

Citizen Science Project, Weather-it, in Science Education: The Scientific Attitudes of Junior High School Students

St E Sururiyatul Muaziyah¹, Topik Hidayat^{2*}, Siti Sriyati³, Lia Lutianasari⁴

¹ Science Education Study Program, Universitas Pendidikan Indonesia, Indonesia, surul_muaziyah@upi.edu

² Biology Education Study Program, Universitas Pendidikan Indonesia, Indonesia, topikhidayat@upi.edu

³ Biology Education Study Program, Universitas Pendidikan Indonesia, Indonesia, sriyati@upi.edu

⁴ Sekolah Menengah Pertama Negeri 19 Bandung, Indonesia, lialutianasari72@guru.smp.belajar.id

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ABSTRACT

Formal education increasingly includes citizen science projects. There is clear evidence of the benefits of citizen science projects for science learning, where one of the goals of science education is to foster a logical mindset and add information to students. This study aimed to measure changes in scientific attitude and the addition of knowledge acquired by students. This project is named Weather-it, which consists of activities to investigate the weather and identify clouds. Thirty junior high school students were involved in this study. Research data were obtained from semi-structured interviews and questionnaires. The experts have verified the 23 statement items on the questionnaire sheet. The results showed that 77% of students were in the good category for the indicator of curiosity, 67% in the sufficient category for the indicator of respect for data, 93% for the sufficient category for the indicator of critical thinking, and 77% for the sufficient category for the indicator of open-mindedness and cooperation. Furthermore, students explained the knowledge they gained through the citizen science project, Weather-it, including knowledge about clouds, technology, the use of Microsoft Excel in processing data, the use of weather in aviation, and the duties of a meteorologist.

Keywords: Citizen science project, Scientific attitude, Knowledge

ABSTRAK

Proyek *citizen science* mulai populer untuk digunakan dalam pembelajaran formal. Terdapat bukti empiris mengenai manfaat proyek *citizen science* bagi pembelajaran sains yang mana salah satu tujuan pembelajaran sains adalah pengembangan sikap ilmiah dan peningkatan pengetahuan. Tujuan penelitian ini adalah untuk mengukur perubahan sikap ilmiah dan peningkatan pengetahuan yang dirasakan oleh siswa. Sebanyak 30 siswa SMP mengikuti kegiatan *citizen science* dengan nama proyek yaitu *Weather-it*. Proyek tersebut berupa investigasi cuaca dan identifikasi awan. Data diperoleh dari lembar kuesioner dan wawancara semi terstruktur. Sebanyak 23 item pernyataan pada lembar kuesioner sudah divalidasi ahli. Hasil penelitian menunjukkan bahwa 77% siswa berada pada kategori baik untuk indikator sikap ingin tahu, 67% kategori cukup pada indikator sikap respek terhadap data, 93% kategori cukup untuk indikator sikap berpikir kritis, dan 77% kategori cukup pada indikator sikap berpikiran terbuka dan kerja sama. Selanjutnya, siswa mengungkapkan mengenai pengetahuan yang mereka peroleh melalui *citizen science*, *Weather-it*, antara lain pengetahuan mengenai awan, teknologi, penggunaan *Microsoft excel* dalam mengolah data, pemanfaatan cuaca dalam bidang penerbangan, dan tugas seorang ahli meteorologi.

Kata kunci: *Citizen science project*, Sikap ilmiah, Pengetahuan

INTRODUCTION

Citizen science is a process where students can actively participate in scientific discovery. Students participate in research activities led by professional researchers to learn about phenomena that occur in nature (California Academy of Science, 2015; Paige et al., 2015). Such learning can show students the relevance of science to their lives while promoting the profession of scientists in science (Kridelbaugh, 2016). In addition, previous research stated that citizen science has the potential to improve student learning outcomes (Phillips et al., 2018), this is due to an increase in student's knowledge about particular scientific objects (Greving et al., 2022; Hsu et al., 2019; Somerwill & Wehn, 2022). In particular, several citizen science projects are designed to provide students with knowledge and skills (Bela et al., 2016; Bruckermann et al., 2021; Santori et al., 2021).

Over the past few years, thousands of citizen science (CS) projects involving millions of participants in collecting and processing data have sprung up worldwide (Bonney et al., 2016). Project topics range from conservation (Aripin et al., 2021b; Ballard et al., 2017), and biodiversity (Kelemen-Finan et al., 2018) to astronomy and zoology (Bonney et al., 2016) with diverse project objectives. However, in Indonesia itself, there are few research programs from scientists who use the CS approach. One example of a CS program in Indonesia is the Asia Waterbirds Census (AWC), which is part of the International Waterbird Census (IWC), which is global. The AWC is a tool for conserving waterbirds and wetlands as their habitat. The activity was coordinated by Wetlands International Indonesia and the Ministry of Environment and Forestry (<http://www.citizenscience.id/program>). In addition, there is also the Elasmobranch Project Indonesia (EPI), which is a citizen science project that aims to map the biodiversity and distribution of Elasmobranch (a subclass of cartilaginous fish) in Indonesia (<https://elasmobranch.id/>).

Studies on student involvement in existing CS projects in Indonesia (AWC and EPI) have never been carried out. Researchers previously designed their own CS programs that they used for formal education, such as butterfly hunting (Aripin et al., 2021a), floral diversity (Rachmawati et al., 2022), and biodiversity (Damayanti et al., 2021). One of the characteristics of CS is the collaboration between students and scientists in conducting scientific research (Saunders et al., 2018). The CS project in this study is named the CS project, Weather-it, in the form of weather investigation activities. This refers to the CS project, Weather-it, owned by Aristeidou et al. (2020), namely CS designed for inquiry learning. At Weather-it, participants from scientific and non-scientific communities participate in weather missions (investigations) related to daily life weather questions, weather phenomena, and climate change (Aristeidou et al., 2020).

CS projects such as Weather-it provide many benefits for those who participate, including increasing interest in science and skills in processing data (Aristeidou et al., 2020). Another potential expected after participating in citizen science is a change in student attitudes or behavior (Bruckermann et al., 2021; Santori et al., 2021). According to Nugraha et al. (2020), two main categories of science-related attitudes are attitudes toward science and scientific attitudes. Previous research has extensively explored students' attitudes toward science after participating in a CS project (Brossard et al., 2005; Chase & Levine, 2018; Queiruga-Dios et al., 2020; Bruckermann et al., 2021). However, studies on student involvement in scientific attitudes have never been conducted. The results of research on attitudes toward science are widely reported. Some researchers said that student's attitudes experienced positive changes toward science (Bruckermann et al., 2021; Chase & Levine, 2018; Queiruga-Dios et al., 2020), but some reported no significant differences in student's attitudes toward science while attending CS

(Brossard et al., 2005). This is the background for researchers to examine what happens to students' scientific attitudes when they participate in CS activities.

Scientific attitude is the foundation or essential attitude that must be possessed when carrying out scientific activities or processes (Suryawati & Osman, 2018). Scientific attitude is a skill that students must possess to achieve new knowledge in science (Ozden & Yenice, 2014). Students with a good scientific attitude will avoid assumptions that are not proven true or have no empirical basis (Olasehinde & Olatoye, 2014). Mukhopadhyay (2014) suggests three essential scientific attitude components: beliefs, feelings, and actions. The aspects of scientific attitude are objectivity, open-mindedness, impartiality, curiosity, ensnared condemnation, critical thinking, and rationality (Lacap, 2015).

Harlen (2018) classifies scientific attitudes that must be developed in students, including: 1) An attitude of curiosity, including enthusiasm for seeking answers, attention to the object being observed, enthusiasm for the science process, and asking questions at every step of the activity; 2) Respect for data/facts, including being honest, not manipulating data, not prejudiced, making decisions according to facts, and not mixing facts with opinions; 3) Critical thinking, including doubting the findings of friends, asking for any changes/new things, repeating activities carried out, and not ignoring data even if it is small; 4) An attitude of discovery and creativity, including using facts as a basis for conclusions, showing different reports from classmates, changing opinions in response to facts, using unusual tools, suggesting new experiments, and explaining new conclusions resulting from observations; 5) An attitude of open disclosure and cooperation, including respecting other people's opinions/friends, willing to change opinions if data is lacking, not feeling that they are always right, considering every conclusion tentative, and actively participating in groups; 6) Persistence, continuing research after the "novelty" is gone, repeatedly trying even though it results in failure, completing one activity even though classmates finish earlier; 7) A sensitive attitude towards the surrounding environment, including attention to surrounding events, participation in social activities, and maintaining the cleanliness of the school environment.

In addition to attitude, a variable widely reported by previous researchers as an impact of the CS project is increased knowledge (Peter et al., 2019). Students gain knowledge of the science content they investigate on CS projects (Bonney et al., 2016; Chase & Levine, 2018; Kermish-Allen et al., 2018). In addition, students also understand the scientific method (Phillips et al., 2019; Saunders et al., 2018). Therefore, researchers want to see how far students gain knowledge through CS. Based on the problems above, this research aims to see changes in the scientific attitude of junior high school students after participating in the citizen science project, Weather-it. This study also aims to analyze the knowledge gained by students while participating in a citizen science project, Weather-it.

METHODOLOGY

The research method used in this study was pre-experimental with a purposive sampling technique (Creswell, 2014). The sample consisted of 30 grade 7 junior high school students in Bandung. The citizen science project, Weather-it, lasted 14 days involving teachers and meteorologists from BMKG (Meteorology, Climatology, and Geophysics). Teachers and meteorologists monitor the activities of the Weather-it project. In contrast, meteorologists are scientists who will teach students about the weather through direct discussions (Kermish-Allen et al., 2018).

This study's data collection instruments were questionnaires and semi-structured interviews. The questionnaire is used at the end of the activity to measure students' scientific attitudes. Pre-

project measurement was not possible, so semi-structured interviews were chosen to confirm the validity of student responses (Brossard et al., 2005). The scientific attitude questionnaire consists of 23 statements based on aspects of scientific attitudes according to Harlen (2018) (Table 1), namely curiosity, respect for facts, critical thinking, and open-mindedness, and collaboration. The questionnaire has been validated by two experts to make it feasible to collect data (Matondang, 2009).

Table 1. Scientific attitude instrument

Aspect	Indicator	Number of Statements
Curiosity	Enthusiastically looking for answers Attention to the observed object	7
Respect for data	Enthusiasm for the science process Not manipulating data Make decisions accordingly fact Do not mix facts with opinions.	4
Critical thinking	Comparing the research results in data with other people's data Doubt the findings of friends Repeat activities	3
Open-mindedness and cooperation	Does not ignore data, even if it is small Respect other people's opinions/findings Want to change opinion if the data is lacking Accept suggestions from friends Do not always feel right Participate actively in groups	9
Total		23

Knowledge gained by students is explored through semi-structured interviews (Aristeidou et al., 2020). Interviews were conducted after the CS project with 30 students, each lasting 10-15 minutes at the site. Post-project interviews focused on the experience and knowledge they gained during the CS project, Weather-it (Ballard et al., 2017).

Data Analysis

The scientific attitude questionnaire was measured using a Likert scale (4=strongly agree, 3=agree, 2=disagree, 1=strongly disagree) and then analyzed with the help of Microsoft Excel 2019 to calculate the percentage of student scores. Student scores on the scientific attitude scale express their scientific attitude categories (Ozden & Yenice, 2014). The range of scores is given in Table 2.

Table 2. Scientific attitude instruments

Category Scientific Attitude	Range
Good	23.00 - 46.33
Sufficient	46.33 - 69.67
Not good	70.00 - 92.00

Interviews were recorded and transcribed to obtain activity patterns to help researchers understand how CS can provide much knowledge to students (Ballard et al., 2017). Therefore, the themes of the interviews focus on the knowledge students have acquired, but at the same time, themes related to data, providing new information, are identified (Aristeidou et al., 2020) and can support data for students' scientific attitudes.

Integration of Citizen Science, Weather-it in the Classroom

There are two distinct stages in this research. The first stage is activities investigation of weather designed by following the inquiry syntax, and the second stage is student involvement in global CS. Phase I: Weather investigation using the AccuWeather app. In this first stage, students become familiar with the scientific process. Students begin the activity by finding problems, creating research questions, formulating ideas, designing research steps, conducting investigations of weather parameters (air temperature, air humidity, and air pressure), and performing data analysis with the help of Microsoft Excel, then make conclusions based on the results of the data analysis. Finally, students show the results of their investigations in front of meteorologists virtually through the zoom meet application.

Phase II: The challenge of becoming a global CS. At this stage, students participate in a global CS project, Global Learning and Observation to Benefit the Environment (GLOBE), through the Globe Observer application (Figure 1). By the theme of the CS project in this study, which is about the weather, students conduct cloud investigations for two days with their families. Students complete their investigations in different places depending on the location of their houses. The research data they get is sent to GLOBE data as a form of student contribution to the meeting (Bonney et al., 2016).

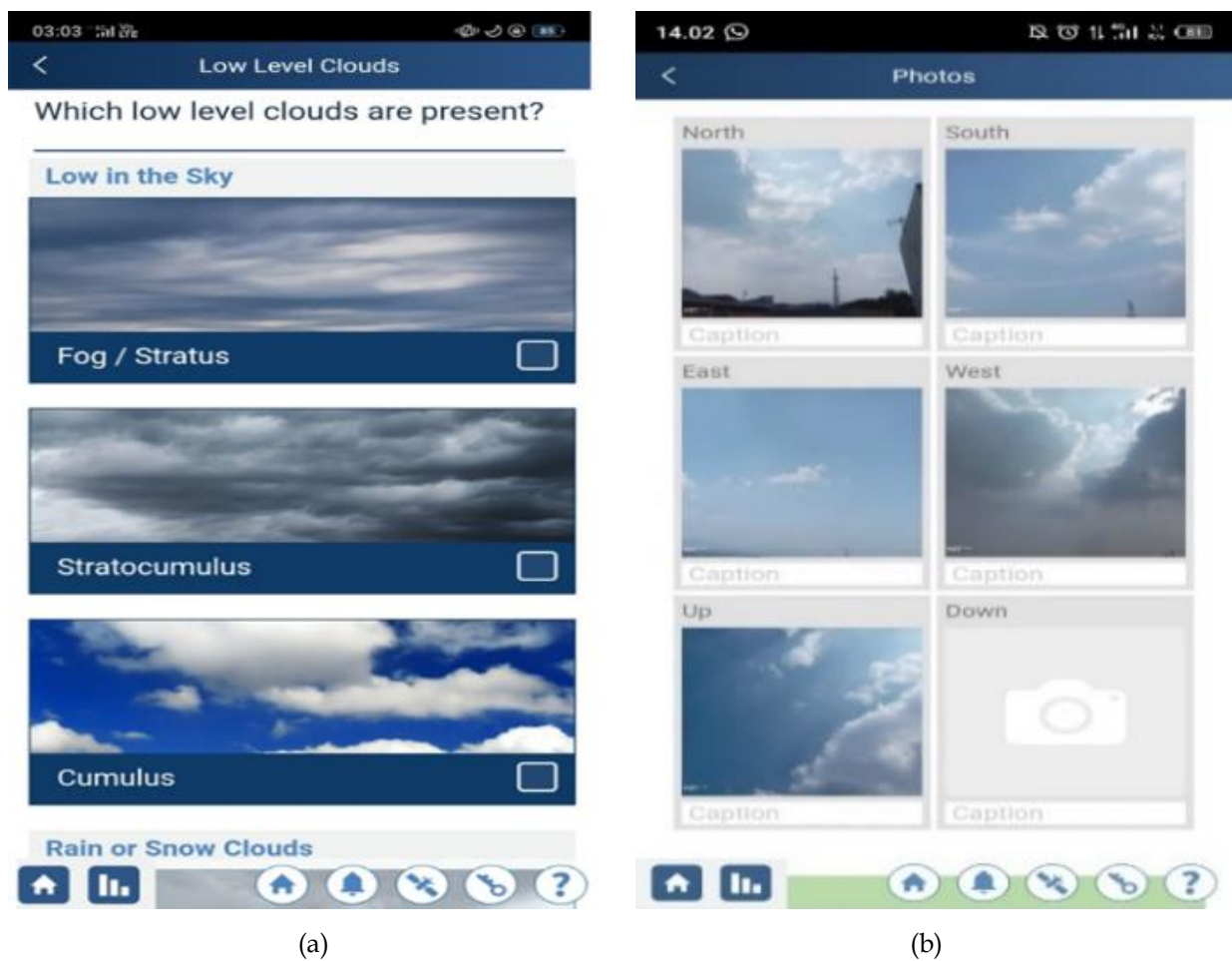


Figure 1. (a) Examples of cloud observation data collected by students through the Globe Observer application, (b) Cloud images taken by students to be sent to GLOBE data

RESULTS AND DISCUSSION

Previous research stated that the scientific attitude of junior high school students was still relatively low due to the lack of authentic scientific learning activities (Sandika & Fitrihidajati, 2018). CS projects, Weather-it, are authentic activities that provide opportunities for students to learn science through direct observation (Weigelhofer et al., 2019; Echeverria et al., 2021; Panitsa et al., 2021). That is, CS Weather-it, is thought to be able to have a positive influence on students' scientific attitudes.

The results showed that most students had sufficient scientific attitudes (Figure 2). This means students have an almost positive scientific attitude (Ozden & Yenice, 2014). Small students are in a good category, which means they have a positive scientific attitude (Demirbaş & Yağbasan, 2011). A positive scientific attitude can have an impact on student learning outcomes. The better the scientific attitude of students, the student's understanding of science concepts will also increase (Sari et al., 2018).

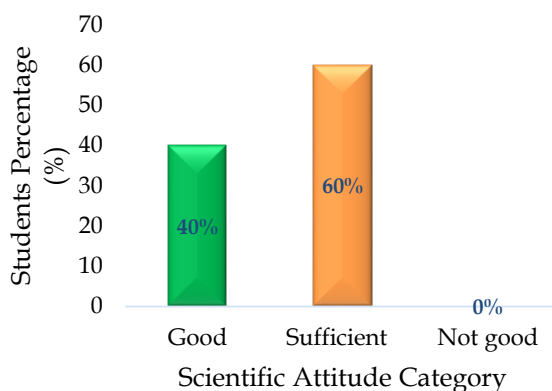


Figure 2. Percentage of students at the scientific attitude level.

Scientific attitude is a pattern of thinking or characteristic of a scientist (Nugraha et al., 2020). Being scientific means having attitudes such as curiosity, respect for data, critical thinking, open-mindedness, and cooperation (Harlen, 2018). This study found that students' curiosity was the most prominent aspect after participating in CS, Weather-it. Almost all students are in the good category for curiosity (Figure 3). This curiosity is stimulated by discussions with scientists (Sandika & Fitrihidajati, 2018). One male student said, "I want to have another discussion with a scientist, but not a weather expert anymore, but a plant expert. I want to know about plants by directly asking the experts." In addition, students' curiosity also arises because of the cloud observation activities they do with their families. A female student said, "I felt normal when I saw the sky. Nevertheless, after observing clouds in citizen science Weather-it, I have more questions when I look at the sky."

The second aspect with the highest percentage in the good and sufficient category is the aspect of open-mindedness and cooperation (Figure 3). This finding shows that students have an open mind and can work as a team. One student stated during an interview that "I learned to respect the opinions of my friends in this CS project." Harlen (2018) says that one indicator of an open-minded attitude is respecting the opinions/findings of others. Furthermore, in Weather-it activities, there is a stage of carrying out weather investigations and student discussions in groups that demand cooperation between students in each group (Dewi et al., 2020). This stage encourages the attitude of student cooperation toward a positive direction. The female student said, "This CS project is fascinating, I get to know my friends better, and we help each other when doing research. Students actively participate in their groups (Harlen, 2018). Even the

student appointed as his group leader felt he was learning to be a leader in this citizen science activity. This is in line with the statement of Ballard et al. (2017) and Phillips et al. (2019), the CS project can be a place to form students with leadership characteristics because it can influence how students think in making decisions like a leader.

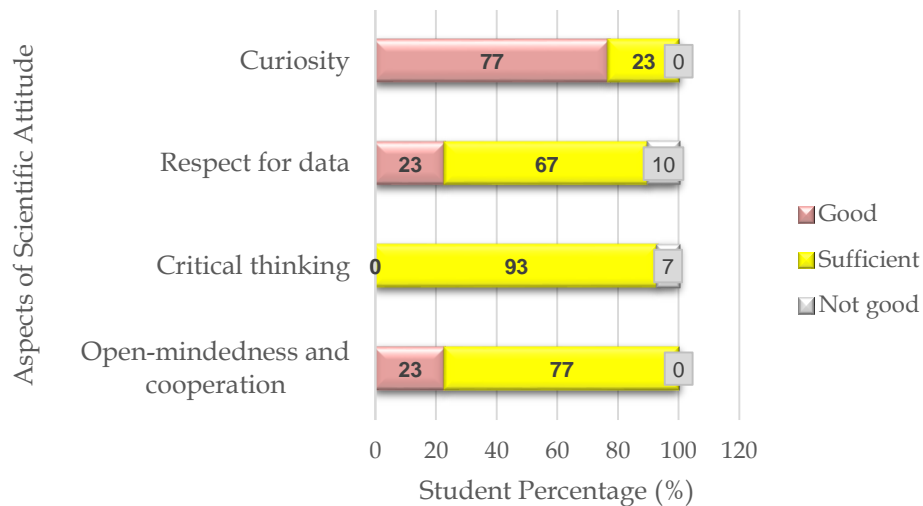


Figure 3. Percentage of students in each aspect of scientific attitude

The next aspect is respect for data, where 10% of students are in the unfavourable category (Figure 3). This means that the scientific attitude in respecting data does not lead positively to a small number of students. Lastly is the attitude of critical thinking, where no students fall into the good category. Most are in a good category, and a few are bad (Figure 3). This is most likely due to the relatively short project time. All students in this research sample are students who have never carried out scientific investigation activities. So for them, research data is something that is still foreign. They need to understand the importance of data for research. The relatively short time is also a factor in the need for change in this aspect of scientific attitude. Time constraints are an obstacle in the implementation of citizen science projects that are still faced by CS project implementers or researchers (Weigelhofer et al., 2019; Aristeidou et al., 2020). Many studies on CS projects involving students are constrained quickly (Weigelhofer et al., 2019).

In addition to students' scientific attitudes, the findings in this study also show that students acquire much knowledge through weather CS as shown on Table 3.

Acquired knowledge	Number of students who stated
Weather knowledge	17
Knowledge of clouds/sky	18
An understanding of the scientific method	5
Information about BMKG (Meteorology, Climatology, and Geophysics Agency)	1
Pengetahuan terkait teknologi	1

Many students reported that the citizen science project Weather-it provided them with new knowledge. Most students reported that they gained knowledge about weather and clouds (Table 3). This is because the citizen science project, Weather-it, raises the theme of weather and clouds, which are science phenomena that students often encounter (Aristeidou et al., 2020).

Citizen science project can support increasing students' knowledge related to certain science content through teaching materials by teachers (Ballard et al., 2017; Kelemen-finan et al., 2018), scientists (Kelemen-finan et al., 2018; Phillips et al., 2019) or project implementation (Panitsa et al., 2021; Phillips et al., 2019). One student said, "I know more about the weather; before I heard the word weather, my mind was cloudy, rainy, and sunny. Nevertheless, after following citizen science, I learned that there is air temperature, air humidity, and air pressure in the weather." Another student stated, "I came to know about the types of clouds, the colour of the sky, and the conditions of the sky."

The citizen science project does not only provide knowledge about science content. Some students reported that they became more knowledgeable about the scientific method. NF: "Now I know how to do research." This is in line with several research results which reveal that citizen science projects provide opportunities for students to learn about the scientific method (Aristeidou et al., 2020; Echeverria et al., 2021; Kocman et al., 2020; Phillips et al., 2019; Queiruga-Dios et al., 2020; Saunders et al., 2018). Students receive training before carrying out investigations or data collection where the training provides knowledge to students on how to collect data, process, and draw conclusions according to scientific principles (Ballard et al., 2017; Honorato-Zimmer et al., 2019; Peter et al., 2021; Weigelhofer et al., 2019).

Furthermore, one student felt he was gaining knowledge about technology, namely using smartphone applications for scientific research. KF: "I learned to use the AccuWeather and Globe Observer applications to research." The student statement is empirical evidence of the benefits of citizen science for technological knowledge (Aristeidou et al., 2020). Another student said, "It is more fun to use an application from a mobile phone." Using smartphones in citizen science can positively encourage student involvement in scientific investigations (Echeverria et al., 2021).

The latest knowledge students get about the duties or work of BMKG scientists (Meteorology, Climatology, and Geophysics Agency). Even students become motivated to work as scientists at BMKG. RT: "I just found out about BMKG, and it occurred to me that I wanted to work at BMKG." The meeting with scientists on this project is inspiring and essential for increasing students' interest in science and research in various disciplines (Ruiz-Mallén et al., 2016).

CONCLUSION

This study found a positive change in students' scientific attitudes after participating in the citizen science project, weather-it, although only slightly. However, this illustrates future research that the citizen science project can improve students' scientific attitudes. In addition, the citizen science project provides much knowledge to students even though the assessment comes from what the students feel. Future research should design more objective measures to measure knowledge beyond science content.

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