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How Students Communicate in Citizen Science Project to Build Knowledge

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Abstract: This research aims to provide information about several ways students communicate to build knowledge in citizen science projects (CSP). As the term "citizen science" applies to science that involves people who are not professional scientist to attract wider public participation in scientific research, leading to the overall advancement of scientific knowledge. Quantitative descriptive research was conducted by implementing as well as observing CSP activities in class and completing surveys to 36 students who had participated in CSP. The findings of this research show that most students (83%) received passing grades above 70 score, the minimum passing criteria. The percentage of completion of learning outcomes falls into the very effective category (n>80%). This means that CSP learning is able to build knowledge through the communication activities trained in it. On average, students responded strongly agree-agree (87.3%) that the communication carried out in CSP builds their knowledge. There are five CSP activities that involve communication between students, schools' community, teacher and expert scientist. The five main activities of CSP, namely (1) focus group discussion (FGD) with scientists, (2) conducting projects, (3) presenting project results to scientists, (4) reporting project results, (5) and finally publishing project results project. The implications of this research inform several communication activities that can be carried out to build knowledge in learning through CSP.

Keywords: communication, knowledge building, citizen science project (CSP)

▪ INTRODUCTION

Students' communication skills are important to measure because studies show that students both in secondary school, diploma and higher education are still less competent in oral and written communication (Trilling & Fadel, 2009). Meanwhile, effective communication skills are a key complement to 21st century skills (Larson & Miller, 2011; Zubaidah, 2016). Göksoy (2014) explained that communication is an effort to share knowledge and ideas between two or more people with the aim of building knowledge.

Communication in the learning context, Pal, Halder, & Guha (2016) defines it as the process of exchanging information, namely learning material from teachers to students. The communication aspect in learning places the teacher as the communicator or sender of the message, while the role of receiving the message (learning material) is the student. In line with Chung, Yoo, Kim, Lee, & Zeidler (2016) states that communication in learning is a process for sharing knowledge, thoughts and understanding between teachers and students so that mutual knowledge, relationships and interactions are built.

This communication skill is also very necessary to be able to collaborate with people in real life (Amin, 2017). Communication in collaboration can be trained by citizen science activities. Citizen science (CS) can be a means of empowering communities to interact, communicate and collaborate with each other and the surrounding environment (Queiruga-Dios, López-Iñesta, Diez-Ojeda, Sáiz-Manzanares, & Vázquez Dorrío, 2020). CS is an activity involving community participation to collaborate in scientific research

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with expert scientists. Through CS, communities share and contribute to data collection (M. M. Haklay et al., 2021; Robinson, Cawthray, West, Bonn, & Ansine, 2018).

Community participation in citizen science can be done through many forms are not limited to data collection. Such as calculations, analysis, evaluation, hypothesis development, methodology design and data dissemination can also be done through CS (Curtis, 2018; Land-Zandstra, Devilee, Snik, Buurmeijer, & Van Den Broek, 2016). Apart from aiming to collect large scientific data, CS in the world of education is usually carried out with project-based learning or what is known as citizen science project (CSP) with students and the school's community as the citizens.

Citizen science projects (CSP) actively involve citizens in scientific endeavour that generates new knowledge or understanding (M. Haklay et al., 2021; Hung, Jonassen, & Liu, 2008). In environmental and sustainability education especially biodiversity, CSP often be used by researchers to gather large amounts of biodiversity-related data and engage the public in biodiversity research (Peter, Diekötter, & Kremer, 2019). Projects carried out in biodiversity learning through CSP are often related to identifying and monitoring biological diversity, collecting biodiversity data, DNA barcoding and volunteering on conservation activity, and so on (Aripin, Hidayat, Rustaman, & Riandi, 2021; Kelemen-Finan, Scheuch, & Winter, 2018; Peter, Diekötter, Höffler, & Kremer, 2021; Schneiderhan-Opel & Bogner, 2020).

For years, citizen science activities have been carried out to monitor and raise environmental awareness, but most activities are contributory. It means that the design of tasks, planning, and analysis of problems are carried out by professional researchers (expert scientists), while citizens act as participants and data (Herodotou, Aristeidou, Sharples, & Scanlon, 2018; Mahajan et al., 2020; Vohland et al., 2021). Unlike other problem-based learning, such as problem-based learning, students become the initiators of the problems they encounter (Hung et al., 2008).

Several studies showed that implementation of CSP on biodiversity learning give some positive impacts on students' knowledge, attitudes, behavior, and literacy regarding biodiversity. CSP also can influence participants' skills and can lead to the increased self-efficacy of participants, an increased interest in the environment, and a variety of other personal outcomes (Aripin, 2022; Palmberg et al., 2015; Peter, Diekötter, & Kremer, 2019). Although many studies have shown that CSP can improve various students' outcomes, there is less description on how students communicate in CSP to build their knowledge and how students respond to implementing CSP in biodiversity learning.

Research to inform student communication to build knowledge in CSP has never been conducted. Even though knowledge is possible to develop along with project-based learning that communicates with fellow citizens and expert scientists (Novitasary, 2023; Nugroho, Jalmo, & Surbakti, 2019; Zubaidah, 2019), research to see how student communication through CSP activities needs to be carried out. Research findings can be used as evidence for references and learning activities that are known to be effective in building student knowledge through communication.

This information is also important for the development of future learning activities. Student responses can be used as accurate considerations regarding the implementation students expect in biodiversity learning. Therefore, this study aims to obtain student responses to implementing CSP in biodiversity learning. In addition to provide information about several students' communication activities to build knowledge in CSP.

▪ METHOD

Participants

The research population was students in Publich High School in Bandung. The samples were taken by using random sampling. The sample participants in this study were 36 students of grade 10 who had received biodiversity learning through CSP activities.

Research Design and Procedure

This research used quantitative descriptive methods through implementation of CSP, observation and surveys. Class observations were carried out when CSP activities were taking place in the learning. The implementation of CSP activities in this research was carried out through five main activities, namely (1) workshops with expert scientists, (2) project implementation, (3) presentation of project results, (4) reporting, and (5) publishing project data. The project activity in this research is plant identification in the school environment. Students communicate with school residents, friends, teachers and expert scientists during the identification process. Then the survey was given to 36 students after the CSP was completed. The research flow is summarized in Figure 1.

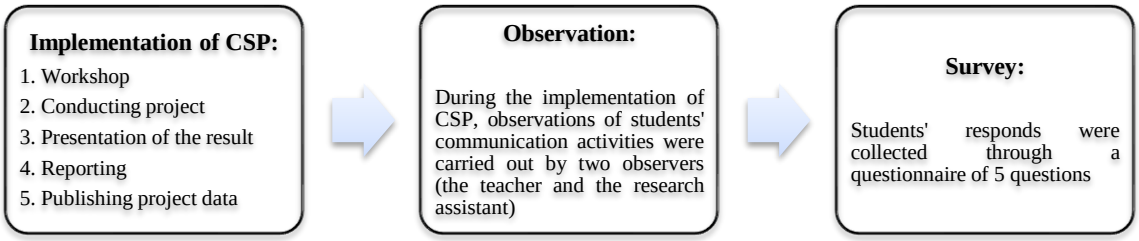

Figure 1. The research flow

Instruments

The instruments of the research were (1) posttest assessment, (2) observation sheet, (3) questionnaire survey. The posttest assessment were 20 multiple choice questions and developed from the biology book (Solihat, Eris Rustandi, Wandi Herpiandi, & Zamzam Nursani, 2022; Widiyati, Rochmah, & Zubedi, 2009) and had 0.532 reliability score. The indicators of posttest assessment are shown in Table 1.

Table 1. The indicators of posttest assessment

No.	Indicators	Number	Score
1.	Understanding of the level of biodiversity	1-8	1
2.	The reality of biodiversity in Indonesia	9-12	1
3.	Classification system in biodiversity	13-14	1
4.	Taxonomy in biodiversity	15-20	1

The observation sheet was compiled based on the CSP learning syntax, namely (1) workshops with expert scientists, (2) project implementation, (3) presentation of project results, (4) reporting and (5) publishing project data (Aripin & Hidayat, 2024). The questionnaire survey consists of five questions regarding student responses to the

communication that occurs in learning. The questionnaire was adapted from a similar study (Devi, 2012). Response questions were given in the form of a 1-4 Likert scale with the following details (1) strongly disagree/SD; (2) disagree/D; (3) agree/A and (4) strongly agree/SA. Table 2 showed the indicators of students' respond questionnaire.

Table 2. The indicators of students' respond questionnaire

No.	Indikator	Nomor
1.	Response to CSP for students' oral communication	1-2
2.	Response to CSP for student written communication	3-4
3.	Response to CSP to build student knowledge	5

Data Analysis

The total of posttest assessment score is processed by the formula below

$$\text{Students' completion of study: } \frac{\sum score\ obtained}{\sum maximal\ score} \times 100$$

The right answer was given by 1 score, the maximum score that students could achieve was 20 score. The passing grade of student's completion study was 70 score. The total of students that completed passing grade was the indicator of the effectiveness of CSP learning. The category of learning effectiveness through the percentage of students who exceed the passing grade or complete learning outcomes is listed in table 3.

Table 3. The category of learning effectiveness

Score	Category
0-20	Not effective
21-40	Less effective
41-60	Enough
61-80	Effective
81-100	Very effective

Response data is processed descriptively in percentages (%). The resulting scores are then used to determine students' communication categories in Table 4. The findings from observations are processed descriptively to produce comprehensive information about how students communicate to build knowledge in CSP.

Table 4. Categories of students' respon in communication

Score (%)	Category
0-20	Very bad
21-40	Bad
41-60	Enough
61-80	Good
81-100	Excellent

▪ RESULT AND DISSCUSSION

The findings in this research are divided into three data, namely (1) The learning effectiveness, (2) observation of student communication activities; (3) and student responses to communication activities during CSP.

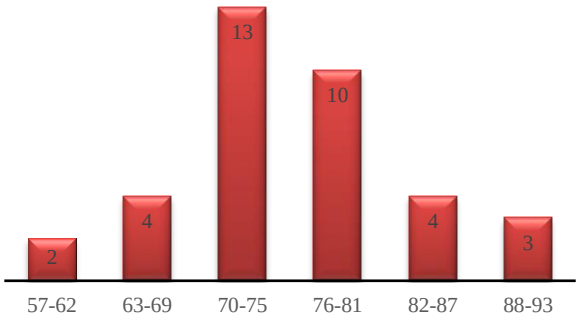

Figure 2. Students's achievement scores

Figure 2. shows that as many as 83% of students (30 people) achieved the minimum completion criteria with a score of ≥ 70. Meanwhile, 7% of other students (6 people) did not achieve the minimum completion with a score of < 70. The percentage of completion is included in the very effective category (80-100%) (Sari et al., 2023). This means that learning biodiversity through CSP is effective to build students' knowledge in biodiversity.

This result is in line to several studies showed that implementation of CSP on biodiversity learning give some positive impacts on students' knowledge, attitudes, behavior, and literacy regarding biodiversity. CSP also can influence participants' skills and can lead to the increased self-efficacy of participants, an increased interest in the environment, and a variety of other personal outcomes (Aripin, 2022; Palmberg et al., 2015; Peter et al., 2019). CSP learning is impressive because it can interact directly with the surrounding environment in a concrete and contextual way, not just material.

Other studies have also found that high school students' Biology learning outcomes increase when using a contextual approach (Irwandi, 2013; Syahril, 2018; Dongoran, 2019). A contextual approach can also increase students' creativity, thinking style, and caring attitudes and actions toward the environment (Mukayatun et al., 2013; Restanti et al., 2013; Rahmatan, 2017). The quality of Biology learning that increases with a contextual approach (Sudarisman, 2013) will indirectly raise students' motivation and passion for learning Biology (Irhami, 2019).

Building knowledge and understanding of the material develop as students complete their projects. In addition to knowledge, scientific attitudes, self-development, understanding of the nature of science, and various skills also increase after CSP learning (Prather et al., 2013; Price & Lee, 2013). CSP is also able to develop several science process skills during the project. Skills in identifying and processing data comprehensively, observation, scientific investigation, and argumentation are known to increase as projects progress in CS (Aristeidou, Scanlon, & Sharples, 2017; Masters et al., 2016; Scanlon, Woods, & Clow, 2014). Therefore, the students's achievement scores

reflects that CSP learning is very effective and can attract students to participate and actively feel the positive impact of collaborative learning.

Communication Activities in CSP

In every learning context, especially science, active communication is very important. So, it must be emphasized more for students. Scientific communication or scientific communication is one of the main skills in communication in science learning. The interaction processes that occur during investigations and the decision-making process are part of scientific communication. Communication skills in learning aim to maintain, produce and expand knowledge during student activities (Nielsen, 2013; Prihatiningsih, 2017).

Table 5. Student communication activities in CSP

No.	Activities
1.	Students actively involve in scientific endeavor that generates new knowledge or understanding by discussion with friends, community, teachers & scientists during CSP
2.	Students have a genuine science outcome by reporting the results of plant identification through student's worksheet, herbarium and poster
3.	Receive feedback from the project by presenting the outcome (students' worksheet, herbarium, and poster) to the scientist and teacher
4.	Project data and meta-data from CSP are made publicly available and results are published in an open access format through Pl@ntNet app
5.	Acknowledgment in project communications, results reporting and publications by receiving evaluation scores from teachers and scientists

The communication activities in CSP shown in Table 5. It shows that student communication in the learning process is very necessary. The existence of five activities that require students to communicate actively both verbally and in writing makes CSP one of the learning activities that can train students' communication. This is in line with the opinion that communication skills can develop along with project-based learning which involves the communication process in it (Novitasary, 2023; Nugroho et al., 2019; Zubaidah, 2019).

Through CSP, students not only communicate with their discussion partners, but students also have the opportunity to communicate with local residents and plant scientists (Professor in Plant Biosystematics). The communication that occurs during CSP activities indirectly builds student knowledge. In line with the statement that exploration/observation is very necessary when students try to understand a concept or build knowledge (Supriadi, 2015). Of course, this exploration and observation requires communication, so that ultimately communication can help students understand concepts and build their knowledge.

The knowledge that students build during CSP is not only about concepts/understanding of material, but also skills (especially science process skills), and attitudes/mindsets in good communication. The importance of students' awareness of good communication as a source of life needs to be instilled from an early age. The need to develop students' competence in presenting their academic work as a disciplinary contribution is also important while establishing themselves as members of society (Qiu

& (Kevin) Jiang, 2021). Of course, this urgency can be carried out through CSP activities which involve many levels of society to collaborate and contribute.

Respon to Citizen Science Project

After identifying plants through CSP activities and all communication that occurs during learning, students were given a response questionnaire on how communication during CSP activities can build students' knowledge of plant identification and classification. Data on student responses are presented in Table 6.

Table 6. Students' response to CSP

No.	Question	SA %	A%	D%	SD%	Category
1.	Learning with CSP can train students' oral communication skills through the involvement of experts and citizen	36.4	45.5	13.6	4.5	Very good
2.	Students' oral communication skills, such as conveying and summarizing observation results, are carried out effectively through the presentation of CSP results	50	36.4	9.1	4.5	Very good
3.	Students' written communication skills from reporting data on worksheets and PlantNet are in appropriate quality	41	50	4.5	4.5	Very good
4.	Students' communication skills in attaching evidence/observation data are appropriate and effective	63.6	27.3	4.5	4.5	Very good
5.	Communication in CSP builds knowledge/understanding of material/concept identification more easily	45.5	41	9	4.5	Very good
	Average	47.3	40	8.2	4.5	Very good

Effective learning output is also clearly illustrated by the very good-good average student response (87.3%) in Table. 3. Students strongly agree that the communication carried out during CSP not only able to practice oral and written communication skills, but also expand collaboration with various parties. Apart from that, building knowledge through communication on CSP is also easier to achieve. Then, students also gain experience when the results of their observations receive recognition/acknowledgement, published widely to the global community through Pl@ntNet plant database application.

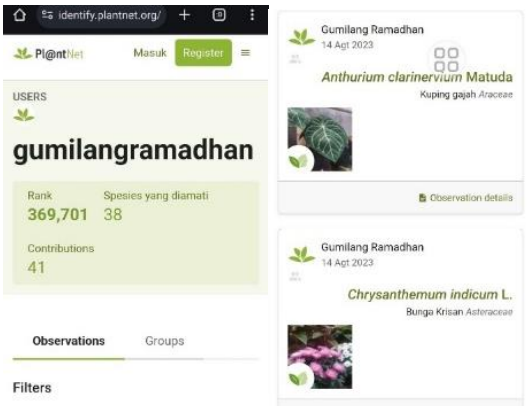

Figure 3. The display of Pl@ntNet for plant identification

One of student's respond stated that, "Learning activities should require a lot of training for students to interact with the community and general public such as CSP". CSP is known by actively involve citizens in scientific endeavour that generates new knowledge or understanding (M. Haklay et al., 2021). In environmental and sustainability education especially biodiversity, CSP often be used by researchers to gather large amounts of biodiversity-related data and engage the public in biodiversity research (Peter et al., 2019). Active participation, effective group work and interact with each other determine the communication skill outcome for students (Aslan, 2021).

Figure 4. The identification project in CSP

Presentation activities are also well responded by students (86.4%) because they can train students' confidence in expressing opinions, train communication and train interaction between each other. In order for students not to have problems with stage fright and nervousness when they do presentation, these skills should be practiced from a young age. The majority of students believe that educational institutions should prepare students for presentations. When giving a presentation, various factors must be taken into account, such as the creation and design of the presentation itself, its creation in one of the tools, the content which must be logically structured, clear and precise language, the appearance of the person giving the presentation, and non-verbal communication (Popović, Hmelina, Cesarec, & Klopotan, 2024).

The others student responses above are in line with the many studies that mention the positive impacts felt by students from CSP learning. CSP learning allows students to interact with spontaneous and new knowledge when projects such as communication skills and digital literacy (Aristeidou & Herodotou, 2020). The use of software platforms and digital instruments is also an advantage for improving students' technological skills (Jennett et al., 2016). In addition to Pl@ntNet for CSP in the field of plant science, there is a lot of software that can be used in CSP in other fields of science such as iSpot, Galaxy Zoo, Citizen Sky and so on.

The findings in this research have implications as a reference for several communication activities in learning that can help students build their knowledge. Students do not gain their knowledge through teacher lectures, but students collaborate and communicate with many parties through CSP to construct their understanding. Therefore, CSP learning activities are known to be effective in building student knowledge through the communication and collaboration that exist within them.

▪ CONCLUSION

Communication can help students understand concepts and build their knowledge through exploration/observation activities such in CSP. The findings of this research show that most students (83%) completed the passing grades. The percentage of completion of learning outcomes falls into the very effective category (n>80%). This means that CSP learning is able to build knowledge through the communication activities trained in it. On average, students responded strongly agree-agree (87.3%) that the communication carried out in CSP builds their knowledge. There are five CSP activities that involve communication between students, schools' community, teacher and expert scientist.

The implications of this research inform several communication activities that can be carried out to build knowledge in learning through CSP. The limitation of this research is the sample of the study only involve a class. The suggestion for the next research is implementing CSP to other subject not only in natural science but also in sosial science or other field of science. The implementation also needs to be wider to get the better sight of the benefit of implementing CSP in learning activities.

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