OPISA Booklet with QR Code Technology: Promoting Green Community Education for Sustainable Waste Management

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ARTICLE INFO

ABSTRACT

Despite the increasing environmental challenges, public awareness of proper waste management, particularly in Indonesia, remains low. This research aims to develop and evaluate the effectiveness of a QR code-based waste sorting booklet to promote practical waste management practices in households and educational institutions. The research method used is development research with the Plomp development model. A one-group pretest-posttest design is used in the study. Forty elementary school pupils from Palaan Village and Karangsari Village served as the research subjects. Initial information on the state of waste management in the neighborhood was gathered through observation and interview tools. Survey tools were employed to gauge how the community and pupils responded to the booklet's use and the degree of green community that had been established following the implementation of the waste management strategies it suggested. As a result of the research, booklets (OPISA) based on QR Code Technology were created to achieve green community education that is both legitimate and useful. These booklets have a 95% validity rating from material professionals and media experts with extremely good standards. In the meantime, the booklet has a medium level of efficacy in achieving a green community, as indicated by the moderate criteria's N-gain value of 0.44 for green community education. In the meantime, 85% of participants who responded to the booklet's use met the very good criteria, according to user response statistics. In order to raise public awareness of the significance of properly processing waste and creating a clean and healthy environment, the study's conclusion explains how the OPISA booklet can assist the community, particularly in educational institutions, in implementing practical and efficient waste management. It can also help to expand the green community in the school environment.

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1. INTRODUCTION

The rapid advancement of science and technology in contemporary times has significantly enhanced human convenience and quality of life, contributing to improved economic conditions, evolving lifestyles, and overall well-being. However, these developments often come at the expense of the natural environment, leading to ecological degradation. Human activities such as road construction, urban expansion, recreational pursuits, deforestation, and emissions contributing to the greenhouse effect are major factors accelerating environmental deterioration (Suryani et al., 2019). This environmental decline exacerbates climate change, posing severe threats to the survival of various species, including plants and animals, and jeopardizing the delicate balance of ecosystems.

Among the many challenges facing the environment today, improper waste management stands out as a significant issue that contributes to pollution, public health risks, and ecosystem degradation. The rate of population increase has an impact on the rate of increase in the amount of waste that occurs in all levels of society. The resulting impact can affect the health and cleanliness of the environment. Waste generated can be organic or inorganic, originating from households, food industries, school environments, and other public places. Most of the waste is in the form of plastic waste, food packaging, plastic bottles, food waste, and so on. In Indonesia, this issue is particularly pressing. According to the National Waste Management Information System (SIPSN), as of 2021, the country generates approximately 23.7 million tons of waste annually, with over 9 million tons remaining unmanaged, contributing significantly to environmental hazards (Ministry of Environment and Forestry, 2021).

The SIPSN platform's 2021 statistics indicate that the waste pile is still growing and that many of the materials have not yet been turned into a product, useful item, or anything with market worth. Another reality is that a large number of people are still ignorant about how to manage both organic and inorganic trash, which harms the environment, sanitation, human health, and other aspects of life. This is consistent with the view of Megah et al. (2018), who claim that waste or occasionally generated waste increases with human activity.

Improving environmental quality cannot be separated from the behavior of the community to have a sense of responsibility and self-awareness of environmental sustainability (Tri et al., 2016). There are several factors that play an important role in shaping individual personality, namely skills, knowledge. There are five variables that influence the personality factors, namely skills, strategic knowledge, locus of control, habits (attitudes), and personal responses.

Based on the results of interviews with community members both in schools and households in Palaan Village and Karangsari Village, most schools have not processed the waste produced every day. Food waste will usually be burned, or the cleaning staff will have to wait for the waste to be transported. Some residents collect waste that can be resold such as plastic bottles, cardboard, paper, and rarely anyone utilizes organic and inorganic waste to be reprocessed as more economically valuable products. This is because there is no practical guidance for the community to manage these wastes into valuable products. In addition, several school environments in Palaan Village and Karangsari Village have not yet implemented waste management for school residents.

Since environmental degradation results in a decline in human life quality within the framework of ecological reliance between humans and the environment, prompt action on environmental care is necessary. Nevertheless, there isn't a single practical way to solve environmental sustainability problems and preserve the ecosystem. Technology development, recovery, or mitigation alone will not address today's environmental challenges (Hutcheson et al., 2018) Rather, multiple activities are required. Education about the environment is one of the many possibilities. Human change is stimulated by education. It is anticipated that environmental education would make people aware of the fundamental requirements for a harmonious connection between humans and nature and the creation of a healthy global ecosystem.

Waste is a challenging issue to address because of the general lack of knowledge and instruction on trash management. People frequently handle their waste in practical but improper ways without considering the additional pollution implications of these practices. In order to learn how to manage

garbage properly and efficiently, the community and educational institutions want a handbook that can present waste management techniques. A booklet on trash management is one example of such a guidance.

Booklets are tools or media, means, and supporting resources to convey messages must adjust to the content of the material to be conveyed. The information in the booklet is written in concise language, and is intended to be easily understood in a short time. Booklets are also intended to attract attention, and are printed on good paper in an effort to build a good image of the services provided (Sadiman, 2009). Through the booklet media containing content about waste management, it is hoped that the community will increasingly understand the importance of awareness in protecting the environment from pollution. Waste management booklets incorporated into elementary school curricula are another attempt to raise environmental consciousness at a young age. If positive behaviors are consistently practiced, students will grow accustomed to taking responsibility for their own waste and will lead healthier lives in the future.

This booklet on waste management will be packaged in electronic form and can be accessed through a QR Code. QR Code is a cell-shaped matrix symbol arranged in the form of a box. QR Code consists of a functional pattern to facilitate reading and a data area where data is stored (Malik, 2010). The advantage of using this QR Code is that it makes it easier for people to access the booklet so they don't need to download the material file, but can directly get access by scanning the QR Code (Firmansyah & Hariyanto, 2019). This makes it easier for the community to access the booklet without having to download so that the smartphone memory does not fill up quickly. People only need to have a QRCode Barcode image to be able to scan and access and open booklet files anywhere and anytime. In addition, QR code technology is very suitable for use in learning because it allows quick access to additional information or materials. By scanning the QR Code, students can go directly to relevant videos, articles, or documents, making learning more interactive and interesting. In addition, QR Codes can save time, facilitate material distribution, and help students learn independently with digital resources that are available at any time.

Waste management instructions packaged in a QR code-based booklet can make it easier for people to access information about waste, so that people are expected to be more sensitive to the environment. A sustainable environment can be realized if people have an awareness of the existence of waste around them. The more people who are aware of the importance of environmental conservation, the easier it is to realize a green community.

A green community plays a crucial role in advancing non-formal environmental education. Ayu and Agustianand (2012) argue that environmental education is integral to addressing environmental degradation by cultivating a populace equipped to manage and sustain the environment effectively. These human resources encompass all segments of society, from children to adults, underscoring the universal nature of environmental education. Such education can be implemented formally, through structured school programs, as well as non-formally, through community interest groups and daily practices that encourage sustainable behaviors.

Environmental education shapes perceptions of the environment, influencing how it is managed and valued. Rather than relying on a top-down model where information flows solely from educators to learners, environmental education fosters a participatory, two-way communication approach, engaging individuals across all age groups in active learning and involvement. As Györek (2018) highlights, the evolution of environmental education emphasizes inclusive participation across formal and informal settings, reflecting a shift toward an interactive and communal learning paradigm. According to Morse (2017), effective environmental education provides essential knowledge about the natural world, its processes, and humanity's role in its preservation and sustainability. Programs dedicated to environmental education should promote sustainable policies and lifestyles, benefiting not only local communities but contributing to the well-being and progress of global society.

Environmental education is initiated by transforming how individuals perceive and engage with nature, offering benefits that extend beyond environmental stewardship into other dimensions of human life. It fosters ethical, environmental perspectives, civic responsibility, and the capacity for individual and collective action. Reflecting on these aspects, this research aims to develop an OPISA (Olah Pilah Sampah) booklet, enhanced with QR code technology, to streamline waste management education among students and the community. This initiative seeks to empower communities to address waste challenges effectively, fostering a green community ethos through accessible and practical educational tools.

2.   METHODS

The research design used in this study was development research using Plomp's (1997) development model. Plomp's development procedure can be seen in Figure 1. The Plomp model is suitable for this study because it provides a systematic framework in designing, developing, and evaluating learning devices or educational technologies. This model consists of three main phases: the initial investigation phase to analyze needs, the design and development phase to create the product, and the evaluation phase to assess the effectiveness of the product. In the context of this study, the Plomp model is in line with the objectives of the study, which focuses on the development of QR Code-based learning media, because this model helps ensure that the resulting product is not only relevant and practical, but also effective in improving students' learning experiences.
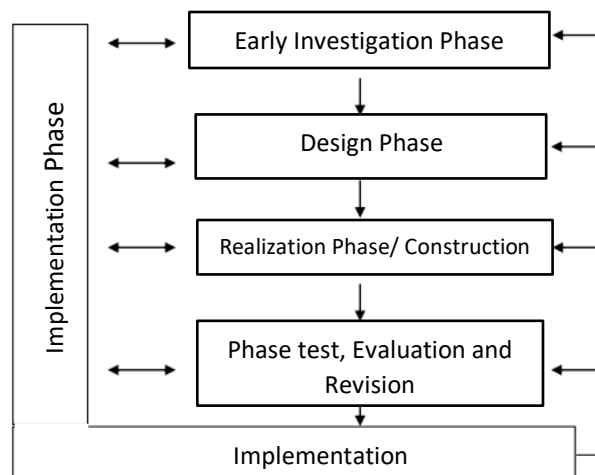
Figure 1: Plomp's Development Model (1997)

The main field trial design used a pre-experimental design design, namely a one-group pre-test-post-test design. The design can be seen from Figure 2. The figure usually shows a research flow with three main stages: pretest (O1), treatment (X), and posttest (O2). This figure shows that the same group is measured twice: once before the treatment and once after.
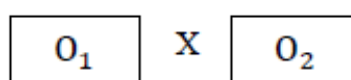
Figure 2. One-group pretest-postest design (Sugiyono, 2012)

The sample selection was carried out using a random sampling technique. The subjects of this research trial were 40 school residents, consisting of 20 elementary school students in grade V and 20 junior high school students in grade VII. In the small group trials, they were divided into 2 groups: 6

elementary school students and 6 junior high school students. In the product implementation, 14 elementary school students and 14 junior high school students were involved.

The data collection techniques used were interviews, questionnaires, and observations. Data collection instruments include interview sheets, questionnaire sheets, and observation sheets. Data collection instruments are divided into three parts: preliminary study instruments, product development instruments, and product trial instruments. Preliminary study instruments include interview sheets and descriptive learning observation sheets. The product development instrument is a product validation sheet. Product trial instruments are, questionnaire grids and green community questionnaire sheets.

The purpose of this interview is to investigate students' knowledge and experiences about waste management practices used in schools. In order to get firsthand feedback on the benefits, drawbacks, and effects of the OPISA booklet with QR code on their learning process, interviews were also done following the treathment. The purpose of the questionnaire was to gauge how instructors and students felt about the green community that has been established in schools. The questionnaire's questions address topics such as waste management practices, encouraging environmental greening, and having a caring attitude toward the environment. The product's validity is assessed using the questionnaire tool. Using the OPISA booklet with QR Code, observations were made throughout the learning process in order to directly see how students responded to and interacted with the media. How students use the booklet, whether they can readily access the content, and how much the QR Code-based booklet encourages active engagement

The percentage calculation used to process data obtained through validation sheets and questionnaires in the form of a percentage of each subject with the formula:

$$P = \frac{\sum x_i}{\sum x} \; x \; 100 \; \%$$

Description:
P = Percentage of assessment
$\sum x_i$ = Number of answers from validators/test subjects
$\sum x$ = Number of highest answers (Sugiono, 2012)
Furthermore, to calculate the overall percentage of subjects/components, the formula is used:
$$P = \frac{\sum p}{n}$$

Description:
P = Percentage of assessment
$\sum p$ = total percentage of all components
n = number of components
The results of the calculation of the percentage of all components in order to provide meaning and decision-making are used the provisions contained in Table 2. The expert criteria for the validation measurement findings are explained in Table 2. Whether or not the criterion table has to be updated, the numbers from the validation sheet will be converted to a percentage, and the results will be compared with them.

Table 2. Criteria for Module Feasibility Based on Percentage Calculation

Feasibility Level (%)	Qualification	Description
81-100	Very Good	No revision needed
61-80	Good	Revised
41-60	Enough	Revised
21-40	Less good	Revised
0-20	Very poor	Revised

Suwastono (2011)

A gain score can be used to determine how well the OPISA booklet increased attitudes and behaviors in the green community. The following formula is used for the calculation, and Table 3 adjusts the findings. The booklet's high and low efficacy levels in fostering a greener community among students are explained in Table 3.

Table 3. Criteria for improvement

Quantitative Score	Qualitative Score
$(\langle g \rangle) > 0{,}7$	High
$0{,}7 \geq (\langle g \rangle) \geq 0{,}3$	Medium
$(\langle g \rangle) < 0{,}3$	Low

3.   FINDINGS AND DISCUSSION

This research and development uses five steps of product development. It aims to produce a development product, namely the QR code-based OPISA (Olah Pilah Sampah) booklet to realize green community education in Palaan Village. This development product has been validated by media experts, and material experts and the results of product trials (small groups), and usage trials (large groups).

3.1 Initial Investigation

The development of this booklet has taken the first step in the form of an initial investigation by identifying problems and collecting information which is then analyzed based on the needs and uses to realize green community education for residents in Palaan Village. The following are the steps taken in the initial development of the QR Code-based OPISA (Olah Pilah Sampah) booklet product to realize green community education in Palaan Village.

The initial investigation was carried out by field observations (survey and observation), this stage was carried out by interviewing and observing residents in Palaan Village including PKK mothers and school residents.

The results of observations made in the field are about waste processing in Palaan Village. Waste management in Palaan Village already has its own waste bank. This waste bank is driven by several PKK administrators, but it is still not running effectively. Some residents also still have little knowledge in various waste management techniques. Residents also have difficulty applying waste processing techniques because there are no written instructions that are systematically organized regarding various kinds of processing. There is a lot of information from the internet, but because there are too many techniques described, residents become confused.

In the school environment, waste management has not been applied, so there is no specific waste management practice in schools in Palaan Village. Students have not been accustomed to processing and sorting waste. School residents also do not have specific instructions on various waste management techniques, so a media outlet is needed that can provide knowledge about waste management and package it in an attractive and practical way.

3.2 Product Development and Validation

The product developed in the form of an OPISA booklet to realize green community education in Palaan Village has been described through a storyboard. This development product is also equipped with instructions for using the media, along with a QR code to access the booklet. The storyboard that has been made is used as reference material for making the product.

This realization stage is the final process of making media. The steps that must be taken in making this OPISA booklet are entering the Canva application, preparing material in the word various kinds of waste processing techniques, and entering the material into the Canva application, then designing the material entered by adding various kinds of photos about waste processing so that the booklet is more interesting. The next step is to download the finished booklet through the Canva application and enter it into the QR code application. The QR Code-based OPISA booklet for realizing

green community education in Palaan Village can be accessed through the QR-code listed in Figure 2 below.

Validation was conducted by media experts and material experts, as well as validators of media-making practitioners and environmental practitioners. Media expert validation was carried out by Media Making Practitioners as an IT teacher. The research data uses a Likert scale with a scale of 1 to 4. The score obtained from the media expert validation obtained 95% categorized as valid without revision. Feedback and suggestions for improvement are described in the comments and suggestions column. Media expert validation measurements are carried out using a valid validation questionnaire instrument. Media expert validation includes the appearance, attractiveness, ease of access, color and font composition, and instructions for using the booklet. The percentage results obtained indicate that the booklet is suitable for use

Figure 3. QR-Code Access
OPISA Booklet
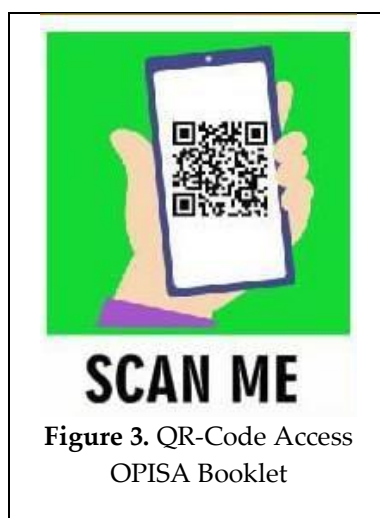
Material expert validation was carried out by environmental practitioners at the Abadi Lestari Waste Bank. The research data uses a Likert scale with a scale of 1 to 4. The score obtained from the material expert validation obtained 95%, categorized as valid without revision. As revisions based on comments and suggestions from material experts as improvements to the media developed.

Environmental Parktisi carried out expert validation of the green community instrument. The research data uses a Likert scale of 1 to 4. The green community questionnaire indicators can be seen in Table 4. The score obtained from the expert validation of the green community instrument was 93%, categorized as valid without revision. As revisions based on comments and suggestions from material experts as improvements to the instruments developed. A valid material expert validation questionnaire tool was used to conduct material expert validation measures. The content, booklet appropriateness with green community indicators, completeness, language use, and presentation of the material are all covered in the material expert's validation. The booklet is suitable for use, according to the findings of the percentage of validation of the material expert received

3.3 Small Group Testing

The results of the User response questionnaire in the small group field trial can be seen from the total score with an average of 95, so it can be categorized as "Very Good". Based on the scores obtained from school residents, it can be concluded that the QR code-based OPISA booklet is suitable for use. This stage focuses on usability testing. In small groups, researchers observed how students accessed and used the OPISA Booklet with QR Code, including the ease of scanning the code, obtaining relevant information, and understanding the learning materials. Feedback from this testing helped identify early improvements, such as the technical use of the QR Code or the clarity of the material presented. The development of the QR code-based OPISA Booklet to realize green community education has gone

through the validation steps of media experts, material experts, and green community instrument experts before being tested for use. Based on the validation results from the experts, there were suggestions for revising the developed product. The results of the revision are as follows.

Table 4. Green Community Education Questionnaire Indicators Table

Indicators	Questions
Caring attitude towards the Environment	1. I often throw garbage in the river because it is more practical 2. I always keep my trash in a bag if I can't find a trash can in a public place. 3. I do not reprimand if I see others littering/burning. 4. I try to reduce the use of plastic bags by bringing my own containers when shopping 5. I prefer to use environmentally friendly disinfectant products over chemical ones
Activities in managing waste	1. I like to sort waste at home to reduce environmental pollution. 2. I always mix food waste and plastic waste when throwing garbage away. 3. I don't understand how to process plastic waste and organic waste properly. 4. I often reuse single-use plastic containers to make more useful products (e.g. for flower vases, pots, or handicrafts). 5. I am active in waste bank or similar activities
Promoting greening of the environment	1. I like to encourage others to plant greenery around the house. 2. I am happy when people in my neighborhood work together in greening the environment. 3. I don't like activities related to waste management because it adds to my homework. 4. I like to encourage others to use plastic bags in their daily activities because they are more practical. 5. I am happy to invite others to sort and process waste with the aim of reducing environmental pollution.

Modification from Green Communities Practices Best, (2014)

3.4 Revisions Based on Feedback

Revision I was conducted based on feedback and recommendations from the validation assessments by media experts, content specialists, and questionnaire instrument experts. The revisions addressed the following key areas. A content specialist reviewed the material to enhance the quality of the booklet, providing suggestions to improve the developed media. One of the main recommendations was to include illustrations of eco-enzyme processing techniques to increase visual appeal and engagement. The revised version of the OPISA booklet, with updated images, is displayed in Figures 3 and 4, showcasing these enhancements.

Media expert validation is carried out by practitioners in the IT field media experts provide suggestions and comments regarding the instructions for using the booklet developed should be written information on how to use it. Improvements are needed to make it easier for others to access the booklet via QR code. Media revisions can be seen in Figures 5 and 6. The validation of the questionnaire instrument conducted by Mrs. Irma is to provide suggestions regarding the instructions for use and the allocation of processing time. Improvements are needed so that users do not feel difficult when filling out the questionnaire.
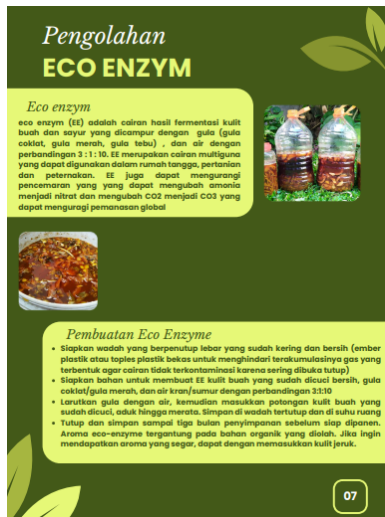
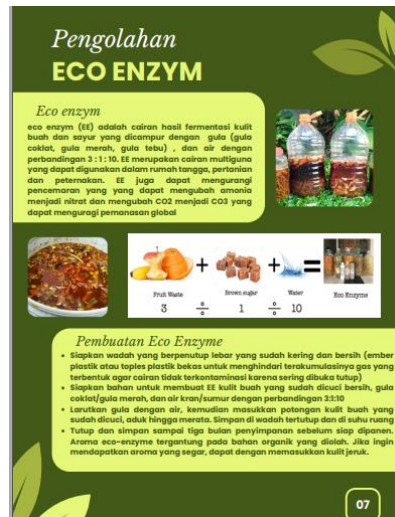**Figure 4.** Contents of the Booklet Before Revision.

Figure 5. Contents of the Booklet After Revision

3.5 Large Group Implementation

Implementation is carried out after making design improvements based on comments and suggestions obtained from material experts, media experts, and green community instrument experts. Evaluations and revisions were made referring to suggestions and comments from observations of small group trials, namely with the subjects of 12 students. The revisions made were that when reading the booklet that had been validated, there were several questions about waste that were not yet known processing techniques so they needed to be added to the contents of the booklet, such as processing broken glass can be used as handicrafts or can be exchanged at the waste bank. This QR Code-based OPISA booklet received a good response, namely that residents became more enthusiastic about sorting and processing waste into more valuable products and could increase the green community in the community.

**Figure 6.** Instructions before revision

Figure 7. Instructions for use after revision

Field implementation (large group) was conducted with 28 students as test subjects. The results at this implementation stage were obtained from the participants' green community questionnaire scores before and after the OPISA booklet implementation activities. The results of the calculation of the average pretest value of 75 while the average posttest value of 86 with an N-gain of 0.44 included

in the moderate category (Hake, 1999). Following treatment, the posttest results demonstrate the students' level of comprehension or mastery of the subject matter. In contrast to the pretest, the posttest in this study assesses how well the OPISA Booklet with QR Code enhances student learning. A high score on the posttest may indicate that the QR Code treatment was beneficial in improving pupils' comprehension. The OPISA Booklet with QR Code effectively increased knowledge at a moderate level, as indicated by the moderate criteria used to determine the N-gain value

The increase in the green community value can be seen in Figure 6. In addition, the results of the participants' responses after the implementation of the booklet product showed an average of 85 with "very good" criteria. Based on these results, it can be seen that the opisa booklet can be one of the media that supports the realization of green community education for Palaan Village residents.
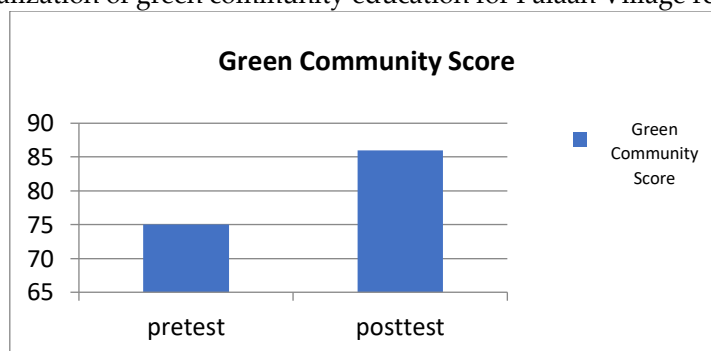
Figure 8. Diagram of Green Community Score Improvement Results

Discussion

The findings show that students' posttest results and N-gain scores increased significantly after using QR codes, which supports the research objective of improving understanding of green communities. Based on constructivism theory, students can be more engaged in the independent learning process when they have direct access to relevant information. QR codes not only increase this access but also allow students to see the connection between the material used in waste management and the real context around them. (Rikala & Kankaanranta, 2014) showed that QR codes can increase the accessibility of learning materials and help students learn more independently. This supports that technology-based education in the environment can encourage higher participation and awareness. These findings have implications for the importance of using simple technology in environmental education to strengthen students' green community education while providing a positive impact that has the potential to spread to society

The development of the OPISA booklet, integrated with QR-code technology, demonstrates its effectiveness in enhancing green community education in Palaan Village. The booklet provides new insights and knowledge, particularly to school communities, on various waste management techniques categorized at a medium level. By incorporating QR codes, the booklet ensures that this information is easily accessible and centralized, addressing previous challenges where waste management knowledge was fragmented and difficult to obtain. With QR code technology, students and community members can quickly access comprehensive waste management information via Android devices, enabling them to learn anytime and anywhere (Firmansyah & Hariyanto, 2019). These findings highlight the OPISA booklet's role in delivering up-to-date, easily accessible information aligned with a technology-based approach to environmental education, fostering the use of digital tools to enhance learning experiences and promote sustainable practices (Siemens, 2014).

By providing systematic information on waste management, the OPISA booklet can be a tool for students and communities to develop waste management projects in their communities. This increases understanding and encourages them to participate in environmental initiatives, in line with the principles of project-based learning. This study shows that environmental education programs designed to empower communities not only increase their knowledge but also encourage collective action for sustainability. The OPISA booklet can serve as an empowerment tool, increasing community

awareness and the ability to manage waste effectively. By providing knowledge to communities, the booklet has the potential to increase their awareness and involvement in waste management, making them agents of change in the community (Amri et al., 2024)

The waste management techniques packaged in this opisa booklet completely discuss various processing techniques for both organic and inorganic waste. With this booklet, people can find out in detail starting from the materials needed for waste processing and processing procedures. Various pictures in the booklet can also attract students to learn various waste processing techniques. The existence of this booklet aims to make students more aware of the importance of preserving the environment by sorting and processing waste first to reduce the amount of waste disposed of in landfills. For example, by processing fruit and vegetable waste into ecoenzymes that can be used as environmentally friendly disinfectants (Megah et al., 2018). The role of students is very important in realizing the green community, namely community groups who are aware of the introduction, understanding and understanding of environmental aspects in daily life, one of which is in overcoming environmental pollution (Wiweko et al., 2018). The 'green community' movement in various regions of the world has now begun to grow and develop along with the efforts of public and state awareness to solve the problems of environmental pollution, climate change to the formation of environmental awareness communities (Pawitro, 2015).

The development of this booklet is also expected to be able to foster the character of environmental care in students. Waste generated by school residents is not only the responsibility of janitors but also the responsibility of all school residents including teachers and students. The character of environmental care can be integrated into learning so that the learning experience gained by students increases and is accustomed to solving problems related to everyday life (Afriyeni, 2019). Based on the green community questionnaire given to students, the results showed that 88% of students expressed a caring attitude towards the environment, 85% carried out activities in managing waste, and 86% of students promoted environmental greening. The percentage achievement of each green community indicator can be seen in Figure 9.
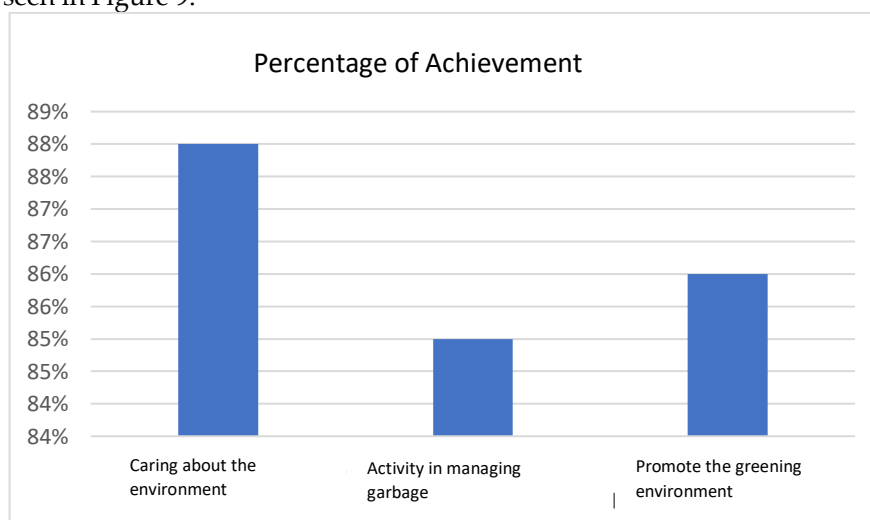
Figure 9. Percentage of achievement of each indicator of green community education

The OPISA booklet serves as a valuable supplement in fostering environmental stewardship among students in schools. Its accessible and practical content effectively enhances students' environmental awareness and knowledge (Darmoko, 2012). Cultivating environmental care in children encompasses developing two key attitudes: social environmental care and natural environmental care. Social environmental care involves actions and attitudes that reflect a willingness to provide both moral and material support to those in need, demonstrating sensitivity to surrounding conditions. Natural environmental care, on the other hand, manifests through behaviors aimed at protecting and restoring

the local environment, which supports sustainability (Ismail, 2021). Instilling these two dimensions of environmental care in children encourages an enduring sensitivity to both social and natural surroundings.

This study reveals that students in Palaan Village responded very positively to the implementation of the OPISA booklet. This is evidenced by the high scores in the questionnaire, reflecting their enthusiasm and improved understanding of the material. Although the village community has initiated a waste bank program, their familiarity with other waste management methods remains limited. The OPISA booklet significantly assists the community by providing accessible information on various effective waste management techniques, enhancing their capacity for sustainable practices.

Waste management is an important aspect in reducing environmental pollution. Therefore, the "green society" movement needs to be socialized more widely so that the community is increasingly aware of the responsibility to maintain environmental balance (Shang, 2019; Reviandani & Pertiwi, 2022). The younger generation also has a crucial role in maintaining environmental sustainability; awareness of being responsible for one's own waste is a fundamental first step (Yanti et al., 2023).

Sustainable waste management requires cooperation between the community, schools, and government to form an effective green society (Sholihah et al., 2022) It is hoped that the existence of this booklet will not only provide information, but also contribute to future generations to protect the earth as a place to live. It is also expected to train students' attitudes to care about the environment through waste recycling efforts for the survival of mankind (Salgiriev et al., 2023)

Although the results of the study show positive impacts, there are several limitations that need to be noted. First, this study was limited to the community of Palaan Village, so the findings may not be fully generalizable to other communities. Second, data collection was only done through questionnaires, which may not capture the full nuance or context of community experiences. These limitations suggest the need for a more in-depth approach, such as qualitative interviews, to better understand community perceptions and experiences related to waste management.

In the future, similar studies can be conducted in different locations to explore the effectiveness of the OPISA booklet across different social and cultural contexts. Longitudinal research is also recommended to assess the long-term impact of the use of this booklet on community knowledge and behavior in waste management. In addition, research can explore the use of other technologies, such as mobile applications, to increase community access and engagement in environmental education. With these steps, it is hoped that the development of the OPISA booklet can further support environmental conservation efforts and increase the "green community education" movement, especially for school residents and the community in Palaan Village.

4.   CONCLUSION

The development of the QR code-based Waste Sorting Booklet (OPISA) has been validated with a score of 95%, indicating its validity in education. The N-gain score of 0.44 indicates a moderate increase in participants' knowledge of waste management techniques, and the response score of 85% confirms the effectiveness of the booklet in promoting green community education. This booklet not only functions as an educational tool, but also as a means to encourage community involvement in environmental issues. In addition to its application in schools, the OPISA booklet can be adapted for other communities and training programs. This study opens up opportunities for further exploration of the long-term impacts of using this tool. Thus, this innovation is expected to increase community awareness and action in waste management, contribute to more sustainable environmental conservation, and strengthen collaboration between education, technology, and society.

It is recommended that interactive content in the OPISA booklet be developed by adding interesting elements, such as case studies, to increase its appeal. In addition, it is important to test the implementation of the booklet in various contexts, such as communities and non-governmental

organizations, to assess broader impacts. Long-term research is also needed to evaluate the effects of the booklet on community behavior in waste management. Furthermore, conducting training can help support the implementation of the booklet and increase community engagement. Finally, technology integration, such as mobile applications, can be explored to increase accessibility and engagement in environmental education.

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