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Developing Students' Research Skills with Adapted Primary Literature

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Abstract

There is a gap between the quantity and quality of research in Indonesia. It is assumed that the research skills of the researchers are still low. Meanwhile, research skills development still relies on the higher education level. Efforts are needed to develop research skills from an early age. This study aims to examine the use of APL in the authentic science approach to develop research skills of junior high school students. The quasi-experimental method was carried out by inviting 81 students from two classes of 7th grade in a state middle school in Bandung, Indonesia. They analyzed three Adapted Primary Literatures with the jigsaw and NHT models. Before and after learning, students took research skills tests. The research instrument has passed the validity and reliability tests. Descriptive and inferential analyses were done. The results of data analysis indicate that the use of APL in the authentic science approach in both learning models can develop students' research skills. Furthermore, the jigsaw model is more recommended to use. This study recommends the use of APL as a science learning resource to develop students' research skills as a beginning to introduce the scientific method.

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Introduction

Innovation has been making our life easier. Not only to fulfill our desires, but sometimes it is also needed to enable us to survive in a very hard situation. Debriefing young students with research skills in science online-learning, for instance, is very beneficial during a pandemic recently. The countries which carry out more research have a greater capacity to produce innovations (World Economic Forum, 2018). The number of research from those countries can be seen through the number of research articles published. While the quality of a scientific publication can be seen through its citation index value (Fatimah, 2018). Based on the number of research articles published in 2019, Indonesia is ranked 21st. This ranking has increased over the past 10 years from the 59th rank in 2009. However, Indonesia's citation index in 2019 is 5.00, so that Indonesia is in 47th place (Scimago Lab, 2018). This shows that Indonesian scientific publications are still lacking in quality (Ristekdikti, 2018).

Scientific publication as a way to disseminate research findings is one facet of research skills (Willison & O'Regan, 2007). Therefore, it is assumed that the gap between the quantity and quality of Indonesian scientific publications is influenced by the low research skills level of the researchers. It turns out that the research skills of bachelor graduates are only in the medium category (Meerah et al., 2012). The lecture process also does not provide sufficient contribution in developing students' research skills (Subekti et al., 2018).

Meanwhile, the development of research skills is still emphasized at the higher education levels (Meerah & Arsad, 2010). Therefore, research skills development needs to be pursued since the previous education level (Landreau, 2011). Accordingly, it is known that the best time to learn is during childhood (Juhász & Németh, 2018) and the best time to acquire new skills is during early adolescence (Janacsek et al., 2012). Thus, the development of research skills should at least begin with junior high school students.

The development of research skills can be achieved through research-based learning activities (Meerah & Arsad, 2010; Odera et al., 2015; Rodríguez et al., 2019). However, teachers and students have limited time to conduct research-based learning (Meerah & Arsad, 2010). Therefore, it is necessary to apply another learning approach as an alternative, but it is still linked to research activities conducted by scientists. One approach which can be applied is authentic science. In this approach, students can be involved in learning activities similar to how scientists work (Anker-Hansen & Andrée, 2019; Chapman & Feldman, 2017; Koomen et al., 2018; Machluf et al., 2017), experimenting and thinking (Labouta et al., 2018).

One strategy for achieving the authentic science approach is assigning students to analyze the Adapted Primary Literature (APL) (Hidayat et al., 2021). APL is an adaptation of the Primary Scientific Literature (PSL) (Yarden et al., 2015b). In the adaptation, the science language used is adjusted so that it can be more easily understood by secondary school students (Ariely et al., 2019). This is because PSL has a different scientific language when it is compared with the language of science in schools (Phillips & Norris, 2009). Moreover, the language used in PSL is increasingly difficult to understand (Ball, 2017).

Even though it is an adaptation of scientific writings from scientists, APL can still increase the opportunity for students to conduct authentic scientific activities like those scientists do (Ford, 2009), so reading APL is considered an authentic scientific practice (Yarden et al., 2015a). The type, structure, and content of the writing and presentation of science in APL are maintained to be equal to PSL (Yarden, 2009). This allows students to continue to follow and learn the flow of reasoning and research. APL is also not only used to introduce scientific literature and scientific research processes to students (Koomen et al., 2016) but APL can also be used as a model of scientific reasoning (Ariely et al., 2019; Ford, 2009). In addition, science teachers at the secondary school level have a high perception of APL (Hidayat et al., 2020). They also have positive experiences when writing and implementing APL (Koomen et al., 2016). Thus, when APL is used as a science learning resource, APL is thought to be able to encourage the development of student research skills.

Research that describes the research skills profile of junior high school students in Indonesia appears to be still limited. However, research that describes the science process skills profile of junior high school students shows that their skill level is in a low category (Atmojo, 2012; Fatmawati & Handhika, 2018; Rahman et al., 2017). Only 20-50% of students have mastered science process skills (Siswanto et al., 2016). The profile of science process skills may be a predictor for the profile of research skills because the two are believed to have overlapping facets. With this research, it will be more obvious about the level of research skills of junior high school students and the efforts to develop them. One of the advantages of developing research skills is that it can also support students in the STEM field (Gilmore et al., 2015; Timmerman et al., 2013).

This study aims to examine the use of APL in the authentic science approach to develop research skills of junior high school students. The research skills of students that are expected to develop are research skills at the level prescribed research in the most basic level of Willison and O'Regan Research Skills Development framework (Willison & O'Regan, 2007). This level is possibly the most suitable to be used as a framework for developing research skills for junior high school students because their research skill level is presumably still low and most students do not have any experience in conducting research.

Method

With a quantitative approach, this study used a quasi-experimental method which has a pre-test, treatment, and post-test (Fraenkel et al., 2012). Two groups of 7th-grade students were invited to be involved in this study as participants. They totaled 81 students consisting of 42 males and 39 females. They were selected on the basis of their school's willingness to support this research. The school is located in Lembang, Bandung. This study was conducted in the even semester of the 2019/2020 academic year.

The instrument used was a research skills test. This test consists of 18 questions which are arranged based on the Research Skills Development framework at the prescribed research level (Willison & O'Regan, 2007). The question is multiple choice with four options. Table 1 shows the rubrics of the test instruments. All items have passed the validity and reliability test with a significance level of 0.05 and r_{table} of 0.254.

Table 1. Instrument Rubrics of Research Skills Test

Facet	Rubrics	Number of Items
Embark and Clarify	Students are able to respond to assignments or research questions that emerge explicitly from the closed inquiry process.	2
	Students are able to clarify questions, terms and research expectations.	1
Find and Generate	Students are able to determine how to collect data or information from predetermined sources, where the data or information can clearly be evidence.	1
	Students are able to record data or information using a predetermined methodology from a predetermined source, where the data or information can clearly be evidence.	1
Evaluate and Reflect	Students are able to evaluate data or information using simple predetermined criteria.	1
	Students are able to reflect on the research process using simple predetermined criteria.	2
Organise and Manage	Students are able to organize data or information using a predetermined structure.	1
	Students are able to manage the linear research process provided.	2
Analyse and Synthesise	Students are able to analyse data or information in the specified format	2
	Students are able to synthesize data or information to reproduce existing knowledge in a specified format.	1

Communicate and Apply ethically	Students are able to use mainly lay language and the type of language specified to show their understanding to the teacher as an audience.	1
	Students are able to apply the results of their research to a similar context in which knowledge is developed.	2
	Students are able to follow research instructions related to ethnic, social and cultural issues.	1

Early in March 2020, the first COVID-19 patient in Indonesia was detected. This pandemic is increasingly widespread in Indonesia. This condition forces learning to be shifted from school to home to suppress the spread of the virus. Therefore, all learning activity is performed online. Treatment, pre-test, and post-test in this study were also performed online. WhatsApp Group (WAG) was used to support the learning activity. It is considered the most effective media to support online learning in the early pandemic because it does not require a large data package and can share almost any file format (Wargadinata et al., 2020). It is also believed to use by all students. Meanwhile, the pre-test and post-test used Google Form—an online form that is believed to use by most teachers in assessing their student achievement. Perhaps, acquaintance with the media used can help this study runs as planned even in the mid of the pandemic.

Before the treatment was performed, students were invited to take a research skills test. The results of this test were considered pre-test scores. Then the treatment was performed in three meetings. This treatment was learning Science on the topic of environmental pollution by analyzing APL as a learning resource. The APL had the theme of soil, water, and air pollution. The APL is the result of an adaptation created by the researchers of this study from the PSL from the environmental engineering journal, from a local university. In the adaptation, not only the language was simplified but the layout design was also made more colorful to make it more appealing for students to read it.

The cooperative learning is considered as one way to optimize online learning (Silalahi & Hutauruk, 2020). Cooperative learning might be able to promote research skills since in research some researchers work together collaboratively. Therefore, the first group of students applied the jigsaw model, while the second group applied the NHT model. These two models have been chosen in consideration of them as the most widely known cooperative learning models among science teachers. As the result, science teachers can be relatively more straightforward to apply the findings of this study in their classes later. In addition, when reading text is a main part of the learning activity, the jigsaw can be primarily used in the learning. It can improve students reading comprehension and learning outcomes. It can also enhance student motivation to learn Science and enhance student involvement in a learning activity. Meanwhile, the NHT can improve students' reading skills, improve student learning outcomes, and enhance student participation in learning (Hidayat et al., 2021).

In the two classes, the students were grouped. In the jigsaw class, each expert group analyzed and discussed different parts of APL, namely introduction, method, result, discussion, and conclusion. Then they came back to their respective home group and shared what they had obtained. This discussion was performed in each WAG of expert and home group. In the NHT class, a complete APL was distributed to each group. They analyzed and discussed the APL. At the end, a quiz was administered to check all group members'

understanding. The scores they got were accumulated into group scores, so they had a responsibility to each group. This discussion was also performed on a WAG of each group. In the two classes, a worksheet for each meeting was provided as well to help students analyzing the three APL. All the learning activities were conducted synchronously. After the treatment was performed, students were again invited to take the research skills test. The results of this test were considered as post-test scores.

The pre-test and post-test scores are expressed on a scale of 100. The mean scores of students' research skills from both groups were compared with the categories in Table 2. This was done to determine the level of research skills of the students at the pre-test and post-test. Then, the score of research skills of the two groups was tested for normality and homogeneity. If the results show that the data is normally distributed and homogeneous, a parametric mean difference test will be performed. Otherwise, a non-parametric mean difference test will be performed (Minium et al., 1993). These analyses are assisted by SPSS software. The results of this mean difference test will be used to analyze the development of research skills in both classes and to conclude which model has a significant impact in developing research skills.

Table 2. Interpretation Guideline of Research Skills Level

Score of Research Skills	Category
0 – 19	Very Low
20 – 39	Low
40 – 59	Moderate
60 – 79	High
80 – 100	Very High

(Sugiyono, 2010)

The identity of the subjects and the name of the school are intentionally not disclosed to protect their privacy rights. We interacted with subjects after obtaining permission from the school. The data obtained from the subject is used only for the purposes of this study.

Results and Discussion

At the end of April 2020, students took a pre-test, but not all students took the test. The following week until early May 2020, students participated in science learning using APL. The first, second, and third meetings discussed soil, water, and air pollution respectively. Student participation in these lessons was assessed based on the number of posts they send on the WAG. There are students who are categorized as active, less active, and even not active. The following week the students took part in a post-test. Because not all students took part in the pre-test and post-test, and not all of them were active during learning, only 44 students were declared as active participants. In data analysis, only the data from these 44 students were analysed. Table 3 shows the data of the participants.

Table 3. Participants

Class and Gender	All Participant	Active Participant
Class of Jigsaw		
Male	20	7
Female	21	10
Class of NHT		
Male	22	14
Female	18	13
Total	**81**	**44**

Some students are believed to come from low-income families. They have limited access to computers and the internet at home. Meanwhile, schools also cannot provide computers for students to use in their homes (Morgan, 2020). This drives us to students' participation problems. Actually, we have anticipated this problem. We recognized that online learning cannot provide a higher quality of interaction than the traditional one (Dumford & Miller, 2018). Students were always reminded of the next lesson schedule. Every meeting was always preceded by filling in attendance to indicate that the lessons through this WAG were also recorded as their attendance in class as usual. However, it seems that the efforts made are not sufficient to make all students actively participate. If this research has sufficient sources, perhaps providing internet access facilities for each student can significantly increase student participation. Eventually, we assessed that the data from 54% of the students' numbers are sufficient for an analysis of their research skills. It was considered by the distribution of active students in each class.

Learning in this study has several activities. Figure 1 shows how each learning activities have the potential to develop certain facets of research skills. These activities are similar to the stages carried out by scientists in conducting research, so this learning is considered to have supported the development of students' research skills. When APL is used in secondary schools as a learning resource, APL can improve the inquiry-based science learning process (Ford, 2009; Yarden et al., 2015b). APL itself is indeed a form of writing that describes a process of inquiry. By reading APL, students can follow the flow of the research. In addition, the advantage of using APL in schools is to introduce examples of complex, authentic, and sophisticated scientific arguments (Ford, 2009). APL can also support scientific discourse (Koomen et al., 2016) and scientific literacy (Koomen et al., 2016; Yarden et al., 2015a).

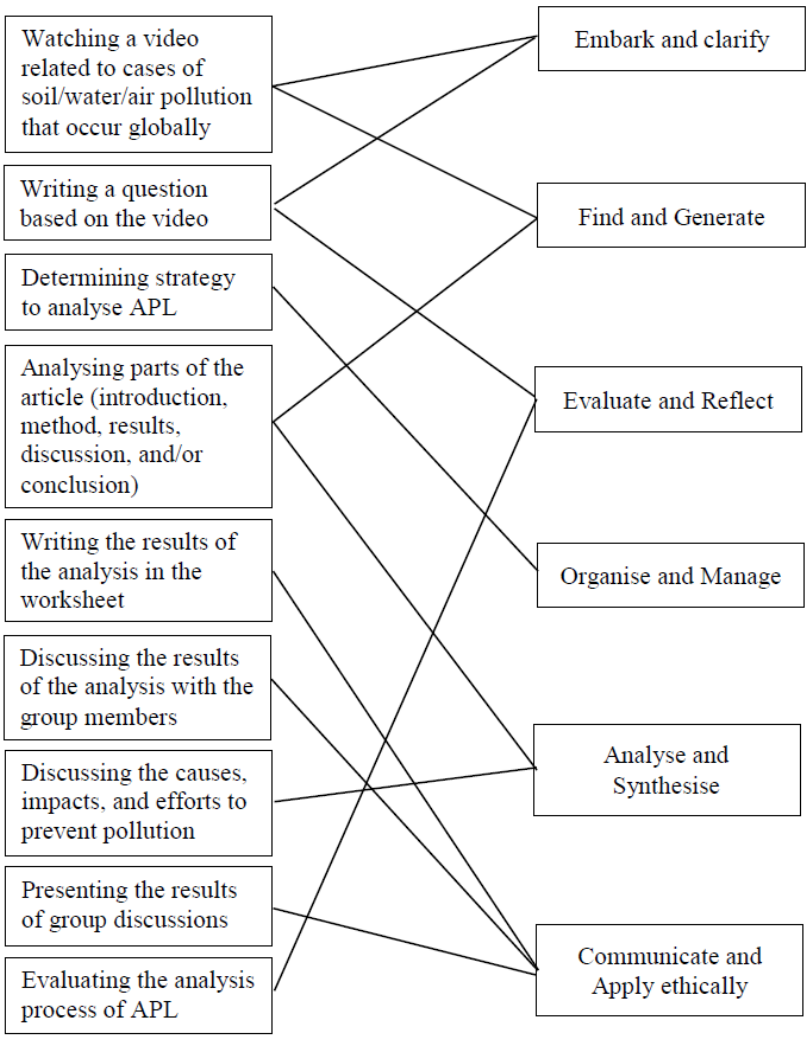

Figure 1. Facets of research skills that might be developed through the learning activities

To test the significance of the development of students' research skills, statistical analyses were performed. Students' research skills were tested before and after the learning in the form of pre-test and post-test. Table 4 shows the descriptive analysis of the research skills score in the two classes at the pre-test and post-test.

Table 4. Descriptive Analysis of Students' Research Skill

Descriptive Statistics	Jigsaw Class		NHT Class	
	Pre-test	Post-test	Pre-test	Post-test
Number of participants	17	17	27	27
Mean	6.86	42.81	6.59	34.57
Standard deviation	4.62	13.58	5.12	16.26
Minimum Score	0.00	16.67	0.00	5.56
Maximum Score	11.11	66.67	16.67	77.78

The average score of students' research skills in both classes at the pre-test was in the very low category. This is in line with our prediction that students' research skills are still low

based on the level of science process skills (Atmojo, 2012; Fatmawati & Handhika, 2018; Rahman et al., 2017). It can be also seen that the minimum score in both classes is 0.00. Meanwhile, the average score of students' research skills at post-test was in a different category. Students in the jigsaw class have an average score of research skills in the medium category. Meanwhile, students in the NHT class have an average score of research skills in the low category. Until the present, we may say that analysing APL using the jigsaw model can offer more significant development toward students' research skills.

The level of students' research skills in both classes in each facet can be seen in Figure 2. At the pre-test, the students' research skills in both classes in most facets were in the very low category. It is not surprising since most students do not have any experience in doing research. Only research skills in the Analyse and Synthesis facet are in a low category. It might be due to this facet having been trained in previous learning when the students were assigned to acquire data or information from a table or graph. Then at the post-test, students' research skills were between the low and medium categories. There was an improvement in all facets. The students' research skills in both classes in the Embark and Clarify facet were in the lowest category compared to other facets. In the research skills tests, students had to determine which research questions and hypotheses that are most appropriate to the research example given. These two terms seem new for the students and they might face difficulties answering them. Perhaps they need more sessions to discuss them. The research skills of students in the jigsaw class on the Organize and Manage facet had the highest score compared to other facets, both in the jigsaw class and in the NHT class. This is possibly a consequence of applying cooperative learning that organizing and managing is a learning activity that stands out in this model. Meanwhile, the highest student research skills in the NHT class are in the Find and Generate facet.

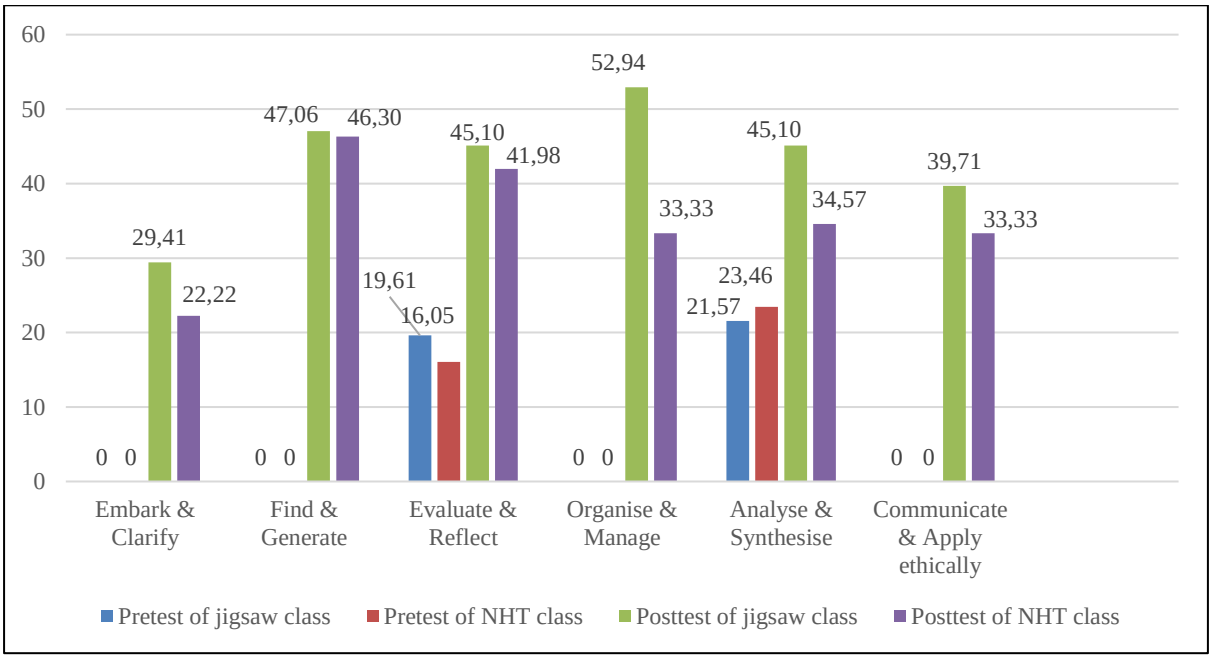

Figure 2. Mean Score of Each Facet of Students' Research Skills

The mean difference of students' research skills in the jigsaw and NHT classes at the pre-test and post-test can be examined through inferential analysis with a significance level of 0.05. Table 5 shows inferential statistics for this purpose. At the pre-test and post-test, students in the jigsaw and NHT classes possessed an equal research skills level. The result of this inferential analysis indicates that both before and after treatment, the students' research skills in both classes were equal. Thus, there are three possibilities, namely, both are unchanged, both are decreasing or both are developing equally. By comparing the mean of research skills in each class at the pre-test and post-test, it can be straightforwardly said that both are developing. However, the next statistical tests are still required to perform for obtaining more valid evidence.

Table 5. Inferential Analysis of Students' Research Skills of Jigsaw and NHT Class

Test	Pre-test		Post-test	
	Jigsaw Class	**NHT Class**	**Jigsaw Class**	**NHT Class**
Normality (Kolmogorov-Smirnov)	P = 0,000 Data are not normally distributed	P = 0,000 Data are not normally distributed	P = 0,200 Data are normally distributed	P = 0,000 Data are not normally distributed
Homogeneity (Levene's Test)	*P-value* = 0,927 Data are homogeny		*P-value* = 0,908 Data are homogeny	
Mean Difference (Mann-Whitney U Test)	*P-value* = 0,665 No difference		*P-value* = 0,054 No difference	

Now, we are examining the mean difference of students' research skills at the pre-test and post-test in each class through inferential analysis with a significance level of 0.05. Table 6 shows inferential statistics for this purpose. The Wilcoxon test provides information that there is a significant difference between students' research skills at the pre-test and post-test in the two classes. This confirms the previous statistical analysis. From these two tests, we are confident to say that the use of APL as a science learning resource can develop students' research skills in both classes. Reading and analysing APL means understanding the research flow from introduction to conclusion. Students are considered to have known what the research background at the APL is. Students are also considered to have known what methods, data collection techniques, and data analysis were used, as well as how the researchers drew the conclusions.

Table 6. Inferential Analysis of Students' Research Skills of Pre-test and Post-test

Tests	Jigsaw Class		NHT Class	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
Normality (Kolmogorov-Smirnov)	P = 0,000 Data are not normally distributed	P = 0,200 Data are normally distributed	P = 0,000 Data are not normally distributed	P = 0,004 Data are not normally distributed
Homogeneity (Levene's Test)	*P-value* = 0,001 Data are not homogeny		*P-value* = 0,002 Data are not homogeny	
Mean Difference (Wilcoxon Rank Test)	*P-value* = 0,000 Difference		*P-value* = 0,000 Difference	

Mastery of skills will be more straightforward to achieve with a learning process through experience (Lander et al., 2019). Then, authentic science provides students an opportunity to practice research skills (Labouta et al., 2018; Ward et al., 2016). Authentic science using other learning sources has also been shown to develop research skills (Xu et al., 2012). Assignments in the form of collecting information, can also provide experience doing research and develop students' research skills (Meerah & Arsad, 2010). What was recently revealed by this study seems to be in line with the previous study. The development of research skills in both classes seems equal. This means the use of the jigsaw or NHT cooperative learning model does not seem to make a significant difference in developing students' research skills through the use of APL in authentic science. Therefore, science teachers can use any of them to develop their students' research skills.

In case the science teachers need to choose only one learning method to use in developing their students' research skills by analysing APL, perhaps we need to determine which is more effective than another. To get the answer, the effect size was calculated. It was chosen to wrap up all data from the pre-test and post-test of the two classes. Even though both classes in this study are considered practical classes, since the average score in the jigsaw class is higher than NHT class, we put the jigsaw class as the experimental one. From the calculation, the effect size is 0.5 (Lenhard & Lenhard, 2016). This value can be interpreted as an intermediate effect. Therefore, we may say that the jigsaw is more effective than the NHT in developing students' research skills by analysing APL. The students in the jigsaw class perceived the analysing APL activity as more similar to what the researchers do (Hidayat et al., 2021).

Research skills development since junior high school is really required. It cannot be achieved by only the temporary development program. It can be through existing learning programs or through special programs (Hughes, 2019). Science teachers must provide the development program throughout the year. The proof is that learning in senior high school which has been specifically designed for the development of research skills was not able to make all students master all facets of research skills (Roito et al., 2019). Moreover, it was also found that bachelor graduates did not fully master all facets of research skills. Even though research skills development has been explicitly provided during college (Ain et al., 2019). Conceptualizing and facilitating the development of students' research skills is the task of all educators (Willison & O'Regan, 2007). There are several strategies in developing students' research skills. One of them is through inquiry-based learning (Rodríguez et al., 2019). Particularly, the development of student research skills can be through research-based learning. In other words, students are granted the opportunity to conduct research (Gilmore et al., 2015; Meerah & Arsad, 2010; Odera et al., 2015; Wisker, 2019). This study has revealed that students' research skills development can be through an authentic science approach that uses APL as the learning resource.

Conclusion

Data analysis in this study found that the use of APL in science learning using a jigsaw and NHT models could develop students' research skills. The research skills in both classes showed significant improvement. Furthermore, the jigsaw model is more recommended to use. Although the number of participants is few, some findings in this study showed that using APL in science class has great potential in developing students' research skills. In addition, we also believe that it can promote the scientific method. For further research, we suggest conducting the research in face-to-face learning in order to obtain maximum participation of the research subject and more data to analyze.

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