Jurnal Pendidikan Sains Indonesia
(Indonesian Journal of Science Education)
https://publications.usk.ac.id/index.php/jpsi

14(1), 243-254, (2026)
e-ISSN: 2615-840X p-ISSN: 2338-4379
https://doi.org/10.24815/jpsi.v14i1.181

Enhancing Students' Environmental Care Character Through the Application of "A Plate of Food" as a Learning Medium in Chemistry Education

Familia Novita Simanjuntak[1*], Leony Sanga Lamsari Purba[1], ST Fatimah Azzahra[1], Nova Irawati Simatupang[1], Elferida Sormin[1], Putri Anjani[1], Lester E. Orpilla[2]

[1]Chemistry Education, Faculty of Teacher Training and Education, Christian University of Indonesia, Jakarta
[2]College of Arts and Science, Don Mariano Marcos Memorial State University, North La-Union Campus, Philippines

*Corresponding author's email: familia.novita@gmail.com

Article History:
Received date: January 19 2026
Received in revised from: January 28 2026
Accepted date: February 2 2026
Available online: February 6 2026

Citation:
Simajuntak, F.N., Purba, L.S.L., Azzahra, S.F., Simatupang, N.I., Sormin, E., Anjani, P., & Ropilla, L.E. (2026). Enhancing Students' Environmental Care Character Through the Application of "a Plate of Food" As a Learning Medium in Chemistry Education. Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education), 14(1), 243-254

Abstract. Chemistry education is not only oriented towards mastering scientific concepts, but also plays an important role in shaping students' character, particularly their environmental stewardship. This study aims to describe the improvement of students' environmental stewardship through the application of the "a plate of food" learning media in chemistry learning. This learning media links the concept of food chemistry with everyday environmental issues, such as food management, waste reduction, and sustainable consumption. This study used a qualitative descriptive method. The research subjects were 54 11th-grade students from Don Bosco High School, selected using a total sampling technique. Data collection was carried out through observation, interviews, and an environmental stewardship questionnaire. Data analysis was carried out through the stages of data reduction, data presentation, and drawing conclusions. The study's results indicate that using the " a plate of food " media in chemistry instruction can increase students' awareness of the importance of protecting the environment. This is reflected in changes in students' attitudes toward managing food waste, increased awareness of waste issues, and students' understanding of the relationship between chemical concepts and environmental issues. Therefore, the " a plate of food " learning medium can be an effective tool for strengthening environmental awareness in chemistry education. This research is expected to contribute to the development of innovative chemistry learning oriented toward character education and environmental sustainability.
Keywords: Chemistry education, environmental care character, learning media, a plate of food, qualitative research

Introduction

In this era of technological development, the use of learning media is still less varied. Learning media is a tool that can support the teaching and learning process so that the meaning of the message conveyed is clearer and teaching and learning objectives are achieved effectively and efficiently. Learning media is a learning resource that helps teachers enrich students' insights. Learning media that is attractive to students can be a stimulus for students in the learning process. Therefore, learning media can be used as an

important tool in teaching and learning activities within the school environment (Nurfadhillah et al., 2021).

The school environment itself is an environment where the teaching and learning process from basic education to higher education is carried out in a systematic, programmed, and planned manner in order to achieve maximum results for both educators and students (Anggraini, 2017). In a broader context, the environment provides all human needs, such as food, drink, oxygen, and other necessities of life. Consequently, humans continuously utilize the environment to meet basic needs and improve their quality of life. In this regard, the school environment has a significant influence on the learning process and learning outcomes, both directly and indirectly. Thus, a supportive school environment is absolutely necessary to enable a quality learning process (Wardani, 2020).

As a response to the importance of environmental awareness within educational settings, on February 21, 2006, the Ministry of Environment and the Ministry of National Education introduced a green school culture through the Adiwiyata program (Wardani, 2020). In accordance with Environmental Regulation Number 5 of 2013 concerning Guidelines for the Implementation of the Adiwiyata Program, this program aims to create environmentally sound schools and foster an environmental culture. The implementation of the Adiwiyata program is based on three main principles, namely educative, participatory, and sustainable principles (Latief et al., 2019). Through these principles, the Adiwiyata program serves as a concrete step toward creating schools that are dedicated to educating students who value and actively cultivate an environmental culture (Fadlillah et al., 2018).

In line with the objectives of environmentally oriented education, a person's character needs to be developed through three stages: knowledge, practice, and habit (Aini et al., 2014). For students who are still in the developmental stage, this process requires a more intensive approach, such as individual mentoring, the provision of role models by teachers and peers, and the implementation of experiential learning methods to enhance the understanding and application of values (Andayani, 2025). One important character value that needs to be developed is environmental care, which should be implemented at all levels of education in schools. Accordingly, all school members need to be aware of the importance of environmental protection and take concrete steps to prevent environmental damage (Purwanti, 2017). An environmentally conscious character reflects an attitude that enables individuals to manage and preserve the environment sustainably without causing long-term damage (Hasanah & Afianah, 2021). Therefore, the character of environmental care must be consistently instilled through learning activities, habituation, and exemplary behavior (Pane, 2016).

However, the character of environmental care does not develop automatically; rather, it must be cultivated continuously from an early age through real activities that are closely related to everyday life (Masturoh et al., 2020). Education plays a strategic role in fostering this character. Recognizing this role, schools as educational institutions need to instill and develop students' concern for the environment from an early stage. Through this effort, human resources can be formed who are able to utilize their potential wisely in creating a conducive, ecological, and sustainable environmental quality in real and lasting ways, while still adhering to local cultural values and wisdom (Arisona, 2022).

The effectiveness of education is greatly influenced by the quality of human resources, particularly teachers, who are a key component of the school environment (Sudjana & Wijayanti, 2018). Teachers are not only required to professionally master teaching skills but also to serve as role models for their students. According to Simanjuntak et al. (2023), chemistry teachers need to provide more space for students to express the difficulties and doubts they experience during the learning process. This is important because teachers' words and behavior are often imitated by students, making teachers central figures not only in the transfer of knowledge but also in shaping students' character.

Various perspectives emphasize the importance of character education, which receives strong cultural and professional attention (Chowdhury, 2018). One concrete form of character education is cultivating environmental awareness, which can be instilled through consistent guidance from teachers, such as reminding students not to litter and to reduce food waste (Astari, 2018).

In this context, food waste emerges as a relevant environmental issue, as it has a considerable impact on the environment both directly and indirectly (Amelia et al., 2019). Consequently, the wise management of food waste is closely related to the character of environmental care (Kasri et al., 2021). Food waste contributes to environmental degradation through the waste of natural resources and its role in pollution and climate change. Therefore, the development of environmental care character is closely linked to awareness of reducing food waste and managing it in more sustainable ways, such as recycling it into compost or sharing it with others (Oktarina, 2021).

One contextual approach that connects daily behavior with environmental awareness is the use of a plate of food as a learning medium or symbol that explains food consumption patterns in everyday life. As part of human daily activities, a plate of food can function as an educational medium that positively influences pro-environmental habits and behaviors. The interpretation of a plate of food can foster environmental care character by helping individuals determine appropriate nutritional content and portion sizes that support health and quality of life, while also encouraging decisions that contribute to environmental preservation. Furthermore, a plate of food can serve as a data bank and a source of chemistry learning material (Simanjuntak, 2020), as well as a medium to encourage active community participation in converting food waste into renewable energy (Chen, 2023).

From a scientific perspective, chemistry is the study of matter and its changes and is developed through experimental processes. In learning chemistry, three inseparable aspects are involved, namely chemistry as a process, attitudes, and knowledge in the form of concepts, facts, laws, principles, and theories. Despite its importance, chemistry is often perceived by students as a difficult subject because it is abstract and contains complex concepts compared to other subjects (Setiawati & Rahmawati, 2019). Essentially, chemical concepts encompass three interconnected levels of representation: macroscopic (observable properties), submicroscopic (particles that compose substances), and symbolic (chemical formulas and symbols).

Considering these challenges, one alternative learning innovation that can be implemented is the use of contextual learning media, such as "a plate of food." This learning media emphasizes food as part of students' daily lives and connects it with concepts of food chemistry, substance composition, chemical reactions, and the environmental impact of food management. Contextual approaches using real-life learning media have been shown to improve conceptual understanding and increase students' awareness of environmental issues (King et al., 2012). Through the use of "a plate of food" in chemistry learning, students are expected to understand the relationship between food choices, chemical processes, and their environmental consequences, including food waste and pollution. As a result, students not only learn theoretical chemistry concepts but also develop an attitude of environmental care through reflective and meaningful learning experiences. Learning media that are closely related to everyday life can thus help students build critical awareness and a sense of responsibility toward the environment (Hazari et al., 2013).

Based on initial observations at Don Bosco Senior High School, chemistry learning has not yet fully integrated explicit environmental character education. Students tend to perceive chemistry as an abstract subject that is detached from everyday life, which leads to the underdevelopment of environmental values. This condition indicates the need for more contextual chemistry learning that is oriented toward character building. Therefore, this study was conducted to describe how the implementation of the "a plate of food"

learning media in chemistry education can improve the environmental awareness of eleventh-grade students at Don Bosco Senior High School. This study employed a qualitative descriptive approach to describe changes in students' attitudes and environmental awareness through a contextual learning process. It is expected that the findings of this study will contribute to the development of chemistry learning that not only emphasizes cognitive aspects but also supports the strengthening of environmental awareness as part of the goals of sustainable education.

Methods

This study employed a qualitative descriptive method. This method was chosen because the study aimed to in-depth describe the learning process and changes in students' environmental awareness following the implementation of the "a plate of food" learning media in chemistry education. The qualitative approach allows researchers to understand phenomena holistically based on students' experiences, attitudes, and responses during the learning activities. This research was conducted at Don Bosco High School. The subjects were 54 eleventh-grade students. The subject selection technique used total sampling, meaning all students in one grade level were selected as subjects, allowing the data to accurately depict the overall condition of the class.

The research instrument used by researchers consisted of 3 categories, which were developed into 10 statements, which describe in Table 1.

Table 1. The research instrument

No	Category	Statement
1.	Food menu criteria that students want	1. What was the last meal you had today? 2. Did you finish your last meal? Why? 3. In general, people choose food based on its taste. How do you choose your food? 4. Based on your experience, what kind of food makes you (happy) to finish your meal?
2.	Student responses on food waste	1. In your opinion, should we waste food? Why? Please explain briefly! 2. What do you think we should do with our leftover food? 3. When in certain circumstances and conditions, you see someone who deliberately throws away food or does not finish the food they take themselves, would you reprimand that person? Why 4. Based on your knowledge and information obtained from social media, what are the impacts of food waste? Please name three impacts
3.	Students' expectations and involvement in reducing food waste	1. What do you expect from yourself regarding the condition of food waste in Indonesia? 2. Are you willing to be involved in reducing food waste? Why?

Data collection in this study was conducted using several techniques, namely: 1) Observations were conducted during the chemistry learning process using the "a plate of food" media. The purpose of these observations was to directly observe student behavior, attitudes, and engagement that reflected environmentally conscious character during the

learning activities. 2) Interviews; semi-structured interviews were conducted with several students and chemistry teachers. The interviews aimed to obtain in-depth information regarding students' views, experiences, and responses to the use of learning media and perceived changes in environmental attitudes. 3) Questionnaire; a questionnaire was used as supporting data to describe students' environmental attitudes after participating in the learning process. The questionnaire was structured in the form of statements related to environmental behavior and attitudes in the context of chemistry learning. 4) documentation; was used to supplement the research data, including photographs of learning activities, teacher notes, and learning materials used during the study.

Data analysis was conducted qualitatively using the following stages: 1) data reduction, which is the process of selecting, focusing on, and simplifying data obtained from observations, interviews, questionnaires, and documentation. 2) data presentation, which is organizing the data into a narrative description so that it is easy to understand and analyze. 3) conclusion drawing, which is formulating the meaning and findings of the research based on the analyzed data

Results and Discussion

Findings

At every level of education, schools should implement environmental stewardship. All students should show concern for the environment by improving the quality of the environment, raising awareness about the importance of caring for the environment, and trying to prevent damage. Education about caring for the environment is instilled from a young age in students so that they can manage natural resources wisely and feel responsible for the benefit of future generations. When the character becomes mentally strong and has concern for the environment, one's behavior in daily life will be based on this. The results obtained after the research was conducted will be discussed in accordance with the division of criteria made by the researcher as a data in Table 2.

Table 2. Participant responses per category

No	Category	Statement	Participant Respont
1	Food menu criteria that students want	1. What was the last meal you had today?	Based on the students' responses, the last foods consumed included rice with chicken, rice with egg, fried rice, bread with jam, fried noodles, sweet potatoes, spaghetti, sausages and nuggets, soup, and corn. These results indicate that the respondents have a diverse eating pattern, with a tendency to choose foods that are practical and easy to obtain. This finding provides a general overview of students' eating habits in daily life and reflects the need for a variety of foods that are tailored to individual preferences and time availability.
		2. Did you finish your last meal? Why?	The student's answer to this question was yes, and the reason for finishing the food was because it was nutritious, delicious, and appreciated Mom's cooking. From the answers given by the students, it can be concluded that the factors that influence students' habits in finishing their meals involve a combination of physical needs (hunger and nutrition) and emotional aspects (good taste and appreciation of parents' cooking). Taste, nutritional value, and gratitude towards the person who cooked

			are interconnected elements in students' eating habits. It also shows that eating habits are not only influenced by physical factors but also by emotional and social aspects that enrich their eating experience
		3. In general, people choose food based on its taste. How do you choose your food?	In response to this question, researchers obtained varied responses. A total of 88% of students stated that their food choices were influenced by various considerations, including mood, taste, flavor, food appearance, nutritional content, texture, price, and calorie content. Based on these findings, it can be concluded that students' decisions in choosing food are influenced by a combination of various factors. Taste is no longer the only major consideration, but is also influenced by emotional, visual, and practical aspects. In addition, awareness of nutritional value and food texture characteristics also plays a role in the decision-making process. These findings show that food selection is a complex process, which is not only based on taste preferences, but also involves considerations of health, aesthetics, and personal circumstances. Thus, individual eating patterns are greatly influenced by habits, personal preferences, and various social and emotional factors
		4. Based on your experience, what kind of food makes you (happy) to finish your meal?	Food that tastes good, suits individual tastes, looks appealing, is a favorite, and is beneficial to health is the answer given by students to this question. Based on these responses, it can be concluded that students' happiness in consuming food is not only influenced by taste, but also by emotional and health factors. Food that is delicious, suits individual preferences, has an appealing appearance, is a favorite, and provides health benefits are the main factors that cause feelings of pleasure when eating. Therefore, an enjoyable eating experience for students involves a combination of physical factors, such as taste, appearance, and nutritional value, as well as emotional factors, such as personal taste and attachment to favorite foods. These findings indicate that food not only serves to fulfill physiological needs, but also plays a role in providing emotional satisfaction that contributes to the overall quality of the eating experience
2	Student responses on food waste	1. In your opinion, should we waste food? Why? Please explain briefly!	From the 54 students as respondents, there were 10 students who answered that it was okay to throw away food if the food was not good, not worth eating, not tasty, and not to taste. While the rest of the respondents answered that it is not allowed on the grounds that it can damage the environment, they must appreciate food and be grateful because they can still eat, and there are many out there who cannot eat. From the results of students' answers, it can be concluded

		that the majority of students think that throwing away food should not be done. They emphasized the importance of appreciating food, being grateful for what is available, and being aware of the negative impacts that food wastage can have, both environmentally and socially. Although a small number of students thought it was acceptable to throw food away if it was not tasty or not to their taste, the more dominant view was not to waste food and to be wiser in managing food consumption. This shows the importance of being aware of the value of food and how we should treat food more responsibly
2.	What do you think we should do with our leftover food?	According to the students, leftover food can be thrown away, left alone, given to pets, or stored and eaten again; it should be spent, and some suggested reprocessing. Based on the answers above, the best thing to do is to reprocess the leftovers or store them for another meal. This not only reduces food wastage but also provides economic and environmental sustainability benefits. Throwing away leftover food should be avoided as much as possible, as apart from harming ourselves, it also has an impact on the environment. Therefore, it is important for us to be wiser in managing our food, whether by reprocessing, storing, or feeding it to our pets, in order to reduce waste and support sustainability
3.	When in certain circumstances and conditions, you see someone who deliberately throws away food or does not finish the food they take themselves, would you reprimand that person? Why?	Students' response to this question is that they tend to say no. The reason is because they think it is not their business, they do not know the person, and they do not care. The reasons are because, according to the students, it is none of their business; they do not know the person, they do not care, they are too lazy to reprimand, they do not dare, they do not want to get into trouble with others, and they let it be the person's personal business until he/she is aware of his/her own behavior. Students' responses to this situation show a tendency to avoid intervention, although in some contexts, reprimanding can be a good action to raise social and ethical awareness. However, barriers such as not wanting to get involved, fear of conflict, or not feeling it is personal often prevent one from taking such action
4.	Based on your knowledge and information obtained from social media, what are the impacts of food waste? Please name three impacts	Food scarcity, environmental pollution, global warming, disease, waste generation, and pollution are students' answers to some of the impacts of food waste. The impacts of food waste are very diverse, ranging from food scarcity to environmental and health impacts. Reducing food waste is not just about saving resources; it is also about preserving the environment and ensuring prosperity for future generations

3	Students' expectations and involvement in reducing food waste	1. What do you expect from yourself regarding the condition of food waste in Indonesia?	The student expectations obtained by the researcher on this statement are that food waste will be reduced and the community will be educated and more aware and wise about the negative impacts of food waste. Students' hopes to reduce food waste in Indonesia reflect a desire to create greater positive change in terms of resource management, the environment, and social welfare. Educating the public and raising awareness is an important step towards achieving this goal. By reducing food waste, Indonesia can take further steps towards sustainability and create a more positive impact on the environment and global food security
		2. Are you willing to be involved in reducing food waste? Why?	Yes, I am willing is the answer that the researcher got from the respondents, arguing that food waste reduction is an action that should be done consciously because of its far-reaching impact on the environment, society, and the economy. As a human being, getting involved in food waste reduction is a good step towards a more sustainable future

Discusion

This study aimed to explore how the application of "a plate of food" as a learning medium in chemistry education contributes to the development of students' environmental care character, particularly in relation to food waste awareness. The discussion interprets the research findings by linking them to relevant theories of contextual learning, character education, and environmental education.

Contextual Chemistry Learning and Student Engagement

The findings indicate that the use of "a plate of food" successfully created a more contextual and meaningful chemistry learning experience. By connecting chemical concepts to students' daily experiences with food consumption, students became more actively involved in classroom discussions and reflective activities. This supports the principles of context-based learning, which emphasize that students learn more effectively when scientific concepts are presented within real-life situations that are familiar and relevant to them. Increased engagement observed during the learning process suggests that contextual learning media can bridge the gap between abstract chemical concepts and practical environmental issues. These findings are consistent with the study by Sari (2025), which states that innovative learning approaches, particularly those supported by technology-based learning media, can improve teaching effectiveness, increase students' learning motivation, and strengthen their understanding, ultimately contributing to better academic achievement.

Development of Environmental Care Character through Food Waste Awareness

The research results show a positive shift in students' attitudes toward food waste after participating in the learning activity. Students demonstrated an increased awareness that food waste is not merely a personal habit but a broader environmental issue with ecological, economic, and social consequences. Students' ability to articulate the impacts of food waste, such as increased landfill accumulation, environmental pollution, and reduced resources, indicates growing environmental literacy. This finding aligns with character education theory, which states that moral knowledge, moral feelings, and moral actions are interconnected stages in character formation (Chowdhury, 2018; Purwaningsih, 2024).

Students' Responses as Indicators of Attitudinal Change

Analysis of student responses to open-ended questions revealed that the majority of students believe food should not be wasted and are willing to take action, such as finishing their meals, sharing leftovers, or reminding others not to throw away food. These responses indicate an internalization of the value of environmental care, not merely compliance with classroom rules. The willingness to politely correct others and the desire to participate in food waste reduction efforts reflect the emergence of a sense of responsibility and social awareness, two key components of an environmentally conscious character. This process of internalizing values is also consistent with the findings of Rizal (2023) research, which showed that students' discipline character develops through treatment such as class agreements, instructor control, and discipline enforcement. This indicates that the students' display of disciplined behavior and environmental concern is a result of internalizing values when those values have become part of their self-identity and are reflected in time management, adherence to rules, and academic discipline.

Chemistry Education and Socioscientific Issues

Integrating the issue of food waste as a socioscientific issue in chemistry learning helps students understand the relevance of chemistry to environmental sustainability. Through discussions about food composition, chemical processes in food processing, and waste management, students are able to connect chemical knowledge with real-world environmental challenges. This finding aligns with previous research showing that socioscientific issues-based learning not only improves conceptual understanding but also develops students' ethical reasoning and decision-making abilities related to environmental issues (Nursyada et al., 2025). This approach also contributes to building social and environmental awareness, supporting scientific literacy, and developing 21st-century skills by helping learners understand scientific concepts more deeply and in a way that is relevant to everyday life. A scientifically literate individual is one who possesses the knowledge, skills, attitudes, perspectives, and values that are collectively needed by students (Rohmaya, 2022).

Implications for Chemistry Education Practice

The findings of this study suggest that chemistry education can play a significant role in character education when supported by appropriate learning media. Character education in chemistry learning is used to help achieve the goals of national education (Astari, 2018). The use of "a plate of food" demonstrates that simple, context-rich media can encourage students to reflect on their daily behaviors and their environmental impact. For chemistry teachers, this implies the importance of designing learning experiences that integrate chemical concepts with environmental and sustainability issues, thereby fostering both cognitive and affective learning outcomes. This aligns with Zuin (2021) research, which states that chemistry education is positioned as a strategic foundation for shaping a more sustainable society and economy through holistic, collaborative, and contextual education.

Comparison with Previous Research

The findings of this study are consistent with previous research emphasizing the effectiveness of contextual and environmental-based learning in science education. The learning medium, A Plate of Food, promotes learning achievement by reducing students' anxiety toward chemistry, improving their well-being, and connecting them with their surroundings (Simanjuntak et al., 2023). This finding aligns with several studies reporting that integrating real-life contexts into chemistry learning can enhance students' engagement and environmental awareness. Sevian et al. (2018) found that context-based

chemistry learning helps students connect abstract chemical concepts with everyday phenomena, leading to deeper understanding and more meaningful learning experiences. Similarly, King et al. (2012) reported that context-rich science instruction promotes students' ability to relate scientific knowledge to real-world environmental issues.

In terms of character and environmental education, the results of this study align with Macintyre et al. (2024), who emphasized that effective environmental education should not only increase knowledge but also foster attitudes and behaviors that support sustainability. The students' increased awareness of food waste and their willingness to take action reflect the stages of character development described by Andayani et al. (2025), which include moral knowing, moral feeling, and moral action. This suggests that the use of a plate of food successfully facilitated the internalization of environmental care values, similar to outcomes reported in earlier character education studies.

Furthermore, this study supports research on socioscientific issue–based learning. Hazari et al. (2013) demonstrated that learning activities centered on socioscientific issues, such as environmental and sustainability problems, can enhance students' moral reasoning and decision-making skills. In line with sadler's findings, students in this study were able to articulate the environmental impacts of food waste and express a commitment to reducing it, indicating the development of both cognitive and affective learning outcomes. Compared to previous studies that primarily employed quantitative or quasi-experimental designs, this research contributes additional insight through a descriptive qualitative approach. By analyzing students' open-ended responses, observations, and interviews, this study provides a more nuanced understanding of how environmental care character develops through chemistry learning. This qualitative depth complements earlier findings and highlights the value of qualitative methods in character and environmental education research. Overall, this discussion highlights that the application of a plate of food as a learning medium in chemistry education is effective in promoting students' environmental care character and is consistent with, as well as supportive of, existing research in contextual learning, environmental education, and character development.

Conclusion

This study concludes that the use of "a plate of food" as a learning medium in chemistry education helps improve students' environmental care character. By connecting chemistry concepts with daily issues related to food and food waste, students were able to better understand the relationship between chemistry and environmental problems. The findings show that students developed greater awareness of food waste, showed more responsible attitudes toward managing food, and expressed willingness to participate in efforts to reduce food waste. Learning activities using real-life contexts encouraged students to be more active, reflective, and engaged during chemistry lessons. In summary, "a plate of food" is a simple and effective learning medium that supports chemistry learning while fostering students' environmental awareness and responsible behavior.

References

Aini, M.H., Rachmadiarti, F., Muji, D., & Prastiwi, S. (2014). Mastery of environmental concepts and environmental care attitudes of Adiwiyata Mandiri senior high school students in Mojokerto Regency. Berkala Ilmiah Pendidikan Biologi (BioEdu), 3(3). https://ejournal.unesa.ac.id/index.php/bioedu/article/view/9573

Amelia, S., Rahayu, A., & Salamah, S. (2019). Counseling and training on utilizing inorganic and organic waste into ecobricks and liquid organic fertilizer. Jurnal Pemberdayaan: Publikasi Hasil Pengabdian Kepada Masyarakat, 3(3), 341–348. https://doi.org/10.12928/jp.v3i3.1132

Andayani, D., Nurmalia, L., Kurniawan, B.A., & Cukarso, S.H.I. (2025). Student Character Transformation Through P5: A Study in Elementary School. Journal of Innovation and Research in Primary Education, 4(2), 72-85. https://doi.org/10.56916/jirpe.v4i2.1194

Anggraini, V. (2017). Improving students' awareness of the school environment through the Adiwiyata program at MIN Bogem Sampung Ponorogo (Undergraduate thesis). IAIN Ponorogo. https://etheses.iainponorogo.ac.id/1899/1/Vera%20Duwi%20Anggraini.pdf

Arisona, R. D. (2022). 3R (Reduce, Reuse, Recycle) waste management in social studies learning to foster environmental care character. Al Ulya: Jurnal Pendidikan Islam, 3(1), 39–51. https://doi.org/10.32665/ulya.v3i1.693

Astari, J.I.R. (2018). Optimizing character education in effective and efficient chemistry learning through interactive media. J-PEK (Jurnal Pembelajaran Kimia). https://doi.org/10.17977/um026v3i12018p024

Chen, Y., Pinegar, L., Immonen, J., & Powell, K.M. (2023). Conversion of food waste to renewable energy: A techno-economic and environmental assessment. Journal of Cleaner Production, 385, 135741. https://doi.org/10.1016/j.jclepro.2022.135741

Chowdhury, M. (2018). Emphasizing morals, values, ethics, and character education in science education and science teaching. Mojes: Malaysian Online Journal of Educational Sciences, 4(2), 1–16. https://research.monash.edu/en/publications/emphasizing-morals-values-ethics-and-character-education-in-scien/

Fadlillah, U., Ngabekti, S., & Lisdiana, L. (2018). The role of Adiwiyata schools in developing environmental care character (A case study at Junior High School 6 Tuban). Journal of Innovative Science Education, 7(1), 53–61. https://journal.unnes.ac.id/sju/jise/article/view/23381

Hasanah, U., & Afianah, V. N. (2021). Infographic media as an effort to improve environmental care character among Generation Z. Primary: Jurnal Pendidikan Guru Sekolah Dasar, 10(6). https://doi.org/10.33578/jpfkip.v10i6.8420

Hazari, Z., Sadler, P. M., & Sonnert, G. (2013). The science identity of college students: Exploring the intersection of gender, race, and ethnicity. Journal of College Science Teaching, 42(5), 82–91.

Kasri, M. A., Novan, Y., & Ramadhani, I. A. (2021). Implementation of the design thinking model in developing learning media based on Macromedia Flash. Jurnal PETISI (Pendidikan Teknologi Informasi), 2(2), 60–71. https://e-journal.unimudasorong.ac.id/index.php/jurnalpetisi/article/view/800

King, D. (2012). Learning science through real-world contexts. In S. R. (Ed.), Second international handbook of science education (pp. 69–79). Springer. https://doi.org/10.1007/978-1-4020-9041-7_6

Latief, J., Hamzah, B., Mahpudz, A., & Khaldun, R. I. (2019). The role of the local government of Palu City in the development of the Adiwiyata program. International Journal of Environmental & Science Education, 14(9), 563–569. http://www.ijese.net/makale_indir/IJESE_2145_article_5dba754a50f43.pdf

Macintyre, T., Tilbury, D., & Wals, A. (2024). Education and learning for sustainable futures: 50 years of learning for environment and change. Taylor & Francis. https://doi.org/10.4324/9781003467007

Masturoh, M., & Ridlo, S. (2020). Building environmental care character among students at Sekolah Indonesia Kota Kinabalu (SIKK), Malaysia. Journal of Biology Education, 9(2), 193–201. https://journal.unnes.ac.id/sju/ujbe/article/view/39522

Nurfadhillah, S., Ningsih, D.A., Ramadhania, P.R., & Sifa, U.N. (2021). The role of instructional media in increasing students' learning interest at SD Negeri Kohod III. Pensa, 3(2), 243–255. https://doi.org/10.36088/pensa.v3i2.1338

Nursyada, A.P., Fadilah, S.N., Auranazwa, K., Wangi, R.R.P.L., Hidayat, N.P., Ramadhani, N., & Usman, U. (2025). Socioscientific-based curriculum in biology learning. Innovative: Journal of Social Science Research, 5(3), 6303–6321. https://doi.org/10.31004/innovative.v5i3.19734

Oktarina, E., & Nisa, A. F. (2021). Development of an environmental care-based curriculum to improve character education in elementary schools. JHSS (Journal of Humanities and Social Studies), 5(2), 126–130. https://doi.org/10.33751/jhss.v5i2.3713

Pane, M. M., & Patriana, R. (2016). The significance of environmental content in character education for quality of life. Procedia – Social and Behavioral Sciences, 222, 244–252. https://doi.org/10.1016/j.sbspro.2016.05.153

Purwaningsih, E. (2024). The role of metacognition in character education: A case study on students' moral and ethical formation strategies. Society, 12(1), 1–13. https://doi.org/10.33019/society.v12i1.617

Purwanti, D. (2017). Environmental care character education and its implementation. Dwija Cendekia: Jurnal Riset Pedagogik, 1(2). https://doi.org/10.20961/jdc.v1i2.17622

Rijal, A., Affandi, I., Kosasih, A., & Somad, M. A. (2023). Internalization model of discipline character values to foster a positive culture in the school environment. JPI (Jurnal Pendidikan Indonesia), 12(3), 408–417. https://doi.org/10.23887/jpi-undiksha.v12i3.60130

Rohmaya, N. (2022). Improving students' scientific literacy through socioscientific issues (SSI)-based science learning. Jurnal Pendidikan MIPA, 12(2), 107–117. https://doi.org/10.37630/jpm.v12i2.5

Sari, A., Yadi, F., & Gulo, F. (2025). Bridging gaps in chemistry instruction: Analyzing the need for interactive learning media at senior high schools in Sungai Pinang District. AL-ISHLAH: Jurnal Pendidikan, 17(1), 771–783. https://doi.org/10.35445/alishlah.v17i1.6089

Setiawati, M. Z., & Rahmawati, A. F. (2019). The role of teachers in using interactive multimedia in the Industrial Revolution 4.0 era. Proceedings of the National Seminar of the Graduate Program, Universitas PGRI Palembang. https://jurnal.univpgri-palembang.ac.id/index.php/Prosidingpps/article/view/2640

Sevian, H., Hugi-Cleary, D., Ngai, C., Wanjiku, F., & Baldoria, J. M. (2018). Comparison of learning in two context-based university chemistry classes. International Journal of Science Education, 40(10), 1239–1262. https://doi.org/10.1080/09500693.2018.1470353

Simanjuntak, F. (2020). Food chemistry. Universitas Kristen Indonesia. http://repository.uki.ac.id/3451/1/BukuKimiaBahanMakanan.pdf

Simanjuntak, F. N., Utomo, S. W., Sika Ery Seda, F. S., Budhi Soesilo, T. E., & Sumiyati, S. (2023). Learning Chemistry, Connecting Ecological Citizenship and Environmental Sustainability:"A Plate of Food" as a Learning Medium. ECNU Review of Education, 20965311231179737. https://doi.org/10.1177/20965311231179737

Sudjana, D., & Wijayanti, I. E. (2018). Analysis of metacognitive skills on solubility and solubility product constant material through a problem-solving learning model. EduChemia (Jurnal Kimia dan Pendidikan), 3(2), 206–221. http://dx.doi.org/10.30870/educhemia.v3i2.3729

Wardani, D. N. K. (2020). Analysis of the implementation of the Adiwiyata program in building environmental care character. Southeast Asian Journal of Islamic Education Management, 1(1), 60–73. https://doi.org/10.21154/sajiem.v1i1.6

Zuin, V. G., Eilks, I., Elschami, M., & Kümmerer, K. (2021). Education in green chemistry and in sustainable chemistry: Perspectives towards sustainability. Green Chemistry, 23(4), 1594–1608. https://doi.org/10.1039/D0GC03313H