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INTEGRATING COMMUNITY OUTREACH INTO NEXT GENERATION SCIENCE STANDARDS FOR PROSPECTIVE SCIENCE TEACHERS' SUSTAINABLE CLIMATE ACTION SKILLS

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ABSTRACT

Human behavior that impacts climate change is increasingly out of control, which is very worrying for the survival of future generations. The weak climate-action skills of prospective science teachers, along with their daily activities that have the potential to cause climate change, need to be addressed. This study aims to integrate community outreach into the three dimensions of the Next Generation Science Standards so that prospective science teachers are skilled at preventing climate change. This study uses a mixed-methods embedded experimental design with a quasi-experimental component. Community outreach is integrated into the three dimensions of NGSS to develop the climate action skills of prospective science teachers by learning from community habits for climate change prevention practices. The study results showed that prospective science teachers are increasingly skilled at preventing climate change by planting trees and sorting organic and inorganic waste, thereby demonstrating economic potential. Integrating community outreach into the three dimensions of NGSS is a new strategy to prepare prospective teachers who are aware of being agents of sustainable climate change prevention.

Keywords: community outreach; Next Generation Science Standards; prospective science teachers; climate action

INTRODUCTION

Climate change can be combated through action and education by preparing students to actively anticipate its adverse effects actively. Climate change cannot be anticipated with mere knowledge; it also requires real action as a contribution to Sustainable Development Goals (SDGs) number 13. Climate change threatens human life by increasing the risk of natural disasters (Mbah, 2024; Tang, 2024; Prentice et al., 2024; Rajabi, 2025). Behavior that impacts climate change is increasingly uncontrolled, which is worrying for human survival in the future (Ghali, 2023; Vrselja et al., 2024; Stephenson & Muzika, 2025). Various ways to solve the problem have been found, but the damage to nature that contributes to climate change is increasingly widespread. Good practices for living in harmony with nature persist in only a small part of traditional society in Indonesia. Community outreach, as a community participation approach, is a good practice for actively involving the community in preventing environmental damage (Hidayat et al.,

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2024; Hapsari et al., 2024; Sulistiadi et al., 2024; McNeill et al., 2025). Community outreach begins by recognizing the potential of the surrounding environment in an integrated way to meet the needs of life. The potential of surrounding nature is easier to introduce when it becomes a source of income with its benefits. A proven participatory community approach to protect nature in forests, beaches, agricultural land, and plantations must be integrated into learning. Modern society finds it difficult to control climate change because applying sustainable living principles in their activities to meet their needs is still weak (Ivanova & Rangel, 2024; Karman et al., 2024; Prasad, 2025). Building awareness requires more innovative problem-solving strategies through real action to prevent climate change (climate action) through education (Lachapelle et al., 2024; Pennacchioni, 2025; Andre et al., 2024; Reijers, Young, & Coeckelbergh, 2025). The integration of community outreach into the preparation of prospective science teachers is an important, innovative strategy to equip them with climate action skills. Prospective teachers have a strategic role as an important educational resource through their teaching functions (Zhai et al., 2024; Chang et al., 2025; Fitzgerald et al., 2024; Ritonga et al., 2025).

Various problems were identified in the analysis of how prospective science teachers teach environmental material in five junior high schools in Semarang, as part of a preliminary study. The environment is considered easy conceptual material, so prospective science teachers tend to be theoretical in teaching it. Learning resources for environmental material also do not explore the surrounding natural environment. Moreover, knowledge about climate change is not translated into real action. Climate change problems are predominantly solved through class discussions rather than through direct practice. Based on the analysis, 72% of students know about climate change, but their problem-solving skills do not follow from that knowledge. Therefore, most students fail to determine solutions to climate change problems. Innovation is needed to prepare prospective science teachers to have climate action skills. In this study, indicators of climate action skills for prospective science teachers refer to SDGs indicators in reforestation, managing plastic waste, turning off unused electricity, and using water efficiently.

The urgency of research to use a new learning model that makes prospective Science teachers have climate action skills. The model used has characteristics that start with exploring various community outreach practices in Indonesian society. The exploration results provide knowledge for developing a lesson plan that integrates community outreach into the NGSS dimensions. This research is limited to three dimensions of NGSS as material for developing the model: how science knowledge is acquired and understood, science knowledge content, and science content connected to community knowledge (Siebert, 2022; Tanas & Fulmer, 2023; Summers, 2024; Hoskinson et al., 2024; Brkich et al., 2025). The model for community outreach activities is part of the NGSS success indicators for sustainable climate action skills practices. This research is important because it aligns with the strategic plan of the corresponding author's university and makes fundamental contributions to advancing conservation insights through education. Prospective teachers with climate action skills have a comprehensive impact because they will teach in schools. Research is urgently needed, as the time for prevention is running out amid uncontrolled climate change.

The weak climate action skills of prospective science teachers need to be addressed. Based on the analysis of the problem's source, the practice of climate action skills among science teachers remains low, so it is feared that they will fail to prepare the future generation of scientists. The success indicators for NGSS were developed by integrating community outreach, so prospective teachers can design and implement sustainable climate action practices. The aspect of community outreach in the study as a model material is limited to the following practical activities: (1) recognizing the surrounding environment, (2) utilizing the surrounding environment to meet life needs, (3) exploring the economic potential of the surrounding environment, and (4) preserving natural resources in the surrounding environment. Community outreach is integrated with the NGSS dimensions for sustainable climate action skills. The study's sustainability aspect is intended to be tiered, starting with climate action practices designed to run continuously.

Science learning contributes to addressing environmental issues, serving as an indicator of success in preparing future generations in Indonesia under NGSS (Parmin et al. 2024). The future generation is realized through education by preparing prospective teachers who can teach with innovative strategies and are oriented towards solving problems in the surrounding environment (Parmin et al. 2024).

METHODS

The objectives of this study were achieved through a mixed-methods design comprising three stages (Creswell, 2012). The chosen mixed-method was an embedded experimental design with a quasi-experimental design. The first qualitative stage was before model use, the second during use, and the third after use. The study requires qualitative data before using the model to sharpen the intervention, develop treatments, and develop instruments. The study requires qualitative data during the intervention to investigate the integration process of community outreach within the NGSS dimensions, which will support the quantitative data. The study requires qualitative data collected after implementing the integrated community outreach model for the NGSS dimensions to explain the intervention's results.

The study's success was determined by two criteria: four community outreach activities and four indicators of climate action skills. This study's four indicators of community outreach activities are recognizing the surrounding environment, utilizing it to meet life needs, exploring its economic potential, and preserving its natural resources. This study's four indicators of climate action skills include reforestation, managing plastic waste, turning off unused electricity, and using water efficiently. Climate action skills focus on prospective teachers' skills in climate change prevention practices, according to SDG indicators. The model used has advantages similar learning models do not have because its syntax integrates community outreach with NGSS dimensions for climate action skills. There are five stages of learning within the integrated community outreach model of NGSS dimensions: recognizing the surrounding environment, practicing climate action, exploring economic potential, building a sustainable environment, and reflection.

The study's target population was 52 prospective science teachers enrolled in introductory biology courses. Specifically, this study developed a new, specific data collection instrument as part of the research innovation. The instrument that was specifically developed was validated by learning evaluation experts. The involvement of experts as lecture observers became an innovation to overcome the weaknesses in the applicability of similar products from previous studies. Experts directly observed the climate action skills of prospective science teachers through the model.

The data collected are climate action skills. The instrument used is new and different from similar research instruments because it is part of a new model that integrates community outreach with NGSS dimensions. Data were analyzed by processing the validation sheet contents using a Likert scale. The product validity percentage is calculated by dividing the number of validators (rounded) by the total score for each selected criterion. The level of achievement in this study is measured using three percentage ranges: very good (86-100), good (70-85), and less good (<70). Data were analyzed descriptively, with results from the calculation of each assessment item used to inform the analysis. The analysis uses the number of answers for each respondent per item, divided by the number of respondents. The questionnaire result criteria are very feasible (3.25-4), feasible (2.51-3.25), and less feasible (<2.50).

RESULTS AND DISCUSSION

The research problem was solved using the community outreach model integrated into the NGSS dimensions. The stages of introductory biology learning include recognizing the surrounding environment, engaging in climate action practices, exploring economic potential, promoting a sustainable environment, and reflecting. The implementation of each stage is measured using a Likert scale. The results of the model implementation analysis are presented in Figure 1.

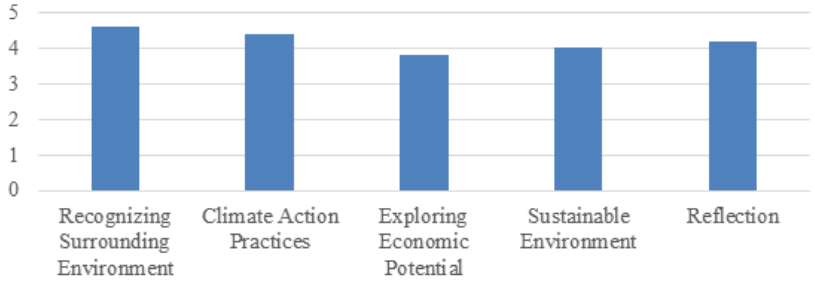

Figure 1. Implementation of the Community Outreach Model Integrated into NGSS Dimensions

The model implementation scored 87 or was categorized as very good. Introductory biology lecturers conducted lectures according to the model. The implementation was analyzed according to the five indicators in this study. Prospective science teachers recognized the surrounding environment with an average class score of 4.6 out of 5. They recognized the surrounding environment through direct observation, which was deepened through interviews with the target community. They used self-developed instruments to collect data and facts to recognize the surrounding environment.

Individual climate action practices received an average class score of 4.4 out of 5. The following is the order of practices from most to least: planting trees, making organic and inorganic waste bins, cleaning water channels for fish seeds, and processing waste into compost. Economic potential is a long term analysis of climate action practices. Prospective teachers analyzed economic potential projections for trees planted to produce fruit and wood, inorganic waste sold, and fish in water channels sold. The exploration of economic potential received the lowest score because this is not something prospective science teachers are used to doing, so they are not trained to analyze it in depth. The study found a relationship between climate action practices that must consider long-term economic potential. Climate change prevention with income projections received a higher response from the community.

The results of the descriptive statistical analysis of the climate action skills measurement of 52 prospective science teachers are presented in Table 1.

Table 1. Prospective Science Teachers' Climate Action Skills

Climate Action Skills	N Statistic	Minimum Statistic	Maximum Statistic	Mean		Std. Deviation Statistic	Variance Statistic
				Statistic	Std. Error		
Observing Community Activities	52	1.00	4.00	2.28	.096	.695	.484
Finding Life Needs	52	1.00	4.00	2.65	.094	.682	.466
Climate Action Practices	52	1.00	4.00	2.59	.129	.934	.873
Prevention Actions	52	1.00	4.00	2.59	.143	1.033	.1.069

Descriptive statistical analysis of climate action skills measurement on 52 prospective science teachers with a minimum score of 1.00 (lowest skill) and a maximum of 4.00 (highest skill). Observation skills to find various community activities that cause climate change have the highest mean of 2.28 (Std. Error: 0.094). Skills to find the availability of community living needs are 2.65. The means for all variables range from 2.28 to 2.65, indicating a tendency for prospective science teachers to have skills in the middle range of the measurement scale or to have pretty good skills. The analysis results of the four indicators of community outreach activities in this study are in Figure 2.

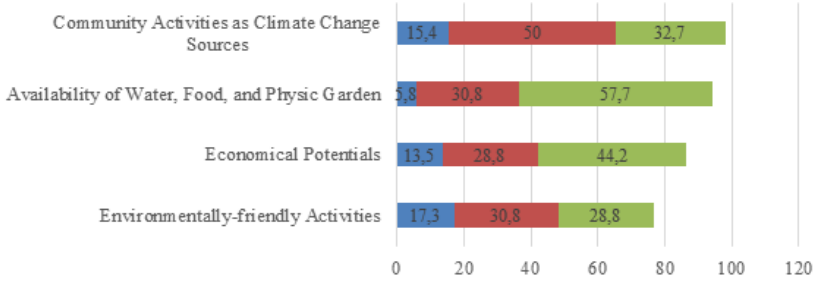

Figure 2. Community Outreach Activity Indicator Achievement

The study analyzed observations of prospective science teachers to collect data on community activities that contribute positively or negatively to climate change. Prospective science teachers themselves determine the location of the community they observe, such as villages, cities, and residential areas around campus. 50% of the community activities observed are sources of high climate change. Communities at various observation locations exhibit similar behavior: they do not reforest, do not separate organic and inorganic waste, and even burn it. The availability of clean water for consumption, food, and gardening is only 30.8%, well below 50%. In preventing climate change, community activities still do not consider economic potential (28.8%). Community habits have a greater impact on climate change than prevention efforts, so only 30.8% of activities are environmentally friendly.

Prospective teachers attended introductory biology lectures with an integrated community outreach model in the NGSS dimension and observed community activities related to climate change. The results of the questionnaire analysis of prospective science teachers regarding changes in climate action habits, comparing before and after the lecture, are presented in Table 2.

Table 2. Prospective Science Teachers' Climate Action Changes

Climate Action	Community Outreach		Increase
	Before	After	
Reforestation	2.8	3.6	1.2
Managing waste	3.0	3.8	0.8
Turning off unused electricity	2.6	3.2	0.6
Using water efficiently	3.2	3.6	0.4

The most significant change in the four daily habits of prospective science teachers was reforestation or planting trees, which increased by 1.2. Introductory biology lectures with the community outreach model have encouraged prospective science teachers to strengthen empathy for community life. Planting trees, separating organic and inorganic wastes, turning off unused electricity, and using water efficiently. The increase in climate actions from before and after shows that the model has a positive impact.

This study found a new way to integrate community outreach into three Next Generation Science Standards dimensions. Integration techniques were found in this study: (1) scientific knowledge is obtained from the habits of communities managing natural resources sustainably; (2) reviewing the content of scientific knowledge that is deepened from various real examples in the community; and (3) real practices that exemplify proven community traditions that utilize nature in a balanced way. Nwankwo et al. (2024); Sulistiawati, (2024); and Sakarya et al. (2025) build awareness that preventing climate change is the most formidable challenge in living habits even though they already have knowledge but have difficulty applying it to protect the environment. The future generation must be prepared to recognize the dangers of climate change (Novak, 2024; Anderson, 2024; Lopes et al., 2024; Tavanti, 2025). The biggest challenge in preparing prospective science teachers is their behavior. Instead of implementing prevention measures, many activities contribute to climate change. Integrating community outreach into the three dimensions of NGSS is a new strategy that can prepare prospective teachers who are increasingly aware of what it means to be teachers in schools.

The integration of community outreach with NGSS found during the research process was carried out by recognizing the traditions of selected communities that have track records of habits of being at one with nature, raising awareness of prospective science teachers through learning from the habits of traditional communities in preserving nature to meet local food needs, clean water, and medicine. The study found changes in attitudes before and after the implementation of the model, and prospective science teachers were aware of how to prevent climate change and preserve sources of life. The lifestyle of the younger generation in preventing climate change, which is carried out with an obligatory approach, only creates momentary awareness that does not continue (Stollberg et al., 2024; Ahmed et al., 2025; Seastedt et al., 2025). This study begins by seeking solutions to build self-awareness, learning from the various traditions of selected communities that live in harmony with nature.

Activities during the study involved helping prospective science teachers understand the nature of life and its sources, so that if nature is damaged, these sources will be threatened with loss. The interesting research results are the

most important findings during the climate action practice, and there is a relationship between the drive to practice and the skills of projecting economic potential. Climate change prevention, approached with economic potential, drives sustainable behavior (Hania et al., 2025; Windisch et al., 2025; Porfiriev et al., 2025). Sustainable future solutions require motivation to strengthen awareness of climate change prevention through the potential to earn money. The drive for economic prosperity among the younger generation has similarities with society, maintaining the tradition of living in harmony with nature to fulfill life's needs.

Prospective teachers' skills are weak in projecting income from climate change prevention practices, yet they receive the highest community response. Climate change prevention has economic benefits, such as planting fruit trees, sorting organic and inorganic waste, composting, and using gutters for fish farming (Lipka & Andreeva, 2024; Labini & Caravani, 2025; Prakapienė, 2026). Prospective science teachers and the community highly respond to the economic potential. Prospective science teachers feel they have the most valuable experience from practical activities that project economic income. The younger generation strongly supports integrating climate change prevention with economic benefits (Lin & Xie, 2025; Somoye & Akinwande, 2025). The preparation of prospective science teachers with sensitivity to climate change prevention is expected to be sustainable once financial income is made a benefit to be obtained.

Integration of community outreach into NGSS has a real impact on preparing prospective science teachers by building sustainable climate action skills. The impact of changes in behavior before and after using the model is that prospective teachers are increasingly aware of the fundamental skills needed to prevent climate change. They also practice climate action by planting trees and separating organic and inorganic wastes. Prospective teachers can create entrepreneurial opportunities by processing waste into organic fertilizer and preventing climate change, thereby increasing income. Prospective science teachers are increasingly confident in becoming educators as agents of preventing climate change (Shallcross et al., 2024; Andrea, Tampakis, & Vasileiadou, 2025). A real contribution to the field of science is preparing prospective teachers to become exemplary educators so that future generations in Indonesia can enjoy a sustainable environment.

Community outreach is integrated into the three dimensions of NGSS to develop climate action skills in prospective science teachers by learning from community habits for climate change prevention practices. The study results showed that prospective science teachers are increasingly skilled at preventing climate change by planting trees and sorting organic and inorganic waste, thereby demonstrating economic potential. Integrating community outreach into the three dimensions of NGSS is a new strategy to prepare prospective teachers to recognize themselves as agents in sustainable climate change prevention.

CONCLUSION

Community outreach, integrated into the three dimensions of the Next Generation Science Standards for prospective teachers with climate action skills, is carried out through learning from community habits for climate change prevention. The impact of the model for prospective science teachers is increasing their practical skills in climate change prevention through planting trees, sorting organic and inorganic waste, and projecting economic potential. Integrating community outreach into the three dimensions of the NGSS is a new strategy for preparing prospective teachers who are increasingly aware of their role as agents of climate change prevention before becoming teachers.

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