Adapted Primary Literature in Authentic Science: Students' Perception

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ABSTRACT Science textbooks only present scientific facts that cause the textbooks to seem not to promote scientific reasoning. Science learning also becomes not in line with the nature of Science. Then, Science learning requires applying authentic Science as an approach. Adapted Primary Literature (APL) is assumed to be able to achieve this objective. Therefore, this study aims to examine how APL is a source of Science learning in actualizing authentic Science. This research using a quasi-experimental method, 81 students from two 7th grade groups were involved as participants. One group analyzed APL using a jigsaw, another using a Numbered Heads Together (NHT). A perception questionnaire of APL was given. Quantitative analysis was only performed on data from 44 students due to other students' participation that is lacked by a pandemic. The result showed both classes possess a high perception of APL. A mean difference test also showed that there were no differences in perception between the two classes. These indicated that analyzing APL was perceived as an authentic Science. Science teachers can utilize APL as an alternative way to actualize authentic Science with a relatively more straightforward model, strategy, and method than commonly applied.

Keywords Adapted primary literature, Authentic science, Students' perception

1. INTRODUCTION

Science textbooks only present various scientific facts without inviting students to think scientifically (Ariely, Livnat & Yarden, 2019a; Rusilowati, 2014; Vesterinen, Aksela & Lavonen, 2013; Wahyu & Markos, 2016). When learning Science, students do not read texts that reflect authentic scientific reasoning (Ariely, Livnat & Yarden, 2019a, 2019b). Reading Science texts does not mean doing Science if the reading activities only obtain facts (Cervetti & Pearson, 2012). This causes the difference between Science in school and real Science. Meanwhile, Science in school must be in line with the nature of Science (McCoach, Gable & Madura, 2013; Tala & Vesterinen, 2015; Upahi, Ramnarain, & Ishola, 2018).

A means to actualize Science learning that reflects natural Science is an authentic Science. Authentic Science is a Science learning approach that provides opportunities for students to think (Crawford, 2013; Labouta et al., 2018), work (Anker-Hansen & Andrée, 2019; Chapman & Feldman, 2017; Crawford, 2013; Koomen, Rodriguez, Hoffman, Petersen, & Oberhauser, 2018; Machluf, Gelbart, Ben-Dor & Yarden, 2017) and feel like scientists. Authentic Science is also an approach to teach Science based on the inquiry process (Anker-Hansen & Andrée, 2019; Broder et al., 2019; Hellgren & Lindberg, 2017;

Koomen, Rodriguez, Hoffman, Petersen, & Oberhauser, 2018; Labouta et al., 2018; Olitsky, Becker, Jayo, Vinogradov, & Montcalmo, 2020; Tsybulsky, 2019). Therefore, Science teaching and learning will be student-centered (Anker-Hansen & Andrée, 2019; Buxton, 2006; Labouta et al., 2018; Rivera Maulucci, Brown, Grey, & Sullivan, 2014; Ward et al., 2016) and also require students' independence (Koomen, Rodriguez, Hoffman, Petersen, & Oberhauser, 2018; Labouta et al., 2018; Machluf, Gelbart, Ben-Dor, & Yarden, 2017; Olitsky, Becker, Jayo, Vinogradov & Montcalmo, 2020; Rivera Maulucci, Brown, Grey, & Sullivan, 2014; Ward et al., 2016).

Authentic Science can be actualized with research-based learning activities (Chapman, 2013; Chapman & Feldman, 2017; Rivera Maulucci, Brown, Grey, & Sullivan, 2014), in the laboratory (Chapman & Feldman, 2017; Labouta et al., 2018; Munn, Knuth, Van Horne, Shouse & Levias, 2017; Olitsky, Becker, Jayo, Vinogradov, & Montcalmo, 2020; Rivera Maulucci, Brown, Grey, & Sullivan, 2014) or out of school (Hellgren & Lindberg, 2017; Koomen, Rodriguez, Hoffman, Petersen, &

Oberhauser, 2018; Ward et al., 2016). Authentic Science can also be actualized by inviting scientists into Science classes (Tsybulsky, 2019), inviting students to have tours in universities and the laboratories (Chapman & Feldman, 2017; Olitsky, Becker, Jayo, Vinogradov, & Montcalmo, 2020; Tsybulsky, 2019), conducting Science exhibitions (Koomen, Rodriguez, Hoffman, Petersen, & Oberhauser, 2018; Rivera Maulucci et al., 2014), and visiting museums (Achiam, Simony & Lindow, 2016). Nevertheless, the learning models, strategies, and methods mentioned above seem to require plenty of teachers' and students' effort to actualize authentic Science. Science teachers need a more straightforward model, strategies, or methods.

Authentic Science imitates what scientists do. The scientists employ about 23% of their work time to read (Phillips & Norris, 2009). Of course, the intended reading is Primary Scientific Literature (PSL) to support their work as scientists. However, scientific language in PSL is complex for students to understand (Ariely, Livnat & Yarden, 2019a). Then, several obstacles allegedly arise when Science teachers assign students to read PSL. The teachers possibly need to use an adapted version of PSL, namely Adapted Primary Literature (APL). The genre, structure, writing content, and science presentation in APL are maintained equal to PSL (Ariely, Livnat & Yarden, 2019a; Yarden, 2009; Yarden, Norris, & Phillips, 2015a). The differences are in the objectives, authors, and readers target (Ariely, Livnat & Yarden, 2019a; Yarden, 2009; Yarden, Norris, & Phillips, 2015a). Even though APL is an adaptation, utilizing APL in Science learning can actualize authentic Science.

Moreover, Science teachers in middle school possess a high positive perception toward APL (Hidayat, Rustaman & Shidiq, 2020). Therefore, this study has the first research question: can APL actualize authentic Science? If the result shows what is assumed, authentic Science can be actualized by applying a learning model, strategy, and method that is relatively more straightforward.

On the other hand, middle school students experience a transition in reading skills, from learning-to-read to reading-to-learn. Several students encounter barriers in this stage (Fang, 2006). In line with that, Indonesian middle school students' reading skills and science achievement are still below the average of the OECD country (OECD, 2019). Science learning that requires them to read allegedly reduces their involvement in the learning activity. Furthermore, students are assigned to read scientific texts. Even though students read the adapted version of the PSL, researchers suspected that these obstacles may still arise. Cooperative learning models should be applied to allow students to assist each other (Slavin, 2012). This is expected to boost their involvement in the learning activity because cooperative learning may be better than traditional techniques when the learning outcome is at a high cognitive level (Slavin, 1980), such as analyzing APL.

Jigsaw and Numbered Heads Together (NHT) were determined as the learning models in this study. These two learning models are believed to be widely known among teachers. Consequently, science teachers can be relatively easy to implement the result of this study into their teaching and learning activity. Moreover, the jigsaw can be primarily used in learning that reading text is an essential part of the learning activity (Li & Lam, 2013). The jigsaw can also improve students reading comprehension (Nurbianta & Dahlia, 2018), enhance student motivation to learn Science (Tarhan, Ayyıldız, Ogunc & Sesen, 2013), enhance student involvement in a learning activity (Goolsarran, Hamo, & Lu, 2020), and improve student learning outcomes (Doymus, 2008; (Goolsarran, Hamo & Lu, 2020); Tarhan, Ayyıldız, Ogunc & Sesen, 2013; Yoruk, 2016). The NHT can improve students' reading skills, enhance student participation in learning, particularly in the question and answer session (Purnomo, 2012), and improve student learning outcomes (Leasa & Corebima, 2017; Mulyana, Hanifah, & Jayadinata, 2016). The researchers consider that learning science using APL will be more effective if performed in these two types of cooperative learning. A question arises between the two, which is more effective. Therefore, this study has the second research question: which model is considered more effective in actualizing authentic Science, jigsaw, or NHT? Finding the answer to this second research question can aid the Science teachers to determine which learning models they can apply in their learning to be more effective in actualizing authentic Science.

In addition, the context of this study has to determine carefully. Environmental pollution is considered an appropriate topic in this study. They consider that environmental pollution has occurred on soil, water, and the air around students' live areas. The pollution seems to be getting worse. Rice fields are polluted by heavy metals from untreated textile factory waste (Komarawidjaja, 2017). Water in the dug well was contaminated by *Coliform bacteria*. The bacteria are thought to have come from animal cages, septic tanks, plantations, and fish ponds (Prilia & Kamil, 2011). The level of carbon monoxide in the blood of people who work in places with air pollution sources correlates with the levels of carbon monoxide in the air of that place (Fitriana & Oginawati, 2012). By raising the topic of problems that occur in the students' lives, it is expected to increase the possibility of actualizing authentic Science.

2. METHOD

2.1. Research Method

This study used a quantitative approach and a quasi-experimental method (Fraenkel, Wallen, & Hyun, 2012). Students learn about environmental pollution by reading, analyzing, and discussing APL. After that, students were given a posttest to ask their perceptions about the learning conducted in actualizing authentic Science. Since APL is

Table 1 Questionnaire rubric of students' perceptions of APL in actualizing authentic science

Rubric of Statements	Example Statement	Number of Items
Students think like a scientist when reading APL	When reading APL, several questions arose in my mind about the topic in the APL	5
Students work like a scientist when reading APL	I made a writing based on data/information in APL that I read	4
Students feel like a scientist when reading APL	After reading APL, I was interested in conducting research	5

Table 2 Participants data

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

allegedly not widely utilized by Science teachers in Indonesia, particularly in Bandung. To capture student perceptions of APL, students require to be acquainted with APL by using it in their learning activity.

2.2 Sample

Participants were determined according to the availability of school to be a location of this research. A total of 81 seventh-grade students of a public middle school in Bandung were invited to this study as participants. There was no randomization of students in this study. Student groups are the same as existing classes.

2.3 Treatment

Two groups of students were involved in this study. One group was designated as experimental class 1, and another group was designated as experimental class 2. Each group learned about environmental pollution in three meetings. One APL was used as a learning source at each meeting. Students in each group were assigned to analyze the APL, beginning from the background, methods, results, discussion to conclusions. The APL analyzed by students were three APL with soil, water, and air pollution that occur in Bandung. Researchers adapted the APL from PSL published by a Department of Environmental Engineering journal from a state university in Bandung. The three APL can be viewed in associated content sections 1 to 3. A worksheet was used in this learning as a guide for students in analyzing the APL. The experimental class 1 and 2 applied a jigsaw and an NHT as the learning models, respectively.

When this research was conducted, a pandemic occurred in the form of the coronavirus outbreak that caused Covid-19. This condition caused all learning activities in schools to shift to the home and conducted online. Therefore, providing treatment to groups of students in this research was also conducted online. The

media used in this learning was WhatsApp Group (WAG). This media was determined for three considerations. First, the school science teacher assessed that the students' gadgets are not yet eligible to use video-based streaming media. Second, WAG was believed by the teacher and researchers as the most widely used communication media by students. Third, WAG can send messages in various forms of media, namely texts, sounds, images, videos, and files. Thus, WAG was considered the most suitable media to be used in this learning.

2.4 Data Collection

After the treatment was conducted, the two groups of students were requested to fill out a questionnaire via Google Form. We told students to fill out the questionnaire honestly and according to what they experienced. We also told students that filling out the questionnaire had no impact on their Science scores. The questionnaire contained 14 statements about students' perceptions of APL in actualizing authentic Science. The statements in the questionnaire were in the form of positive and negative statements. Students can choose a scale that matches their perception in a positive statement, scale 1 for strongly disagree and scale 4 for strongly agree. In a negative statement, the opposite applies. Table 1 shows the questionnaire rubrics. This questionnaire statement's validity and reliability test item were performed at the significance level of 0.05 two-sided and r_{table} of 0.254. All statements have a p-value greater than r_{table}. Then all statements are declared valid and reliable. In associated content sections 4 and 5, a complete questionnaire, validity, and reliability test are provided, respectively.

Data was collected from the end of April to the beginning of May 2020. From a total of 81 students, only 44 students were declared to be active in the research process from the first treatment to completing the questionnaire. Therefore, at the data analysis stage, only data from 44 students were processed. Participant data is shown in Table 2.

2.5 Data Analysis

To obtain how the level of students' perceptions of APL in actualizing authentic Science, the total scores of each student were converted into percentages. The mean percentage of each group of students is calculated and interpreted using the criteria in Table 3 (Sugiyono, 2010).

To examine the difference in perception between the two groups of students, a comparison test of the mean
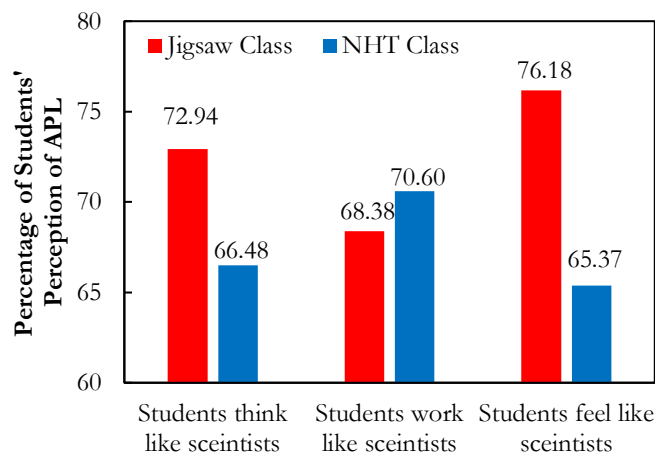
Table 3 Interpretation guideline of perception percentage

Percentage of Perception	Category
0 – 19	Very Low
20 – 39	Low
40 – 59	Moderate
60 – 79	High
80 – 100	Very High

Table 2 Descriptive statistics on the percentage of students' perceptions of APL

Descriptive statistics	Class Jigsaw	Class NHT
Number of participant	17	27
Mean	72.79	67.26
Standard deviation	10.82	7.18
Minimum Score	51.79	55.38
Maximum Score	92.86	82.14

percentage of each group was conducted. Because the data came from two different groups and had non-normal distributed data, the Mann-Whitney test has been conducted (Minium, King, & Bear, 1993). This test can provide answers to which learning model is more effective in actualizing authentic Science by using APL. Furthermore, the effect size is also calculated to contrast the discrepancy (Minium, King, & Bear, 1993; Thalheimer & Cook, 2002).

3. RESULT AND DISCUSSION

Learning using internet media is growing and becoming a trend nowadays (Palvia et al., 2018), particularly amid a pandemic. Face-to-face teaching and learning is considered a threat to students' and teachers' health (Murphy, 2020). But in its implementation, there are still obstacles in the form of limited student access to the internet (Assareh & Bidokht, 2011). For example, students have a poor internet connection (Pitaloka, Anggraini, Kurniawan, Erlina & Jaya, 2020). Therefore, as many as 40% of students experienced obstacles in accessing technology used in online learning (Shahmoradi, Changizi, Mehraeen, Bashiri, Jannat & Hosseini, 2018). This study also encountered similar obstacles. As a result, about 45% of students in this study were declared less active, so the number of active participants was only 44. Even though student involvement in learning can be improved by jigsaw (Goolsarran, Hamo & Lu, 2020) or NHT (Purnomo, 2012), the learning models applied in this study were not the two cooperative

learnings; the number of active students could be possibly lower.

The first research question is how students' perceptions of APL in actualizing exact science. Figure 1 shows the average percentage of student's perceptions of the two indicators, and it appears that students in both classes have high perceptions of APL. All indicators also show a high perception. This can be interpreted that the use of APL in both classes has succeeded in actualizing authentic Science.

Based on data from 44 students, the use of APL as a source of Science learning has been able to actualize authentic Science. Assigning students to analyze APL means asking students to read the writings of scientists. One strategy for achieving an authentic Science is to posit students in the perspective of scientists, namely by reading their writings (Larison, 2018). Although in the form of an adaptation from scientists' writings, APL can still allow students to conduct authentic scientific activities such as those of scientists (Ford, 2009). Reading APL is also considered an authentic scientific practice (Yarden, Norris, & Phillips, 2015a) to improve the learning process of Science based on inquiry (Ford, 2009; Yarden, Norris, & Phillips, 2015b).

The second research question is whether there is a difference in perception of APL between students who analyze APL with jigsaw and students who analyze APL with NHT. Table 4 shows the descriptive statistics of the two classes regarding their perceptions of APL. The mean percentage of perception in the jigsaw class is higher than in the NHT class. Inferential analysis needs to be performed to prove the significance of the difference.

All test is conducted at a significance level of 0.05. The homogeneity test for both classes produces a p-value of 0.112. This means that data from both classes are homogeneous. The normality test for data from the jigsaw class and NHT class results in p-values of 0,567 and 0,038, respectively. This means that data from the jigsaw class has a normal distribution, while data from the NHT class does not have a normal distribution. A non-parametric test (Mann-Whitney) was used to compare perceptions between the two classes. This is because the data from the NHT class are generally not distributed (Minium, King, & Bear, 1993). The Mann-Whitney test produces a p-value of 0.054. This means that there is no significant difference between the perception of APL of jigsaw and NHT class students in actualizing authentic science.

Figure 1 Percentage of students' perceptions on each indicator

Scientists can conduct research individually or in groups. When the research is conducted in groups, there is a distribution of tasks. The distribution can be different (Fraenkel, Wallen, & Hyun, 2012). For instance, in conducting a literature review, this stage can be performed by one or several researchers (s). When several researchers perform a literature review, the distribution of tasks may be similar to the distribution of tasks when students learn with jigsaw or NHT. Jigsaw is a cooperative learning model (Goolsarran, Hamo & Lu, 2020), and reciprocally NHT (Baker, 2013). Thus, both with jigsaw and NHT, the learning activities are similar to what scientists do when analyzing PSL. Therefore, students from the two experimental classes perceived equal learning activities. Both of them perceived that what they did was the work of scientists.

On the other hand, the value of effect size is 0.647. This value can be interpreted as a medium effect. Commonly, the effect size is calculated from an average score of the experiment and control class. Nevertheless, both classes in this study are considered practical classes. Since the average perception percentage in the jigsaw class is higher than NHT class, it can be said that jigsaw is more effective in actualizing authentic Science even though the inferential statistic shows that both classes are the same. Applying jigsaw is possibly a more appropriate option for Science teachers to actualizing authentic Science by utilizing APL.

4. CONCLUSION

This study has confirmed that APL as a source of Science learning can actualize authentic Science. A significant difference did not appear between students' perceptions of APL in the jigsaw and NHT classes. The students' perception of APL in both classes was also in the high category of all measured indicators of perception. Thus, APL can be a means for Science teachers to actualize authentic Science with a more straightforward strategy, mainly if other learning strategies are almost impossible to implement because of limited resources.

Authentic Science is conducting experiments, observations, and interacting with scientists, but this study shows that reading, analyzing, and discussing APL is also considered authentic Science. These results can also be a background for strengthening the use of APL as a source of Science learning. We suggested the promotion of APL to Science teachers in Bandung notably. Thus, Science learning in Bandung is expected to be in line with the nature of Science.

This research is recognized to have several limitations. One of them is the number of participants. This was caused by this learning used online media, while online learning facilities owned by students were still not sufficient. Therefore, students encountered obstacles to be present and active in learning. Further research is suggested to conduct face-to-face learning and apply other cooperative

learning models. The demographic factors of students can also be traced to examine their effect on their perception.

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