work in STAD groups, (3) phase 3: class presentation, (4) phase 4: individual assignment, and (5) phase 5: group recognition. The procedures in INSTAD model are visualized in Table 3.

Table 3. Procedures of INSTAD model.

Step	Teacher's Activity	Students' Activity
Problem orientation	• The teacher forms heterogenic groups. • The teacher presents inquiry problem.	• The students participate in groups formed by the teacher
Inquiry work in STAD groups	• The teacher leads the students to find out and formulate the problems. • The teacher guides the students to formulate a hypothesis. • The teacher helps the students design experiments to collect data. • The teacher leads the students to analyze the data and test the hypothesis. • The teacher guides the students to draw a conclusion.	• The students find and formulate the problems. • The students formulate a hypothesis. • The students design experiments to collect data. • The students analyze the data and test the hypothesis. • The students draw a conclusion.
Class presentation	• The teacher asks each group to present the group's discussion result in front of the classroom.	• Members of each group present the discussion result in front of the classroom.
Individual assignment	• The teacher hands out individual assignment.	• The students work on the individual assignment.
Group recognition	• The teacher gives recognition to each group.	• Each group receives the teacher's recognition for their hard work.

The results of the analysis of covariance of the science process skills data on the learning model, academic skills, and the interaction between learning model and academic skills can be seen in Table 4. Table 4 indicates the significance of learning model variation as $p<0.0001$, less than the value of alpha = 0.05 (<0.05), which means that implementing different learning models significantly affects the students' science process skills.

Table 4. Analysis of covariance of the effect of different learning models on science process skills.

Source	Sum of Squares	df	Mean Square	F	p
Corrected Model	21813.285a	8	2726.661	58.341	0.001
Intercept	26731.859	1	26731.859	571.967	0.001
SPS Pre-test	275.464	1	275.464	5.894	0.017
Model	15608.696	3	5202.899	111.324	0.000
Academic Model*	344.772	3	114.924	2.459	0.066
Error	5935.566	127	46.737		
Total	589743.750	136			
Corrected Total	27748.851	135			

a. R Squared = 0.786 (Adjusted R Squared = 0.773)

The role of each learning model in improving the students' science process skills based on the LSD test is shown in Table 5. Table 5 indicates that the effect of INSTAD significantly differs from that of inquiry-based learning, and the effect of STAD significantly differs from that of conventional learning method. In addition, it can be seen that INSTAD and inquiry-based learning have similar results but are better than STAD and conventional learning in improving science process skills. The STAD model is believed to be effective in improving the students' science process skills compared with conventional method.

Table 5. Science process skills in different learning models.

Learning Model	XSPS	YSPS	Difference	SPSCor	Notation
Conventional	18.382	48.529	30.147	48.741	a
STAD	17.206	58.677	41.471	59.243	b
Inquiry-based	20.221	73.603	53.382	73.258	c
INSTAD	20.515	76.324	55.809	75.890	c

Note: XSPS: The average result of science process skills pre-test, YSPS: the average result of science process skills post-test, SPSCor: The average corrected science process skills.

Based on Table 4, the significance of academic achievement variation is sig. = 0.001, less than the level of alpha = 0.05 (<0.05), which means that the students' academic achievement significantly influences their science process skills. The average corrected score of science process skills in different academic skills is shown in Table 6.

Table 6. Science process skills in different academic skills.

Academic Skill	XSPS	YSPS	Difference	SPSCor
Low (LA)	15.846	59.007	43.161	59.985
High (HA)	22.316	69.559	47.243	68.581

Note: XSPS: The average result of science process skills pre-test, YSPS: the average result of science process skills post-test, SPSCor: The average corrected science process skills.

Table 6 indicates that the average corrected score of science process skills in HA students is 68.581 and in LA student is 59.985. The skills owned by HA students are different from the ones owned by LA students. HA students have better science process skills than LA students do.

Based on Table 4, the influence of the interaction between different learning models and the students' academic achievement and the effect on their science process skills is sig. = 0.066, higher than alpha level of 0.05. This means that there is no significant effect of the interaction between different learning models and the students' academic achievement on their science process skills. The interaction between learning models and academic achievement and how it affects the students' science process skills is indicated by the LSD test result presented in Table 7.

Table 7. Interaction between teaching model and academic achievement and its influence on science process skills.

Model	Academic	XSPS	YSPS	Difference	SPSCor	Notation
Conventional	Low (LA)	15.441	41.471	26.030	42.571	a
Conventional	High (HA)	21.324	55.588	34.264	54.910	b
STAD	Low (LA)	13.529	54.559	41.030	56.237	b c
STAD	High (HA)	20.882	62.794	41.912	62.250	c
Inquiry-based	Low (LA)	16.470	66.912	50.442	67.701	d
INSTAD	Low (LA)	17.941	73.088	55.147	73.433	e
INSTAD	High (HA)	23.088	79.559	56.471	78.348	e
Inquiry-based	High (HA)	23.971	80.294	56.323	78.816	e

Note: XSPS: The average result of science process skills pre-test, YSPS: the average result of science process skills post-test, SPSCor: The average corrected science process skills.

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Table 7 shows that the outcomes of inquiry-based learning model applied to HA students and INSTAD model applied to HA and LA students are significantly different from the outcomes of inquiry-based learning model applied to LA students, STAD model applied to HA and LA students, and conventional learning model applied to HA and LA students.

The outcomes of inquiry-based learning model applied to LA students are significantly different from the outcomes of STAD model applied to HA and LA students and conventional learning model applied to HA and LA students. The outcomes of STAD model applied to HA students are significantly different compared with the outcomes of conventional model applied to HA and LA students. The outcomes of STAD model applied to LA students are significantly different compared with the outcomes of conventional model applied to LA students but only slightly different with the outcomes of conventional model applied to HA students. The inquiry-based model applied to HA students and INSTAD model applied to HA and LA students have a comparable effect on students' science process skills. The outcomes are better than inquiry-based model applied to LA students, STAD model applied to HA and LA students, and conventional model applied to HA and LA students. The inquiry-based model applied to LA students helps improve the students' science process skills more effectively than conventional model applied to HA and LA students. HA and LA students were seen to have improved their science process skills after learning using STAD models. For LA students, STAD model seems to improve their science process skills more effectively than conventional model. STAD model successfully improved the science process skills of LA students at the same rate as conventional model improved the science process skills of HA students.

Discussion

Table 4 indicates that there is a significant influence of teaching model on science process skills. Table 5 shows that INSTAD and inquiry-based improve students' science process skills more effectively than STAD and conventional model. INSTAD and inquiry-based model have equal efficiency in improving science process skills. The STAD model has better efficiency than conventional model in improving science process skills.

STAD model is proven effective in teaching higher-order thinking skills (Nasir & Zaheer, 2010; Zakaria & Iksan, 2009). Students who have higher-order thinking skills are believed to have better science process skills than students who do not. This is in line with the argument of Adey (1999) and Lu et al. (2015) that using higher-order thinking skills for example problem-solving skills, inquiring skills, reasoning skills, communicating skills, and conceptualizing skills will positively contribute to a student's achievement and science process skills. (Adey, 1999; Edwards & Briers, 2000) argued that analytical, logical, and rational thinking are necessary to help students master science process skills.

Conventional teaching model forces students to memorize all knowledge they receive, which restrict the development of their science process skills. Edwards & Briers (2000) stated that science process skills could be mastered by students who have developed higher-order thinking skills. For this reason, students who learn through conventional model tend to have lower science process skills than students who learn using the STAD model. Unfortunately, there have not been many reports about the qualities of the STAD model that may lead to integrated science process skills improvement. The STAD model was not developed to teach science process skills. Instead, it was expected to improve and maintain students' existing science process skills better than conventional method (Corebima, 2007; Moraga & Rahn, 2007).

Inquiry-based learning improves science process skills better than the STAD and conventional model. Inquiry-based method is developed to teach science process skills to students (Gormally et al., 2009; Wenning, 2007). There are five steps in this method, which include: (1) Phase I, identifying and scoping problem. (2) Phase II, formulating hypothesis. (3) Phase III, collecting data. (4) Phase IV, interpreting data. (5) Phase V, drawing conclusion. The steps in inquiry-based learning are adopted from the procedures of scientific works (Douglas & Chiu, 2009; Leech et al., 2004; Marimuthu, Jusoh, & Ismail, 2003; Nelson & Ketelhut, 2007). Inquiry-based learning method has been proven effective in improving science process skills (Umar & Maswan, 2007; Wenning, 2007).

Compared with the STAD and conventional model, the INSTAD model is more effective in improving science process skills. Even when compared with inquiry-based, STAD and conventional models, INSTAD leads to the best result. INSTAD is an integration of inquiry-based model and the STAD model. Therefore, it has the characteristics of both inquiry-based and the STAD model. One of the features of inquiry-based method is that it teaches science process skills effectively. The character of STAD is effective in providing scaffolding during inquiry-based learning group activities. The STAD model enables students to work together and help each other through peer tutoring in order to comprehend the learning material (Gok, 2014).

The INSTAD model requires the students to perform inquiry-based learning in STAD groups. Inquiry-based activities in STAD groups facilitate the teachers in teaching integrated science process skills more effectively compared with inquiry-based and STAD model. The character of inquiry-based learning model that is able to teach science process skills is supported by the character of STAD that facilitates the scaffolding applied to HA students to be implemented to LA students. The scaffolding in the INSTAD model is more effective because it is performed by the teacher as well as the HA students. The character of inquiry-based learning in the INSTAD model requires the teacher to guide the inquiry of the students. The character of STAD in the INSTAD model requires HA students to provide peer tutoring to LA students. This way, both HA and LA students will be highly motivated throughout the learning process (Škoda, Doulík, Bílek, & Šimonova, 2015). Scaffolding by both the teacher and the HA students leads to the success of all students to improve their science process skills (Bodrova & Leong, 1998).

Table 4 illustrates a significant correlation between academic skills and science process skills. Table 6 indicates that HA students have significantly higher science process skills compared with LA students. Students in conventional classrooms have different talents, diligence, and capability in understanding the lesson. The differences are mainly caused by aspects such as family, school, and psychosocial factors. Family support, competitive classroom, and low social self-esteem can contribute to the diversity. The students' talents, diligence, and capability in the classroom are represented as a normal distribution. Under this condition, if all students receive the same teaching model, learning material, and study period, their academic achievement will be normally distributed. The students will be categorized into two groups: low academic achievement and high academic achievement. HA students have a better capability of responding to and understanding the lesson compared with LA students. With the skills and capabilities, they possess, HA students will understand the lesson better, and thus their science process skills are significantly higher than that of LA students.

In the classroom, HA students successfully comprehend the learning materials, while LA students need extra assistance in order to understand the lesson. LA students can understand the lesson better when they receive scaffolding from both the teacher and their classmates. Scaffolding from the teacher, as well as the classmates, encourages LA students to be able to enter the zone of proximal development (ZPD) (Lu, Hong, & Tseng, 2007). Learning models that do not facilitate scaffolding make it less feasible for LA students to enter the ZPD, which lead to apparent science process skills gaps between HA and LA students.

Table 4 indicates the deviation of the average science process skills scores between pretest and posttest. The science process skills of LA students increased by 272% and the science process skills of HA students increased by 212%. The statistical test result indicates that while the science process skills of HA students are significantly better than that of LA students, the science process skills potential of LA students is elevated more highly than that of HA students. LA students are able to improve their science process skills better than HA students. Peer tutoring and the teacher's guidance play an important role as scaffolding for LA students. HA students who have already mastered the integrated science process skills give peer tutoring to LA students who have not. As a result, the science process skills of LA students successfully improved.

Scaffolding through peer tutoring provides more study time for LA students (Lu et al., 2007). Adequate time to study can improve the academic achievement of LA students. The academic achievement improvement can be observed from the improved science process skills score from pretest to posttest. The improvement shows that the learning outcome of LA students is more optimal than that of HA students.

Table 4 also presents that learning model is not related to academic achievement. The LSD test as presented in Table 7 indicates that the STAD model applied to HA students is equally optimal compared with the STAD model applied to LA students. The STAD model can reduce the science process skills gaps between HA students and LA students since it facilitates the scaffolding appropriately. The scaffolding in the STAD model is performed through peer tutoring. HA students who already mastered science process skills give tutoring to their LA classmates to help them enter the zone of proximal development. It can be determined that peer tutoring effectively improves students' academic achievement (Gok, 2014; Shi, 2013). Peer tutoring provides a longer study period based on the need of LA students.

Table 7 shows that inquiry-based model is more effective to improve science process skills when applied to HA students. In addition, inquiry-based model cannot reduce the science process skills gaps between HA and LA students. Inquiry-based model does not facilitate scaffolding as well as the STAD model. When applied to conventional group, the learning situation becomes highly competitive. The learning process did not go very well because the students were required to compete with their classmates to be the best. Due to the atmosphere of competition, the positive synergy of the group did not develop. The competitive state caused HA students to be reluctant to

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

give peer tutoring to their LA classmates. Therefore, LA students did not enter the zone of proximal development successfully, which leads to the science process skills gaps between HA and LA students.

In addition, Table 7 indicates that the INSTAD model applied to HA students is equally effective compared with the INSTAD model applied to LA students. The INSTAD model successfully reduced the gaps of integrated science process skills between HA and LA students. Since INSTAD is an integration of inquiry-based model and the STAD model, it has the characteristics of both inquiry-based and the STAD model. Inquiry-based method is developed to teach students to master science process skills. Therefore, when combined with the STAD model, it successfully improves the students' science process skills. One of the characteristics of the STAD model is that it is designed to train the scaffolding of the students. The STAD model requires students learn by teaching each other (Adesoji & Ibraheem, 2009), so when combined with the inquiry-based model, it successfully reduces the science process skills gaps between HA and LA students.

Inquiry-based activities in the INSTAD model are conducted in STAD groups. The INSTAD model teaches science process skills to students through the characteristics of inquiry-based model. The process of teaching and learning science process skills is conducted in STAD groups, where HA students who have mastered the integrated science process skills must provide scaffolding to LA students who have not. Thus, the science process skills of HA students are not significantly different from that of LA students.

Table 7 also indicates that the INSTAD model is the most effective model to teach science process skills to both HA and LA students compared with inquiry-based model applied to LA students, the STAD model applied to HA and LA students, and conventional method applied to HA and LA students. This finding points out that the INSTAD model is proven effective in improving the science process skills of HA as well as LA students compared with inquiry-based model applied to LA students, the STAD model applied to HA and LA students, and conventional model applied to HA and LA students.

The advantages of the INSTAD model are determined by the characteristics of both inquiry-based and the STAD model. The syntax of inquiry-based model is proven effective to teach science process skills in STAD groups, which facilitates the students to study together and teach each other. The process of teaching science process skills in the INSTAD model is performed through inquiry-based assistance from the teacher and peer tutoring from the HA students. The effective method to teach science process skills has placed the INSTAD model number one in improving science process skills in HA and LA students.

Table 7 shows that conventional model improves science process skills better when applied to HA students than LA students. Conventional model does not optimally reduce the science process skills gaps between HA and LA students. This model places the teacher as the main source of information throughout the learning process. It is dominated by transfer knowledge between the teacher and the students. Conventional model does not facilitate students to improve their science process skills because the teaching and learning process is conducted in classical classrooms with competitive and isolated atmosphere. This atmosphere prevents the students from working together and teaching each other, which creates science process skills gaps between HA and LA students. HA students are able to master science process skill better than LA students. Conventional model was implemented to the traditional group. The students are grouped randomly, regardless of their diverse academic skills, understandability, and academic needs. As a result, HA students will be able to master science process skills better than LA students. The findings of this research is in line with the research of (Bilgin, 2009), which stated that inquiry-based learning model managed in collaborative groups is proven more effective to improve learning outcomes compared with inquiry-based learning model in traditional groups.

Conclusions

Inquiry-based Learning combined with Student Team Achievement Division is the most effective method in increasing science process skills. High Academic students have higher science process skills than lower academic ones. It can be argued that inquiry learning integrated with cooperative learning will effectively close the science process skills gap between high and low academic achievement students.

There are two points that must be considered when teacher applies the model: guarantee that the cooperative learning, and the inquiry process work. The cooperative learning can be confirmed by grouping strategy, which should focus on how scaffolding and peer-learning will be smoothly run. Randomly grouped students in the class will might be put only high academic students in one group, as well as the low academic students. Therefore, grouping should not be pure heterogeneous or random, but have to consider the academic level of students. However, some unexpected condition might happen during the process, such as the high academic students do not eager to be tutors for their peer. To solve this problem, grouping should be based not only by the academic achievement, but also the engagement or motivation of students to do scaffolding. Moreover, inquiry process must be guaranteed that it precisely occurs in each cooperative group. This process needs an extra effort of teacher to actively check the learning process in all groups. Before the model is practiced, practitioners have to surely know what the inquiry process is. Future research should pay more attention on studying the grouping strategy to certainly close the gap of achievement and skills in the classroom.

Low academic skills students can improve their science process skills to catch up with high academic achievement students if the learning process facilitates them to study through peer tutoring. Cooperative learning, either individual or integrated with other learning models are recommended to be applied in the science classroom to improve the academic achievement or science process skills of lower attain students, instead of applying competition-based learning which can create a gap between high and low academic achievement students.

Acknowledgement

The researchers would like to thank the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia for funding this research. In addition, the researchers also credit all members of the Biology Education Research Group, Faculty of Teacher Training and Education, Sebelas Maret University, for their constructive criticism and useful suggestions throughout the research.

References

Adesoji, F. A., & Ibraheem, T. L. (2009). Effects of student teams-achievement divisions strategy and mathematics knowledge on learning outcomes in chemical kinetics. *The Journal of International Social Research*, *2* (6), 15–25. Retrieved from http://www.sosyalarastirmalar.com/cilt2/sayi6pdf/adesoji_ibraheem.pdf.

Adey, P. (1999). *The science of thinking, and science for thinking: A description of cognitive acceleration through science education (CASE)*. Geneva: The International Bureau of Education. Retrieved from http://eric.ed.gov/ERICWebPortal/recordDetail?accno=ED442622.

Ambarsari, W., Santosa, S., & Maridi. (2013). Penerapan pembelajaran inkuiri terbimbing terhadap keterampilan proses sains dasar pada pelajaran biologi siswa kelas VIII SMP Negeri 7 Surakarta [The implementation of guided inquiry on biology to improve scientific process skills of students grade 8th of Junior High School 7 Surakarta]. *Jurnal Pendidikan Biologi*, *5* (1), 81–95. Retrieved from http://jurnal.fkip.uns.ac.id/index.php/bio/article/view/1441.

Bilgin, I. (2009). The effects of guided inquiry instruction incorporating a cooperative learning approach on university students' achievement of acid and bases concepts and attitude toward guided inquiry instruction. *Scientific Research and Essay*, *4* (10), 1038–1046. Retrieved from http://www.academicjournals.org/article/article1380559513_Bilgin.pdf.

Bodrova, E., & Leong, D. J. (1998). Scaffolding emergent writing in the zone of proximal development. *Literacy Teaching and Learning*, *3* (2), 1–19. Retrieved from https://pdfs.semanticscholar.org/f6d6/22f55f17daf2d66e51282d17c0e00a350155.pdf.

Brotherton, P. N., & Preece, P. F.W. (1996). Teaching the science process skills. *International Journal of Science Education*, *18* (1), 65–74. Retrieved from https://doi.org/10.1080/0950069960180106.

Corebima, A. D. (2007). Review on: Learning strategies having bigger potency to empower thinking skill and concept gaining of lower academic students, presented at *Redesigning Pedagogy Conference: Culture, Knowledge, and Understanding*, Singapore, 28-30 May 2007. Singapore: National Institute of Education Singapore.

Deta, U. A., Suparmi, & Widha, S. (2013). Pengaruh metode inkuiri terbimbing dan proyek, kreativitas, serta keterampilan proses sains terhadap prestasi belajar siswa [Effect of guided inquiry, project creativities and science process skills to student achievement]. *Jurnal Pendidikan Fisika Indonesia*, *9* (1), 28–34. Retrieved from http://journal.unnes.ac.id/nju/index.php/JPFI/article/view/2577.

Douglas, E. P., & Chiu, C. C. (2009). Use of guided inquiry as an active learning technique in engineering, presented at Research in Engineering Education Symposium, Palm Cove, Australia, 20-23 July 2009. Quensland: The University of Melbourne. Retrieved from https://doi.org/10.1109/FIE.2009.5350762.

Edwards, M. C., & Briers, G. E. (2000). Higher-order and lower-order thinking skills achievement in secondary-level animal science: Does block scheduling pattern influence end-of-course learner performance? *Journal of Agricultural Education*, *41* (4), 2–14. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.540.2253&rep=rep1&type=pdf.

Gok, T. (2014). Peer instruction in the physics classroom: effects on gender difference performance, conceptual learning, and problem solving. *Journal of Baltic Science Education*, *13* (6), 776–789. Retrieved from http://www.scientiasocialis.lt/jbse/files/pdf/vol13/776-788.Gok_JBSE_Vol.13_No.6.pdf.

Gormally, C., Brickman, P., Hallar, B., & Armstrong, N. (2009). Effects of inquiry-based learning on students' science literacy skills and confidence. *International Journal for the Scholarship of Teaching and Learning*, *3* (2), 1–22. Retrieved from https://doi.org/10.20429/ijsotl.2009.030216.

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Hamilton, R. L., & Swortzel, K. A. (2007). Assessing Mississippi AEST teachers' capacity for teaching science integrated process skills. *Journal of Southern Agricultural Education Research*, *57* (1), 1-22. Retrieved from http://www.clemson.edu/agcom/saerc-2007/papers/b-3.pdf.

Karsli, F., & Şahin, Ç. (2009). Developing worksheet based on science process skills: Factors affecting solubility. *Asia-Pacific Forum on Science Learning and Teaching*, *10* (1), 1–12. Retrieved from https://www.ied.edu.hk/apfslt/download/v10_issue1_files/sahin.pdf.

Kurnia, F., Zulherman, & Fathurohman, A. (2014). Analisis bahan ajar fisika SMA kelas XI di Kecamatan Indralaya Utara berdasarkan kategori literasi sains [Analysis of physics learning sources of grade 11th based on scientific literacy in North Indralaya County]. *Jurnal Inovasi dan Pembelajaran Fisika*, *1* (1), 43–47. Retrieved from http://ejournal.unsri.ac.id/index.php/jipf/article/view/1263.

Kusdemir, M., A.Y. Yusuf, & Tüysüz, C. (2013). An analysis of the effect of problem based learning model on the 10th grade students ' achievement , attitude and motivation in the unit of " mixtures ." *Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi (EFMED)*, *7* (2), 195–224. Retrieved from http://connection.ebscohost.com/c/articles/94928706/analysis-effect-problem-based-learning-model-10th-grade-students-achievement-attitude-motivation-unit-of-mixtures.

Leech, M. L., Howell, D. G., & Egger, A. E. (2004). A guided inquiry approach to learning the geology of the U.S. *Journal of Geoscience Education*, *52* (4), 368–373. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-5544228216&partnerID=40&md5=394df9a4b6cdd7f0ee748c6dd0194da6.

Lu, C., Hong, J., & Tseng, Y. (2007). The effectiveness of inquiry-based learning by scaffolding students to ask " 5 why " questions, presented at Redesigning Pedagogy Conference : Culture, Knowledge and Understanding, Singapore, 28-30 May 2007. Singapore: National Institute of Education Singapore. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.530.7731&rep=rep1&type=pdf.

Lumbantobing, R. (2005). Comparative study on process skills in the elementary science curriculum and textbooks between Indonesia and Japan. *Bulletin of the Graduate School of Education Hiroshima University, Part II-Arts and Science Education*. Retrieved from http://ci.nii.ac.jp/naid/110004667319.

Marimuthu, T., Jusoh, A., & Ismail, R. (2003). *Amalan dan masalah pelaksanaan strategi inkuiri-penemuan di kalangan guru pelatih sains semasa praktikum* [Practices and problems in implementing strategy of inquiry among science student teachers during teaching practicum], presented at Seminar Penyelidikan Pendidikan Guru Peringkat Kebangsaan, Kuching, Malaysia 19-20 August 2003. Kuala Lumpur: Kementerian Pelajaran Malaysia. Retrieved from https://www.academia.edu/3661879/Amalan_dan_Masalah_Pelaksanaan_Inkuiri-Penemuan.

Mei, G., Kaling, C., Xinyi, C. S., Sing, J. S. K., & Khoon, K. N. S. (2007). *Promoting science process skills and the relevance of science through science ALIVE!* Programme, presented at Redesigning Pedagogy Conference: Culture, Knowledge and Understanding, Singapore, 28-30 May 2007. Singapore: National Institute of Education Singapore. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.489.2768&rep=rep1&type=pdf.

Moraga, R., & Rahn, R. (2007). Studying knowledge retention through cooperative learning in an operations research course, presented at IIE Annual Conference and Expo 2007 - Industrial Engineering's Critical Role in a Flat World, Nashvile, 19-23 May 2007. Retrieved from https://iwe.pure.elsevier.com/en/publications/studying-knowledge-retention-through-cooperative-learning-in-an-o.

Murray, T., & Arroyo, I. (2002). *Toward measuring and maintaining the zone of proximal development in adaptive instructional systems*, presented at The 6th International Conference on Intelligent Tutoring Systems, San Sebastian, Spain 2-7 June 2002. San Sebastian: Springer. Retrieved from http://ile2005-t3.tripod.com/text/towards_measuring_and_maintaining_the_zone.pdf.

Nasir, M., & Zahir, A. (2010). Effects of cooperative learning vs. traditional instruction on prospective teachers' learning experience and achievement. *Journal of Faculty of Educational Sciences*, *43* (1), 151–164. Retrieved from http://ssrn.com/abstract=2361353.

Nelson, B., & Ketelhut, D. J. (2007). Inquiry learning in multi-user virtual environments. *Educational Psychology Review*, *19* (3), 265–283.

Orhan, A. (2008). Assessment of the inquiry-based project implementation process in science education upon students' points of views. *International Journal of Instruction*, *1* (1), 1–12. Retrieved from http://eric.ed.gov/?id=ED503452.

Ozden, M. (2008). Improving science and technology education achievement using mastery learning model. *World Applied Sciences Journal*, *5* (1), 62–67. Retrieved from http://idosi.org/wasj/wasj5(1)/10.pdf.

Ozguc, C. S., & Cavkaytar, A. (2015). Science education for students with intellectual disability: a case study. *Journal of Baltic Science Education*, *14* (6), 804–820. Retrieved from http://www.scientiasocialis.lt/jbse/files/pdf/vol14/804-820.Ozguc_JBSE_Vol.14_No.6.pdf.

Prabowo, S. A. (2015). The effectiveness of scientific based learning towards science process skill mastery of PGSD students. *Indonesian Journal of Science Education*, *4* (1), 15–19. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.695.3353&rep=rep1&type=pdf.

Probosari, R. M. (2015). Improvement of students' scientific writing of biology education of Sebelas Maret University through reading project based learning. *Indonesian Journal of Science Education*, *4* (1), 31–35. Retrieved from http://journal.unnes.ac.id/nju/index.php/jpii/article/view/3498.

Rambuda, A. M., & Fraser, W. J. (2004). Perceptions of teachers of the application of science process skills in the teaching of geography in secondary schools in the Free State Province. *South African Journal of Education*, *24* (1), 10–17. Retrieved from https://www.ajol.info/index.php/saje/article/view/24960.

Rusmiyati, A., & Yulianto, A. (2009). Peningkatan keterampilan proses sains dengan menerapkan model problem based-instruction [The improvement of scientific process skills through problem based-instruction]. *Jurnal Pendidikan Fisika Indonesia*, *5* (1), 75–78. Retrieved from http://journal.unnes.ac.id/artikel_nju/JPFI/1013.

Shi, W. Z. (2013). The effect of peer interactions on quantum physics: a study from China. *Journal of Baltic Science Education*, *12* (2), 152–158.

Siew, N. M., Chong, C. L., & Lee, B. N. (2015). Fostering fifth graders' scientific creativity through problem-based learning. *Journal of Baltic Science Education*, *14* (5), 655–669.

Škoda, J., Doulík, P., Bílek, M., & Šimonova, I. (2015). The effectiveness of inquiry based science education in relation to the learners' motivation types. *Journal of Baltic Science Education*, *14* (6), 791–804.

Tifi, A., Natale, N., & Lombardi, A. (2006). Scientists at play: Teaching science process skills. *Science in School*, *5* (1), 37–40. Retrieved from http://www.scienceinschool.org/2006/issue1/play.

Umar, I. N., & Maswan, S. (2007). The effects of a web-based guided inquiry approach on students' achievement. *Journal of Computers*, *2* (5), 38–43. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.523.3665&rep=rep1&type=pdf.

Wenning, C. J. (2007). Assessing inquiry skills as a component of scientific literacy. *Journal of Physics Teacher Education Online*, *4* (2), 21–24. Retrieved from http://www2.phy.ilstu.edu/pte/publications/assessing_ScInq.pdf.

Zakaria, E., & Iksan, Z. (2009). Promoting cooperative learning in science and mathematics education: A Malaysian perspective. *Eurasia Journal of Mathematics, Science & Technology Education*, *3* (1), 35–39. Retrieved from http://www.cimm.ucr.ac.cr/ojs/index.php/eudoxus/article/viewArticle/448

Received: *February 15, 2017*

Accepted: *April 20, 2017*

Baskoro Adi Prayitno	Dr., Lecturer, Department of Biology Education, Faculty of Teacher Training and Education, Sebelas Maret University, Surakarta, Indonesia, Jl. Ir. Sutami 36 A Kentingan Surakarta, Central Java, Indonesia. E-mail: baskoro_ap@fkip.uns.ac.id Website: http://baskoro.staff.uns.ac.id
Herawati Susilo	Ph.D, Professor, Department of Biology, Faculty of Mathematic and Natural Science, State University of Malang, Indonesia. Jl. Semarang 5 Malang, East Java, Indonesia. E-mail: herawati_susilo@yahoo.com Website: http://www.um.ac.id
Duran Corebima	Ph.D, Professor, Department of Biology, Faculty of Mathematic and Natural Science, State University of Malang, Indonesia. Jl. Semarang 5 Malang, East Java, Indonesia. E-mail: duran.corebima.fmipa@um.ac.id Website: http://www.um.ac.id
Siti Zubaidah	Ph.D, Professor, Department of Biology, Faculty of Mathematic and Natural Science, State University of Malang, Indonesia. Jl. Semarang 5 Malang, East Java, Indonesia. E-mail: siti.zubaidah.fmipa@um.ac.id Website: http://www.um.ac.id
Murni Ramli	Ed.D., Lecturer, Department of Biology Education, Faculty of Teacher Training and Education, Sebelas Maret University, Surakarta, Indonesia, Jl. Ir. Sutami 36 A Kentingan Surakarta, Central Java, Indonesia E-mail: mramlim@staff.uns.ac.id Website: http://dosen.fkip.uns.ac.id/data/index.php?prodi=P18&id=1971071401