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Implementing the OBE Model in Plastic Waste Management Using the 4R EPR Pattern for Green Campus

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ABSTRACT

For quite some time, Universitas Negeri Malang (UM) has paid much attention to waste management due to the rapidly increasing waste generated by campus activities, including from the offices, classes, canteens, and major events held by the university. The waste has caused issues related to environmental cleanliness and aesthetics. This research aims to 1) understand plastic waste management on the UM campus using the 4R pattern: reduce, reuse, recycle, and replace; 2) understand efforts to optimize plastic waste management on the campus through Extended Producer Responsibility (EPR); and 3) implement the OBE model with the 4R EPR pattern at UM to support the green campus initiative. This research used a mixed-method approach, combining quantitative and qualitative descriptive methods. Data were collected through observation, interviews, documentation, and actions related to plastic waste management on the UM campus. Results show that plastic waste management on the UM campus, using the 4R (reduce, reuse, recycle, and replace) pattern, has been conducted in collaboration with leaders, lecturers, groundskeepers, and students. Efforts to optimize plastic waste management through Extended Producer Responsibility (EPR) were carried out in partnership with the Malang City Waste Bank and PT Zerolim, two parties that strictly sorted waste according to type so that the waste sold could get a high price. Implementing the OBE model with the 4R EPR pattern at UM was carried out to support a Green Campus to show UM's support for environmental sustainability. In the future, UM students can play a more active role in reducing plastic waste, such as recycling, producing creative goods from plastic waste, or developing more efficient plastic waste processing technology to support the Green Campus.

1. INTRODUCTION

Environmental sustainability has been a global issue lately [1, 2]. Environmental problems occur due to relatively low environmental knowledge and awareness of the people [3]. The main source of environmental problems is human beings who show no responsibility for their actions, including polluting the environment with so much plastic waste [4]. Human behavior, however, can be conditioned learning, including the behavior dealing with environmental awareness.

Empirical findings confirm that the OBE learning model, an approach that emphasizes innovative, interactive, and effective learning [5], can be applied to all forms of education [6]. The curriculum in OBE is based on visionary goals [7] to help students gain knowledge, skills, and competencies [8].

OBE is based on competencies, goals, and needs and focuses more on results and student-centered learning [9, 10]. OBE is a sustainable teaching model that combines theory and practice so that students are able to master knowledge and skills comprehensively [11]. OBE has three characteristics: 1) driven by achievement, 2) students as the center of learning, and 3) continuous improvement [12]. The development of OBE in plastic waste management requires three assumptions: 1) all students can achieve success according to their own methods and time, 2) student success can be encouraged by a suitable learning style, and 3) lecturers determine whether students are successful or not [12].

The development of OBE in this research was based on the assumption that the model could influence the behavior related to plastic waste management. This assumption is strengthened by the fact that OBE is student-centered learning, and knowledge acquisition is obtained when solving a problem in the learning process [13]. Empirical findings show that learning with OBE allows students to play a role in being responsible for learning, while educators plan and manage learning well and parents motivate their children to learn [14]. This is in line with findings in previous research that students' knowledge will grow due to learning with lecturers and support from parents [15].

Students with environmental knowledge and awareness will not litter. Waste management is one of the key aspects of efforts to create a sustainable campus environment [16]. Higher Education can be a role model for environmental management to support sustainable waste reduction [17],

energy efficiency [18], reduced water use [19], and the creation of an environment free of air pollution [20]. Activities related to environmental preservation, including managing plastic waste on campus, are expected to support environmental sustainability [21]. Therefore, higher education must participate in implementing environmentally friendly practices, and this is usually known as a green campus [22].

It has not been easy to deal with plastic waste. Waste management using the 4R method has been proven effective by some previous studies [23, 24]. Managing plastic waste using the 4R method, which consists of refuse, reduce, reuse, and recycle, can reduce plastic waste generation [25, 26]. The 4R method in waste management begins with refusing or rejecting products, which can lead to waste generation [27, 28]. The next step is to reduce waste [29], reuse goods that can still be used [30], and recycle used goods [31].

Plastic waste management can be anticipated with the 4R method combined with the EPR (Extended Producer Responsibility) method [32]. EPR is a waste reduction system that focuses on making goods that can be reused and recycled by producers-in which the recycling can be managed by companies themselves or third parties [33]. Research findings in Japan show that companies can do plastic waste management, but the public, as consumers and product sellers, also have a responsibility to manage plastic waste [34, 35]. Findings from India show that EPR has also been implemented as an effective and environmentally friendly plastic waste management [36].

Most people, including the campus community, view waste as useless, not as a resource that can be utilized. The traditional "collect-transport-dispose" approach to waste management can heavily burden landfills. To manage waste optimally, a change in paradigm must be made, namely reducing and handling waste from its sources.

The "clean process" concept above is applied more specifically in waste management, emphasizing the 4Rs, namely efforts to minimize or reduce waste that must be handled. Furthermore, waste processing or destruction aims to reduce the negative impact of waste on the environment if the residue is released into the environment. Most waste processing and/or destruction involves transforming dangerous materials to produce harmless materials.

The project-based learning which in this case is OBE model is a systematic learning outside the classroom that involves integrating technology and real actions to increase student creativity [37]. OBE is based on competencies, goals, and needs, focusing more on results and student-centered learning [9, 10]. OBE is a sustainable teaching model that combines theory and practice so that students are able to master knowledge and skills comprehensively [11]. The OBE model has three characteristics: 1) driven by achievement, 2) students as the center of learning, and 3) continuous improvement [12]. In environmental learning, OBE can be implemented in the form of waste management using waste management technology and real environmental action [38].

Integrating OBE with 4R EPR is necessary because both focus on developing students' independent abilities and knowledge OBE with 4R EPR can involve students in plastic waste management and stimulate student initiative to learn [12]. Based on a literature review, universities are a large producer of plastic waste, yet they have not implemented appropriate plastic waste management [39]. Some universities directly throw plastic waste into the landfill without sorting it; therefore, developing an OBE model with 4R EPR is necessary to increase university students' independence and ability to learn, have an awareness of issues around them, and take real action [12].

OBE, which prioritizes project-based learning, can be a means of capacity building for students because, with waste management activities, students can improve their divergent thinking skills, collaboration, brainstorming, project management techniques, empathy, curiosity, and creativity through downstream waste management [40]. In addition, transdisciplinary student collaboration in OBE allows for the sharing of ideas, which improves the quality of project learning and activity output [41].

This collaboration also helps students to think critically and be vocal about current issues regarding waste in the community, thus encouraging networking, communication skills, and building trust between peers [42]. The existence of networking, good communication, and trust within the student community will strengthen the sustainability of environmental volunteer-based waste management movement projects [43].

The short-term plan for waste management is to conduct massive outreach to educate campus residents. Medium-term planning creates cash for customers to exchange their waste. Long-term planning is for the mobility of waste, in which the management immediately picks up waste from customers and turns it into economically valuable goods [44-46]. Waste management is closely related to mindset-if it has not been changed, people will go around their old habits of not managing their waste properly.

Students, as potential leaders in society, are expected to fight for environmental quality [47, 48]. Therefore, they must be well-prepared through the learning model on campuses [49]. Students must prepare themselves to know about caring for the environment and become volunteers in maintaining the cleanliness of their campus environment [50].

Through the plastic waste awareness movement that involves students as volunteers, students are expected to develop awareness of the environment. Students concerned with the environment will be urged to express environmental values by solving ecological problems. These conditions influence students to be proactive in using and managing waste as a solution to ecological problems [51, 52]. With a well-implemented OBE learning model integrating environmental volunteers to support the Green Campus, the UM campus environment is expected to be clean and healthy [51, 52].

This research aims to (1) understand plastic waste management on the UM campus using the 4R pattern: reduce, reuse, recycle, and replace; (2) understand efforts to optimize plastic waste management on the campus through Extended Producer Responsibility (EPR); and (3) implement the OBE model with the 4R EPR pattern at UM to support the green campus initiative.

2. LITERATURE REVIEW

2.1 Outcome-Based Education (OBE) model

OBE is adapted from the American education system [53]. It focuses more on results and student-centered learning [54]. Previous studies confirm that OBE is suitable to replace traditional curriculum [55] and it can be implemented in many curriculum settings [56]. OBE has been found effective for English learning [57], for problem-solving activities in mechanical engineering specializations [58, 59], and for

improving student professionalism in industrial engineering learning [59].

OBE is often implemented in learning processes [60] in many countries, including the United States [61], Australia [62], Africa [63], and Asia [64]. Implementing OBE in university settings will impact students' knowledge and competitive advantage [57, 60].

2.2 Managing plastic waste

Plastic has a light texture and good durability, so it is often used in various activities [65-67]. Global plastic production is estimated to be close to 380 million tons, making plastic waste an emergency for the whole world [68].

Plastic waste is categorized based on its size into macroplastics (>25mm), mesoplastics (5-25mm), microplastics (<5mm), and nanoplastics (<1mm) [69]. Plastic waste not managed properly threatens the ecosystem and is a worldwide topic [70]. Land and marine ecosystems are seriously affected by plastic waste accumulation [71, 72]. It has been proven that plastic waste causes problems for human health [73], threatens animals [74], causes pollution [75], and pollutes land areas [76] and waters [77].

Plastic waste has caused anxiety among society [78]. Plastic waste management is one way to reduce the negative impacts caused by plastic waste [79]; it is a major concern for various countries [80]. Recycling is one way to reduce the problem of plastic waste [81]. Findings show plastic waste recycling faces several challenges if the plastic itself contains dangerous additives, halogen flame retardants, and stabilizers [82, 83].

The four approaches commonly used in plastic waste management are primary, secondary, tertiary and quaternary recycling [83, 84]. The primary recycling process involves re-extruding leftover plastic waste to create similar plastic items. Secondary recycling has similar mechanisms to the primary recycling process, but recycled products generally do not have the same function as secondary recycling [85]. The next process is different from tertiary recycling and quaternary recycling because the recycling process involves the transformation of the chemical structure of the plastic [79]. Tertiary recycling uses chemical and thermal processes to break down plastic waste into smaller molecules [86]. Quaternary recycling uses the combustion method.

2.3 4R EPR

Waste is a problem caused by human behavior [87, 88]. The continued increase in the amount of waste is a concern for society, academics, and the government [89]. Findings show that the large use of plastic bags among people in Africa causes microplastics that pollute the sea [90]. There is growing concern among the public and government due to plastic waste [91]. Apart from that, evidence in previous research shows that every human being produces waste from their daily activities, so waste management measures are needed [92].

Waste management has a hierarchical system that can be used with the "R" framework, including waste management using the 3R method [93], waste management using the 4Rs [94], waste management using the 6Rs [95, 96], and waste management using the 9Rs [97]. The "R" method is a guideline for good waste management [98]. Previous research shows that the 3R method has been able to reduce the impact of organic and inorganic waste [99]. 3Rs in waste management consists of three mechanisms, including reusing, reducing and recycling [93]. The 3R method is often implemented for environmental management [99] in various countries, such as Japan, Malaysia, Turkey and China.

Reduction is the first choice for waste management, followed by reuse and recycle [100]. Previous studies mention that the 4R method is a more effective waste management step compared to the 3R method [28]. Compared to the 3R method, which only has three steps in managing waste, the 4R method proposes a difference, namely the "refusal" stage [95], meaning that we can choose not to use goods or products that cause waste [98].

Plastic waste management using the 4R method is appropriate and can be combined with the EPR method [32, 101]. There must be policies to improve environmental cycles and environmental protection that guarantee the implementation of a circular economy for producers [102]. The EPR method has been implemented in various countries. There are findings in India that the EPR method can reduce the impact of environmental pollution [103]. In addition, the EPR method that has been implemented in Europe significantly reduces the impact of products on the environment by providing regulations for manufacturers to recycle waste and prohibiting the use of hazardous materials [104]. Similar things are also found in research conducted in Taiwan that the application of EPR effectively reduced the disposal of lithium battery waste [105].

2.4 Green campus

Environmental issues continue to develop, especially related to plastic waste [106]. Human awareness of the environment is necessary and can be implemented through the transfer of environmental knowledge to create a balance between the environment and humans [107]. Higher education is the reference to provide scientific knowledge and common sense [108, 109]. Higher education institutions also have an important role in sustainable development by implementing environmental friendliness by greening the entire university environment [110].

Universities with environmental practices to perform environmentally friendly sustainable development completed by creating green open spaces are known as green campuses [111]. The environmental practices that the green campus has implemented for students can increase students' environmental awareness [112]. Kingston University, England, implements an environmental education curriculum so that environmental practices can be implemented among students [113]. Apart from that, green campuses also play a role in reducing carbon dioxide as a form of balancing the climate in the campus environment [114].

3. METHOD

3.1 Research design

This study uses a mixed method with a combination of quantitative and qualitative descriptive models. The research began by exploring data regarding plastic waste management in depth at each faculty and unit at Universitas Negeri Malang (UM). The locations for this research included 10 faculties (FIP, FEB, FS, FMIPA, FT, FIK, FIS, FPsi, FV, and FK), postgraduate buildings, joint lecture buildings, and head offices.

3.2 Data collection

We collected data on plastic waste management from various departments and units at the National University of Malang (UM). The data collection spanned 5 working days and included information gathered from 2 university-level events. The timeframe for data collection ensured comprehensive and reliable data acquisition.

Data were collected through observations, interviews, documentation, and plastic waste management actions on the UM campus. The UM Waste Bank, developed with OBE, has 3 divisions: waste collection division, plastic waste sorting division, and business division. The collection division collects plastic waste from each faculty and unit at UM. The sorting division then sorts organic and inorganic waste, including plastic. The business division deals with waste with economic value, including using waste for plant nurseries and selling the sorted waste to buyers or to the Malang Waste Bank; it also holds training to educate students and the general public regarding plastic waste processing.

The data collected was quantitative data. Several criteria for the instruments were established to ensure the validity of the data obtained during the research activities. These criteria were developed collaboratively by a research team comprising a Professor with over 30 years of experience, a Senior Lecturer with over 25 years of experience, two PhD lecturers in Geography Education with research areas in teaching models and environmental education, and three Master's graduates in Geography specializing in plastic waste management. The criteria were assessed using Intraclass Correlation Coefficient (ICC), with a value of 0.8, to measure the consistency and reliability of the data. The ICC was calculated to ensure the reliability and validity of the research instruments used [115].

In this study, a periodic calculation was done every 1 month on (1) how many waste volunteers actively participated, (2) how many kilograms of plastic waste were collected, and (3) how much money was obtained from plastic waste management. The results of implementing the OBE model were measured using interviews regarding the satisfaction felt by volunteers in implementing OBE by revealing the obstacles faced in waste management and what future efforts must be made so that the UM Green Campus can be sustainable.

To ensure the accuracy and validity of the data, pre-processing steps were implemented to remove outliers. Data showing unusually high or low amounts of plastic compared to previous periods were further examined, and any input errors, such as recording weights in grams instead of kilograms, were corrected or removed. Valid data were normalized to ensure consistency in format and units, such as converting all plastic weights to kilograms, and standardizing the dates and times of waste collection for consistency.

Following data cleaning, further education was provided to volunteers on the importance of accuracy in data collection and methods to reduce future errors, including proper use of digital scales and adherence to standardized data formats. These measures aimed to ensure high levels of accuracy and reliability in the data, enabling more precise analysis and valid conclusions

3.3 Data analysis

Data analysis was carried out by analyzing quantitative and qualitative data using the interactive analysis model by Ridder [116], which includes data collection, data reduction, data presentation/data display, conclusion drawing and verification. The innovation carried out in this research was a combination of quantitative and qualitative descriptive models.

The application of the mix method provides in-depth understanding and provides a more complete picture by presenting data along with descriptions of the research findings [117]. Apart from that, the mix method is a popular method in research that has been carried out, because it can provide stronger inferences compared to using one approach [118]. In this case, it is in line with previous research findings that using a mix method can provide strong numerical data, while qualitative data provides an explanation of the findings that can enrich the interpretation of research results [119].

The integration of these methods provided a comprehensive understanding of the problem. Qualitative data, collected through interviews and observations, offered deep insights into the experiences, perceptions, and challenges faced by volunteers and stakeholders. Quantitative data, gathered through periodic measurements of plastic waste quantities, volunteer participation rates, and financial outcomes, provided objective and measurable evidence. The qualitative insights were used to interpret and explain the quantitative findings, creating a holistic view of the plastic waste management process. This combined approach ensured that the study's conclusions were well-rounded and robust, highlighting key challenges, successes, and areas for improvement, ultimately informing effective and sustainable waste management strategies at UM (see Figure 1).

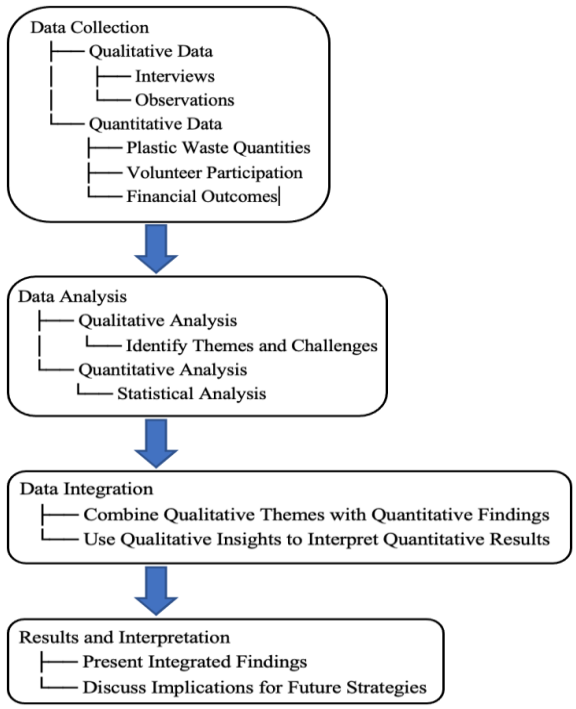

Figure 1. The mixed-methods approach for investigating plastic waste management at UM

Several criteria are used to ensure the validity of the data obtained during research activities: 1) degree of confidence, which was done through in-depth observations, triangulation and member-checking; 2) transferability, which was done by explaining in detail, thoroughly, carefully and in-depth the main problem being studied, so that the data obtained could be differentiated from the researcher's interpretation; 3) dependability, in which to meet the accuracy of the data, the

researchers performed careful re-examination of components, processes, and research results; and 4) certainty, a step done to meet the level of certainty regarding plastic waste management by the UM Groundskeepers Team.

4. RESULT AND DISCUSSION

4.1 Identify plastic waste management using the 4r pattern at universitas negeri malang

Plastic is a polymer that has a high molecular weight and is easy to shape [89], so people tend to use plastic in everyday life. The increasing use of plastic has caused environmental problems [120]. Plastic waste management is very important to do and plan well [30]. Without proper management, plastic waste causes environmental problems and pollution [121].

Accumulating plastic waste cannot be managed easily. There is evidence from previous research that plastic waste management generally uses the 3R concept [122]. However, in practice, the 3R concept of plastic waste management has not been optimal in reducing plastic waste generation [123]. Therefore, the European Commission introduces the 4R concept for waste management [124, 125]. The 4R concept is believed to be more efficient and effective so that it can be adopted as a general waste processing practice [28, 126].

The difference between the 3R concept and the 4R concept actually lies in replacing products for daily activities by choosing the more environmentally friendly ones. Figure 2 shows the use of tumblers for drinking water as the first step to reducing single-use plastic bottles. Findings in previous research mention that single-use plastic bottles for drinking water are the largest source of plastic use in the world [127]. Other findings in previous research show that people generally choose to use plastic bottles for single-use drinking water packaging due to health, taste, and odor problems [128].

However, using tumblers is better than using single-use plastic bottles since they can be used continuously and repeatedly. The temperature of the water in the tumbler can be maintained. Tumblers also help reduce the risk of spills and viruses entering because they have a cover designed as a safety measure. Apart from that, using tumblers is very environmentally friendly.

Most of the plastic waste accumulated on campus comes from canteens, dormitories, faculties, and work units at UM. Plastic waste is often produced from plastic detergents, milk cans, plastic bags, and mineral water bottles. Management of plastic waste produced from household waste needs to be carried out to avoid environmental pollution and maintain human health [129]. Environmental management practices need to involve actors by implementing ways to handle plastic waste effectively [130]. Therefore, the 4R method can be applied to plastic waste by reusing used goods and changing the used goods into something valuable.

Figure 3 shows environmental activities with students using the 4R method. These activities aim to manage plastic waste using the reuse method. Plastic waste from detergent packaging is reused as plant pots-plant pots made from used materials are usually called recycled pots [131]. Plant pots made from plastic waste are alternative pots; they are durable and can be used repeatedly in a sustainable and environmentally friendly manner [132] to help reduce plastic waste [133] and environmental pollution [134].

Organic and inorganic waste is an environmental problem currently being discussed worldwide [135]. Organic and inorganic waste comes from industrial, household, and agricultural activities. Both are found at UM. Thus, waste problems must be handled by involving all stakeholders at UM and applying the 4R method (reduce) by sorting and reducing waste.

Plastic waste is a very serious environmental problem and requires environmental management action. Plastic waste is increasing every day and polluting the environment of UM. Environmental management actions need to be taken by implementing the 4R method to reduce the amount of plastic waste piled up. The recycling stage of the 4R method is effective in reducing the number of plastic waste deposits.

Figure 2. Using tumbler for drinking water

Figure 3. Sing plastic waste as plant pots

Figure 4 shows that the concrete actions demonstrating love for the environment in the form of collecting plastic waste during *Halal Bihalal* (gathering during the Eid al-Fitr celebration) are carried out jointly between lecturers, students, and janitors for proper management of plastic waste at UM. In line with previous findings, waste sorting using the 4R method at the reduction stage is effective and efficient in reducing waste [136].

Waste management will be done sustainably at UM since empirical findings confirm that sustainable processing of plastic waste in the form of the 4R method at the recycling stage is important and efficient [137]. Mechanical recycling is often applied; it is reprocessing plastic waste into raw materials and products using physical methods [138]. Mechanical recycling requires a series of processing and preparation steps [139]. The first stage is to categorize the plastics and then put them in a storage container. The second stage is separating the bottle caps from the plastic because the recycling process for bottle caps and plastic bottles uses a different method. The third stage is selling the plastic to third parties to process it into new products.

(a) University gathering event in 2024

(b) Green campus volunteers and students sort plastic waste from university gatherings

Figure 4. Initial processing of plastic waste in the university environment

(a) Directions by the green campus chairman to volunteers and students before collecting plastic waste

(b) After collecting plastic waste by volunteers and students

Figure 5. Collecting plastic waste with students to commemorate National Waste Awareness Day (Hari Peduli Sampah Nasional - HPSN) 2024

In the OBE model, students are also invited to participate in certain events, such as commemorating National Waste Awareness Day (Figure 5). Students were asked to collect rubbish in Buildings A19 and A20. It is a 9th-floor multi-storey building with a waste storage area separating the waste into paper, plastic, and organic waste. The aim is to educate students have put their rubbish in the right place.

4.2 Identifying efforts to optimize plastic waste management at um through Extended Producer Responsibility (EPR)

3R waste management still leaves residue in the form of inorganic waste, especially plastic product packaging, which cannot be recycled by the public and has no selling value. With the EPR concept, the product packaging waste is returned and managed by the producer. EPR is implemented in industry by replacing raw materials with more environmentally friendly ones, reducing materials that can produce waste, and reusing and recycling packaging waste (Figure 6). The mechanism for returning packaging waste from consumers to producers can be done through waste banks, waste collectors, discounts or cash replacement (Figure 7).

(a) Green campus volunteers sort plastic waste

(b) Plastic waste is collected before proceeding to the next stage

Figure 6. Sorting plastic waste

Plastic waste sorting can be done by UM janitors, students, and also environmental volunteers. Certain buildings at UM, such as Buildings A19 and A20, already use separate trash bins for faster subsequent sorting. However, some buildings do not use the sorting system, making garbage mixed up. The groundskeepers do the subsequent sorting. Some of the

organic waste at UM is processed into compost, and the rest is disposed of at the Supit Urang landfill.

(a) Plastic waste collects at UM

(b) Purchase of plastic waste by third parties

Figure 7. Cooperating with third parties to purchase the waste collected at UM

Regarding product packaging, producers who use packaging to market their products are the initial link in the waste management chain regulated by the law. EPR is known as a strategy designed to internalize environmental costs into the production costs of a product, not limited to the main product but also including the packaging of such product. In this way, environmental costs, such as costs for handling residues or waste arising from the use of the product, become part of the price component of the product being marketed. The EPR implemented in Japan goes through several steps. *Step 1* is saving raw materials in the production process. *Step 2* is about producing long-lived goods and encouraging repairs on damaged goods, including guaranteed service. *Step 3* deals with accepting returns of used products, including packaging, using raw materials or producing products derived from recycling and making efforts to use and develop recycling technology. Apart from encouraging producers to implement EPR, in several developed countries, the role and responsibility of producers are included in overall waste management, known as the internalization of environmental costs in product costs. Thus, the costs of handling waste and its impacts are included in it.

Indonesia now has only one law that regulates waste management, while in Japan, there are at least 9 (nine) laws related to waste, namely the law on 1) a material-cycle society, 2) waste management and cleanliness, 3) effective use of resources, 4) recycling containers and packaging, 5) recycling household equipment, 6) recycling food waste, 7) recycling building debris, 8) vehicle end-of-life recycling, and 9) promotion of green products. In addition, 60% of municipal waste in Japan is containers and packaging. Based on the Law on Recycling Containers and Packaging, those regulated for recycling are a) glasses and/or bottles (colourless, brown, and green), b) PET bottles (for alcoholic and non-alcoholic drinks, as well as soy sauce bottles), c) paper containers and wrapping, and d) plastic containers and wrapping.

The EPR mechanism for containers and packaging in Japan is as follows: The municipal government is responsible for the costs of collecting, sorting, and storage, while the entrepreneur is responsible for the costs of recycling and processing. Entrepreneurs are responsible for the packaging or containers they make or sell with their products. To carry out this obligation, the Japanese Government assigned the Japan Containers and Packaging Recycling Association (JCPRA) to carry out recycling activities on behalf of entrepreneurs who pay recycling fees to JCPRA.

Based on a literature review, EPR is more widely known for managing electronic waste, but in principle, EPR can be used for all types of products, including plastic [138]. The EPR concept emphasizes that anyone who produces or distributes packaging products must also be responsible for the packaging life cycle even though the product is no longer used [140-142]. EPR can be combined with the 4R principle (reduce, reuse, recycle, replace) as an alternative to managing plastic waste by involving producers and students by referring to the zero waste concept to deal with environmental problems [143].

4.3 Implementing the OBE learning model with the 4R EPR pattern for plastic waste management at UM to support the green campus initiative

In this study, UM was chosen as the subject of this research for several key reasons. First, UM is one of the universities participating in the UI Green Metric, demonstrating its commitment to environmental sustainability. Additionally, UM is one of the top-ranked educational institutions in Indonesia, making it an ideal location for the implementation of the OBE model. The aim is for the findings of this research to be further promoted as a best practice example in plastic waste management and OBE implementation, as well as UM's contribution to environmental sustainability and quality education in Indonesia. Implementing OBE at UM is crucial as part of UM's efforts to enhance the intelligence and skills of its students. Furthermore, UM is one of the largest campuses in Malang, providing a broad and representative scope for the research.

Actions for managing plastic waste can be done through the OBE learning model. OBE is one of the appropriate learning models for educating students about plastic waste management. OBE is not only about applying knowledge but it is also integrated with the use of technology and environmental practices [11]. This is in line with findings in previous research that the OBE model is visionary learning and has a curriculum that can be implemented in all types of learning [7]. OBE is often carried out in various countries, such as Pakistan [144], Malaysia [145] and China [146].

The OBE learning model is implemented through lecturing, workshops, and training. Figure 8 shows a workshop on plastic waste sorting by PT Zerolim and FGD on plastic waste with leaders of UM, janitors, and students as environmental volunteers in managing plastic waste. The theme for the

workshop was adapted to the problems in the UM environment, which is to reduce plastic waste and sort it according to its types. Presenters for the workshop were selected based on their areas of expertise related to plastic waste.

(a) FGD by PT Zerolim

(b) Workshop by PT Zerolim

Figure 8. Workshop on plastic waste sorting by PT Zerolim and FGD on plastic waste with leaders of UM, janitors, and students

Workshop trainees were taught how to sort waste based on its types: PET (Polyethylene Terephthalate), HDPE or PEDH (High-Density Polyethylene), PVC (Polyvinyl Chloride), LDPE (Low-Density Polyethylene), and PP (Polypropylene). Sorting (plastic) waste will increase economic value because waste collectors can immediately process the waste without sorting it.

The workshop or training continues with real actions. It also resulted in an agreement between the leaders, students, and groundskeepers that waste sorting from each faculty and work unit will continue (Figure 9). Sorting plastic waste is an environmental action that provides a stimulus in the form of environmental knowledge and increases student creativity. Previous research shows that environmental awareness and attitudes will increase if students participate in environmental activities [147, 148]. In addition, environmental knowledge will increase when students face environmental problems directly [149].

After implementing the OBE model, the students' scores on concern about plastic waste are as follows: very low 0%, low 44.44%, high 44.44%, and very high 11.11% (Figure 10). This needs to be improved so that students will become more aware of plastic waste management at UM in the future.

As a form of plastic waste management, EcoBricks have come into popularity. When asked about making EcoBricks, 33.33% of students never made it, 11.11% sometimes made it, 33.33% often made it, and 22.22% of students very often made it (Figure 11).

The following results show students' ability to educate others about sorting plastic waste: 66.67% of students at the advanced level, 22.22% of students at the intermediate level, 0% at the elementary level, and 11.11% at the beginner level (Figure 12). This means that students have good ability to educate others about sorting plastic waste, and it needs to be maintained (Figure 13).

Figure 9. A collection point of plastic bottles in front of each building at UM

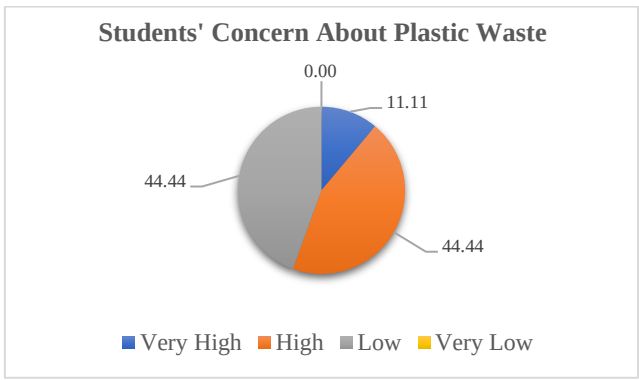

Figure 10. Students' concern about plastic waste

Figure 11. Students' willingness to make ecobrick

In general, if a table is too long to fit one page, the table

number and heading should be repeated on the next page before the table is continued. Alternatively, the table may be spread over two consecutive pages (first an even numbered, then an odd-numbered page) turned by 90, without repeating the heading. Here is an example:

Improving environmental learning, including education on plastic waste management at UM, has increased UM's ranking in green campus management at the national and international levels (Table 1). The increase in ranking in the last three years is described in Table 2.

The results show that UM is a campus that pays close attention to education issues and needs to continue increasing its commitment, including educating students about plastic waste management.

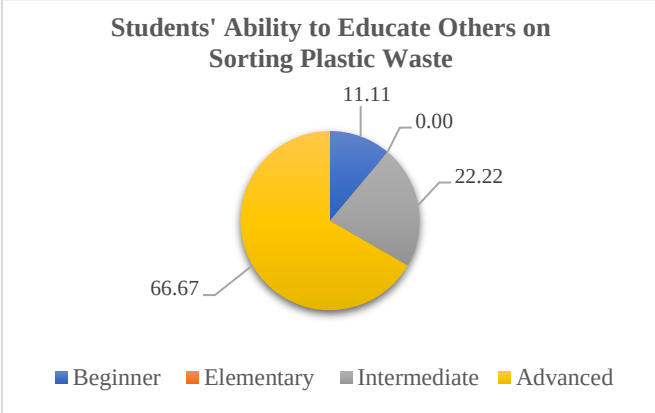

Figure 12. Students' ability to educate others about sorting plastic waste

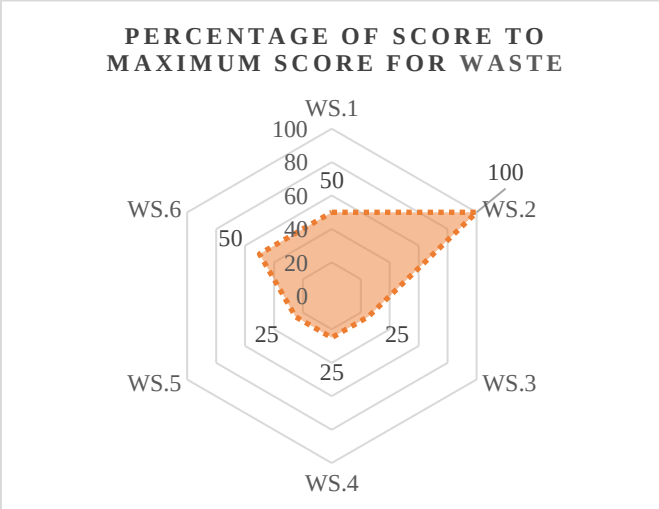

Figure 13. Percentage of score to maximum score for waste

Table 1. UI green metric assessment score for Universitas Negeri Malang year 2023

	Indicator	Score
WS 1	Recycling program for university waste	150
WS 2	Program to reduce the use of paper and plastic on campus	300
WS 3	Organic waste treatment	75
WS 4	Inorganic waste treatment	75
WS 5	Toxic waste treatment	75
WS 6	Sewerage disposal	150

Table 2. UM Assessment and Ranking in the 2021-2023 UI Green Metric World University Ranking

Year	Setting and Infrastructure	Energy and Climate Change	Waste	Water	Transportation	Education and Research	Total Score	National Rank	Global Rank
2021	775	1675	825	700	1150	1250	6375	37	346
2022	900	1725	825	700	1400	1475	7025	32	288
2023	1150	1600	1125	800	1400	1675	7750	28	210

Source: UI green metric world university ranking, 2023

5. CONCLUSIONS

From the research results and discussion, it can be concluded that the management of plastic waste at UM used the 4R (reduce, reuse, recycle, and replace) model through collaboration between leaders, lecturers, groundskeepers, and students. Efforts to optimize plastic waste management through Extended Producer Responsibility (EPR) were carried out in collaboration with the Malang City Waste Bank and PT Zerolim, two parties that strictly sorted waste according to type so the waste sold could get a high price. Implementing the OBE model with the 4R EPR pattern at UM was carried out to support a Green Campus to show UM's support for environmental sustainability.

DATA AVAILABILITY

The data supporting our research results are under privacy or ethical restrictions. The data are available from Sumarmi for researchers, who meet the criteria for accessing confidential data.

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APPENDIX: INTERVIEW TRANSCRIPT

The student interviews were conducted on National Waste Care Day (HPSN) February 21, 2024:

Interview 1: Rizieq

Researcher:
Selamat siang, mas. Boleh tahu namanya?
Good afternoon, sir. May I know your name?

Rizieq:
Nama saya Rizieq, mas.
My name is Rizieq, sir.
Researcher:
Jurusan apa, mas Rizieq?
What is your major, Rizieq?

Rizieq:
Saya jurusan Pendidikan Sejarah.
I'm majoring in History Education.

Researcher:
Sudah sempat minum hari ini, mas?
Have you had a drink today?

Rizieq:
Sudah, mas. Tadi beli minum di kantin.
Yes, I have. I bought a drink at the canteen.

Researcher:
Minumnya pakai botol sendiri atau beli yang sekali pakai?
Did you use your own bottle or buy a single-use one?

Rizieq:
Pakai botol sekali pakai, mas.
I used a single-use bottle, sir.
Researcher:
Oh, begitu. Oh, iya mas, hari ini ramai ya mas, kira kira mas Rizieq tau ga hari ini hari apa?
Oh, I see. By the way, it's quite busy today. Do you know what day it is?

Rizieq:
Hari Rabu, mas.
It's Wednesday, sir.

Researcher:
Hari ini hari Peduli Sampah Nasional, mas.
Today is National Waste Awareness Day, sir.

Rizieq:
owalah iya mas, saya lihat ada beberapa kegiatan kebersihan kampus, tapi saya tidak tahu detailnya, mas.
Oh, really? I saw some cleaning activities around the campus, but I didn't know the details, sir.

Researcher:
Iya mas, hari ini, kami voluntir dari green campus UM sedang memperingati HSPN, mas. Apakah mas, Rizieq pernah terlibat dalam kegiatan volunter Green Campus?
Yes, today we, the Green Campus volunteers from UM, are commemorating National Waste Awareness Day. Have you ever participated in Green Campus volunteer activities?

Rizieq:
Saya sebenarnya baru beberapa kali ikut kegiatan green kampus, mas. Biasanya saya bantu-bantu teman mengumpulkan sampah plastik di sekitar kampus.
I've only joined a few Green Campus activities, sir. Usually, I help my friends collect plastic waste around the campus.

Researcher:
Hari ini kan, Hari Peduli Sampah Nasional. Apa Rizieq sudah tahu tentang ini sebelumnya?
Today is National Waste Awareness Day. Did you know about this before?

Rizieq:
Oh, saya baru tahu, mas. Saya tidak tahu kalau hari ini adalah Hari Peduli Sampah Nasional.
Oh, I just found out, sir. I didn't know today is National Waste Awareness Day.
Researcher:

Apakah Rizieq mengetahui tentang model OBE (Outcome-Based Education) yang diterapkan di UM?
Are you aware of the OBE (Outcome-Based Education) model being implemented at UM?

Rizieq:
Jujur, saya tidak terlalu paham, mas. Saya ikut kegiatan ini karena diajak teman saja. Saya tahu sedikit bahwa OBE itu berorientasi kepada hasil belajar, tapi tidak tahu detailnya.
Honestly, I don't really understand it, sir. I joined this activity because my friends invited me. I know a bit that OBE is oriented towards learning outcomes, but I don't know the details.

Researcher:
Menurut Rizieq, seberapa penting pengelolaan sampah plastik?
How important do you think plastic waste management is?

Rizieq:
Menurut saya, sampah plastik memang masalah, tapi saya pribadi belum terlalu peduli, mas. Saya ikut kegiatan ini lebih karena ajakan teman dan ingin membantu saja.
I think plastic waste is a problem, but personally, I'm not too concerned about it, sir. I joined this activity more because of my friends' invitation and the desire to help

Researcher:
Apakah Rizieq merasa ada perubahan dalam kesadaranmu mengenai sampah plastik setelah ikut kegiatan ini?
Do you feel there's been a change in your awareness about plastic waste after joining this activity?

Rizieq:
Mungkin sedikit ada, mas. Tapi saya masih perlu belajar lebih banyak dan melihat dampaknya secara langsung.
Maybe a little, sir. But I still need to learn more and see its impact directly.

Researcher:
Terima kasih, Rizieq, atas waktunya. Semoga kegiatan ini bisa membantu meningkatkan kesadaran kita semua tentang pentingnya mengelola sampah plastik dengan baik.
Thank you, Rizieq, for your time. Hopefully, this activity can help increase our awareness of the importance of managing plastic waste properly.

Interview 2: Qonita

Researcher:
Selamat siang, mbak. Siapa namanya?
Good afternoon, miss. What is your name?

Qonita:
Nama saya Qonita.
My name is Qonita.

Researcher:
Jurusan apa, Qonita?
What is your major, Qonita?

Qonita:
Saya jurusan Hukum dan Kewarganegaraan.
I'm majoring in Law and Citizenship.

Researcher:
Sudah sempat minum belum hari ini?
Have you had a drink today?

Qonita:
Sudah, mbak. Saya bawa minum dari rumah.
Yes, I have. I brought a drink from home.

Researcher:
Bagus sekali. Bawa botol minum sendiri, ya?
That's great. You brought your own bottle, right?

Qonita:
Ya, pakai botol sendiri, mbak. Saya usahakan bawa botol minum sendiri terus.
Yes, I use my own bottle. I always try to bring my own drinking bottle.

Researcher:
Bagus sekali. Apakah Qonita aktif ikut dalam volunter Green Campus?
Very good. Are you active in Green Campus volunteering?

Qonita:
Ya, saya aktif dalam volunter Green Campus. Karena betul membangun kebiasaan bagus buat saya.
Yes, I'm active in Green Campus volunteering. It really helps build good habits for me.

Researcher:
Kebiasaan apa itu, mba?
What kind of habits, miss?

Qonita:
Iya mbak, saya dulu ga perduli sama sampah plastik, saya beli makanan dan minuman tidak pernah mikirkan sampahnya akan kemana dan diapakan. Tapi setelah ikut voluntir, saya kalau beli makanan atau minuman saya usahakan banget untuk minimalisir penggunaan plastik.
Yes, sist. I used to not care about plastic waste. I would buy food and drinks without thinking about where the waste would go and what would happen to it. But after volunteering, I always try to minimize the use of plastic when I buy food or drinks.

Researcher:
Alhamdulillah kalau begitu, mba. Selain perilaku terhadap sampah plastik, apalagi kebiasaan yang lain yang berhubungan dengan pengurangan sampah plastik?

Thank goodness for that, miss. Besides behavior towards plastic waste, what other habits do you have related to reducing plastic waste?

Qonita:
Oh iya, saya suka edukasi teman-teman saya. Saya ajak teman-teman tentang pentingnya memilah sampah dan bagaimana mengurangi penggunaan plastik sekali pakai. Saya juga ajak mereka untuk jadi voluntir Green Campus.
Oh yes, I like educating my friends. I encourage them about the importance of sorting waste and how to reduce the use of single-use plastics. I also encourage them to become Green Campus volunteers.

Researcher:
Saya terkesan, mba. Kebiasaan yang terbangun sangat bagus banget, dari voluntir memberikan pembelajaran yang bermakna. Apakah mba Qonita tahu tentang model OBE (Outcome-Based Education) yang diterapkan dalam program ini?
I'm impressed, miss. The habits built are very good. Volunteering provides meaningful learning. Do you know about the OBE (Outcome-Based Education) model implemented in this program?

Qonita:
Ya, saya tahu. OBE berfokus pada hasil akhir dari pembelajaran, jadi dalam konteks pengelolaan sampah plastik, tujuannya adalah untuk membuat kampus lebih hijau dan bebas sampah plastic.
Yes, I know. OBE focuses on the outcomes of learning, so in the context of plastic waste management, the goal is to make the campus greener and free of plastic waste.

Researcher:
Menurut Qonita, seberapa penting pengelolaan sampah plastik?
In your opinion, how important is plastic waste management?

Qonita:
Menurut saya sangat penting. Sampah plastik adalah masalah besar yang harus kita tangani bersama. Melalui program ini, kami berharap bisa memberikan kontribusi nyata dalam mengurangi sampah plastik di kampus.
I think it's very important. Plastic waste is a big problem that we have to handle together. Through this program, we hope to make a real contribution in reducing plastic waste on campus.

Researcher:
Apakah Qonita melihat ada perubahan dalam kesadaran teman-teman mengenai sampah plastik setelah ikut kegiatan ini?
Do you see any change in your friends' awareness about plastic waste after joining this activity?
Qonita:
Ya, saya melihat banyak teman yang awalnya tidak peduli sekarang mulai sadar dan aktif terlibat. Saya senang ketika edukasi yang saya sampaikan membantu mereka memahami bahaya sampah plastik dan cara mengelolanya dengan benar.
Yes, I see a lot of friends who initially didn't care, now becoming aware and actively involved. I'm happy when the education I provide helps them understand the dangers of plastic waste and how to manage it properly.
Researcher:
Terima kasih, Qonita, atas waktunya. Semoga kegiatan ini terus memberikan dampak positif.
Thank you, Qonita, for your time. Hopefully, this activity continues to have a positive impact.

Interview 3: Gania

Researcher:
Selamat siang, mbak. Boleh tahu namanya?
Good afternoon. May I know your name?

Gania:
Nama saya Gania.
My name is Gania.

Researcher:
Jurusan apa, Gania?
What is your major, Gania?

Gania:
Saya jurusan Geografi.
I am majoring in Geography.

Researcher:
Sudah minum belum, mbak?
Have you had something to drink?

Gania:
Sudah, mas.
Yes, I have.

Researcher:
Minumnya pakai botol sendiri atau botol sekali pakai?
Did you use a reusable bottle or a single-use one?

Gania:
Pakai botol sendiri, mas. Saya usahakan untuk tidak menggunakan botol sekali pakai.
I used my own bottle. I try to avoid using single-use bottles.

Researcher:
Bagus sekali. Apakah Gania aktif ikut dalam volunter Green Campus?
That's great. Are you actively involved in Green Campus volunteer activities?

Gania:
Ya, saya aktif. Saya terlibat dalam kegiatan daur ulang sampah plastik dengan mengumpulkan sampah dan mengirimkannya ke UKM Bhumi dan Bank Sampah Malang.
Yes, I am active. I am involved in plastic waste recycling activities by collecting waste and sending it to UKM Bhumi and Bank Sampah Malang.
Researcher:

Gania tahu tentang model OBE (Outcome-Based Education) yang diterapkan dalam program ini?

Are you familiar with the OBE (Outcome-Based Education) model applied in this program?

Gania:

Ya, saya tahu. OBE memastikan bahwa setiap kegiatan yang kami lakukan memiliki tujuan yang jelas dan dapat diukur hasilnya. Dalam konteks ini, tujuannya adalah untuk mempromosikan daur ulang sampah plastik secara efektif dan mengurangi dampak lingkungan.

Yes, I am aware. OBE ensures that every activity we undertake has a clear objective and measurable outcomes. In this context, the goal is to effectively promote plastic waste recycling and reduce environmental impact.

Researcher:

Menurut Gania, seberapa penting pengelolaan sampah plastik?

In your opinion, how important is plastic waste management?

Gania:

Sangat penting. Daur ulang sampah plastik membantu mengurangi jumlah sampah yang masuk ke tempat pembuangan akhir dan juga mengurangi dampak negatif terhadap lingkungan. Melalui kegiatan ini, kami berusaha untuk membuat dampak positif yang berkelanjutan.

It is very important. Recycling plastic waste helps reduce the amount of waste going to landfills and also decreases the negative environmental impact. Through this activity, we strive to make a sustainable positive impact.

Researcher:

Apakah Gania melihat ada perubahan dalam kesadaran teman-teman mengenai sampah plastik setelah ikut kegiatan ini?

Have you noticed any change in your friends' awareness about plastic waste after participating in this activity?

Gania:

Ya, saya melihat banyak teman yang sekarang lebih peduli dan terlibat dalam pengelolaan sampah plastik. Ini menunjukkan bahwa program ini efektif dalam meningkatkan kesadaran dan mendorong tindakan yang lebih bertanggung jawab.

Yes, I have noticed that many of my friends are now more concerned and involved in plastic waste management. This indicates that the program is effective in raising awareness and encouraging more responsible actions.

Researcher:

Terima kasih, Gania, atas waktunya. Semoga kegiatan ini terus memberikan dampak positif.

Thank you, Gania, for your time. I hope this activity continues to have a positive impact.

DESCRIPTION OF INTERVIEW RESULTS

Name: Rizieq

Major: History Education

Description: Rizieq is a student majoring in History Education who participates in plastic waste management activities on campus. Although his knowledge about the Outcome-Based Education (OBE) model and the importance of plastic waste management is still limited, he joins these activities due to friends' invitations and a desire to help. Rizieq was unaware that the day was National Waste Care Day, but he acknowledges an increased awareness of plastic waste issues after participating in these activities.

Name: Qonita

Major: Law and Citizenship

Description: Qonita is a Law student actively involved in educating others about plastic waste management. She understands the OBE model and considers plastic waste management to be very important. Qonita has observed an increase in her peers' awareness regarding plastic waste management following the program. She also makes efforts to reduce single-use plastic by bringing her own water bottle.

Name: Gania

Major: Geography

Description: Gania is a Geography student actively volunteering in plastic waste recycling activities on campus. She is knowledgeable about the OBE model and focuses on reducing plastic waste by sending it to UKM Bhumi and Bank Sampah Malang. Gania has observed positive changes in her peers' awareness of the importance of plastic waste recycling and encourages more responsible environmental actions.