Sustainable Waste Management in Indonesian Higher Education: Behavioral Insights

ARDYANTO TANJUNG

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Graduate School of Environmental Engineering

The University of Kitakyushu

Supervisor:

Prof. Toru Matsumoto

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Table of Content

List of Figures

List of Tables

Chapter 1 Introduction Waste Management in Higher Education Institution

1.1. Introduction

Higher education institutions (HEIs) in Indonesia, often comparable in size to small municipalities, are experiencing rapid growth. Over the past decade, the number of students has increased by 67.2% (Digdowiseiso, 2020). The total number of colleges has generally decreased, from 4,670 in 2018 to a low of 4,481 in 2021, with a slight recovery to 4,522 in 2022. Meanwhile, the number of newly established colleges fluctuates, with 148 new institutions in 2018, peaking at 208 in 2019, dropping to 169 in 2020, and then rising again to 218 in 2022 (Higher Education Statistics of Indonesia, 2022). This data indicates a general decline in the total number of colleges but a resurgence in establishing new institutions in recent years. Figure 1. illustrates the trends in the number of colleges and universities established in Indonesia over the five years from 2018 to 2022.

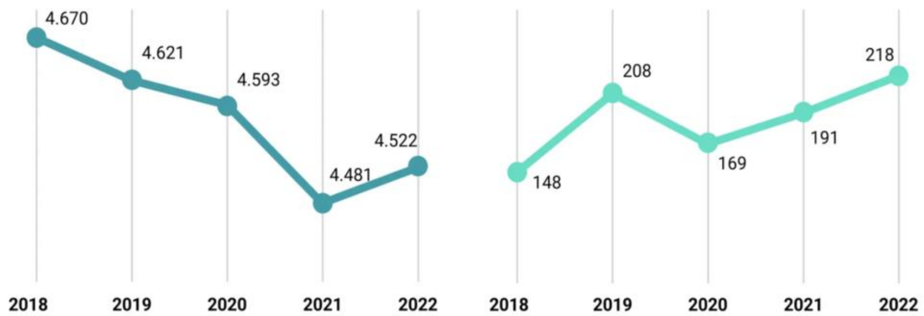


Figure 1. Number of colleges and universities and number of new colleges in the last five years. (Statistic of higher education of Indonesia, 2022)

The exponential growth in student populations at HEIs has resulted in a substantial increase in waste production across campuses, posing significant challenges for waste management. Studies and reports show that university campuses generate considerable waste annually (Bahçelioğlu et al., 2020). For instance, the University of Indonesia generates approximately 10 tonnes of waste daily. It has implemented waste separation and recycling programs to manage the waste produced by its large student population (Budihardjo et al., 2021). Similarly, the Diponegoro University (UNDIP) campus produces approximately 50 m^3 of solid waste daily, contributing up to 1% of the solid waste generated in Semarang City (Budihardjo et al., 2021). This waste is a mixed composition of organic, non-organic, and residual materials. Addressing these challenges requires a multifaceted approach involving policy, infrastructure, and community engagement.

Firstly, many universities in Indonesia need more infrastructure for effective waste management (Oh & Hettiarachchi, 2020). This includes inadequate waste collection facilities, a need for more recycling bins, and insufficient waste treatment plants. For example, Universitas Indonesia has emphasized the need for more comprehensive waste management systems to handle the growing volume of waste generated on campus (Rimantho et al., 2021). Secondly, low awareness and engagement among students, faculty, and staff are a significant barrier to effective waste management. Studies have shown that many academic community members need to practice proper waste separation or recycling, primarily due to a need for more education and awareness regarding the importance of these practices (Bashir et al., 2020). Thirdly, while some universities have implemented waste management policies, the enforcement and implementation of these policies often need to be improved. Policies mandating waste separation are only sometimes strictly enforced, resulting in mixed waste that complicates recycling efforts (Serge et al., 2020). Fourthly, funding is a critical issue for many HEIs in Indonesia. Budget constraints can limit the ability to invest in the necessary infrastructure and programs for effective waste management. This includes the costs associated with establishing recycling facilities, hiring additional staff for waste management, and conducting educational campaigns (Moustairas et al., 2022). Fifth, the rapid increase in student numbers has exacerbated waste generation challenges. For instance, the growing student population at Universitas Gadjah Mada has led to difficulties in effectively managing the resulting waste (Kusumawanto & Setyowati, 2020). A study by Arafah and Wibowo (2018) found that universities in Indonesia generate an average of 0.3 to 0.5 kilograms of waste per student per day, leading to thousands of tons of waste annually. Finally, there needs to be more comprehensive data and research on waste management practices at HEIs in Indonesia. This deficiency hampers the development of effective strategies and policies to address waste management issues comprehensively. This gap makes it challenging to develop targeted strategies and measure the effectiveness of existing programs (Ramdan et al., 2023).

There has been some improvement in Indonesia's efforts to handle waste management problems. Reducing, reusing, and recycling just 14.58% of the nation's waste is accomplished. In contrast, 34.60% is managed using incineration and landfilling, generating a 49.18% national waste management rate (Kubota et al., 2020). The Indonesian government responded to these issues by enacting Circular Letter Number 12 of 2019, which forbade the use of plastic bags and single-use drinking water containers made of plastic (Mahardika & Pratamo, 2024). By 2020, the overall rate was 54.15%, with the waste reduction rate rising to 16.23% and the waste management rate maintaining at 34.60%. By 2025, Indonesia wants to reduce waste by at least 30% and recycle, reuse, and reduce the remaining 70% through effective waste management (KLHK, 2019). This regulation, which applies to educational institutions of all dimensions, shows that the government is taking the initiative to require the education sector to work together to minimize the amount of waste-producing products used. Academic events like meetings, outreach initiatives, training sessions, and the like are specifically prohibited.

Additionally, reducing advertising materials like plastic banners and billboards is important. Several campuses have already improved waste management (Debrah et al., 2021). The concentrated populations and diverse activities within HEIs offer a unique opportunity to implement and model effective sustainability initiatives. For instance:

1. Universitas Indonesia has implemented waste separation bins and conducted educational campaigns to improve waste management on campus. However, challenges remain in achieving full participation and ensuring proper waste separation (Universitas Indonesia Sustainability Report, 2020).
2. Institut Teknologi Bandung has introduced various sustainability initiatives, including waste reduction programs. Despite these efforts, the institution struggles with consistent application of waste management practices across the campus (Institut Teknologi Bandung, 2018).

3. Universitas Gadjah Mada has developed a comprehensive sustainability strategy that includes waste management. The university has launched composting programs and recycling initiatives but continues to face challenges related to the high volume of waste and limited infrastructure (Universitas Gadjah Mada, 2019).
4. Universitas Negeri Malang has launched green campus movement start in 2019. The university launched recycling and composting that part of waste management but still lake of infrastructure (UMgreencampus report, 2020).

Given their substantial size and influence, universities can serve as microcosms for testing and refining sustainability practices before scaling them up to larger communities. For example, comprehensive recycling programs, waste separation initiatives, and composting schemes can be piloted within campus settings to assess their effectiveness and gather data on best practices (Torrijos et al., 2021).

Moreover, educational institutions are critical in fostering environmental stewardship among students, faculty, and staff. By integrating sustainability into the curriculum and campus operations, HEIs can educate future leaders and professionals about the importance of sustainable practices (Leal Filho et al., 2019). This integration can take several shapes, from practical activities like green campus operations and student-led sustainability projects to academic courses on environmental science and policy(Murray, 2018). However, implementing effective waste management and sustainability initiatives in HEIs takes time and effort. This includes the need for substantial initial investments, ongoing operational costs, and securing buy-in from all stakeholders within the institution.

Additionally, varying levels of awareness and engagement among the campus community can impact the success of these programs (Johnson & Stage, 2018). The academic community's active participation is essential to successfully implementing this waste reduction strategy. Given the possible effects of waste separation and recycling intentions (WSRI) on the environment, the economy, and society, it is crucial to understand how the academic community behaves. By studying and supporting effective waste separation and recycling practices, many problems can be solved, and major advantages can be realized.

1.2. Review of existing research

Effective waste disposal in universities is crucial for promoting sustainable behaviors and minimizing the ecological impact of academic grounds. This is in line with the wider purpose of education in nurturing awareness of the environment and advocating for sustainability, which has become more important in tackling worldwide environmental issues. Education plays a crucial role in fostering environmentally conscious attitudes and behaviors, which are necessary for reaching sustainable development targets (Kopnina, 2020). Research shows that environmental education increases understanding of environmental issues and provides individuals with the knowledge and abilities to make informed choices and take responsible actions for the environment (Zsóka et al., 2013). The main goal of environmental education is to increase comprehension of environmental problems and encourage a sense of responsibility in students. Efficient environmental education helps people examine their relationship with the environment and promote sustainable behaviors. This method assists in connecting awareness with action, allowing individuals to turn their understanding into impactful environmental actions (ElHaffar et al., 2020). A key result of environmental education is influencing people's behavior, as they gain knowledge about environmental issues and acquire the drive and abilities to participate in pro-environment actions. Education is essential in addressing these factors by imparting knowledge and cultivating the attitudes needed for sustainable behavior (Z. Liu et al., 2021).

Recent studies highlight the importance of incorporating environmental education into traditional education systems to reach sustainable objectives in the long run. According to Karpudewan et al. (2012), students who participate in extensive environmental education programs demonstrate increased environmental literacy and are more inclined to adopt sustainable behaviors. Likewise, studies on practical learning experiences, like outdoor education and hands-on projects, greatly improve students' environmental consciousness and dedication to sustainability (Jose et al., 2017). Moreover, education shapes societal values and norms regarding environmental responsibility (Alfirević et al., 2023). By incorporating sustainability principles into curricula, educational institutions can influence future generations' attitudes and behaviors towards the environment. Universities and schools play a critical role in promoting sustainability by fostering a culture of environmental responsibility and embedding sustainable practices within their operations and educational programs(Menon & Suresh, 2020). However, translating environmental knowledge into behavioral change is not always straightforward. Individuals with high environmental awareness might not engage in pro-environmental behaviors due to barriers such as perceived lack of efficacy or social norms (Carducci et al., 2021). Educational programs need to address these barriers by building self-efficacy, providing social support, and creating enabling environments for sustainable behavior.

Despite the recognized importance of environmental education, challenges still need to be addressed to implement it across diverse educational settings effectively. Issues such as inadequate teacher training, lack of resources, and varying levels of institutional support can hinder the successful integration of environmental education (Margot & Kettler, 2019). The importance of Education for Sustainable Development (ESD) in shaping environmentally responsible behaviors, particularly within higher education institutions, is well recognized. However, there needs to be more comparative studies elucidating various trends related to sustainability processes and their impact on higher education (Gulzar et al., 2023). This systematic review aims to address this gap by exploring how current research trends can inform feasible solutions for improving ESD implementation with a focus on waste behavior. Therefore, this chapter aims to systematically review and synthesize current research trends related to sustainability and waste behavior, identify gaps in the current body of research concerning the implementation and effectiveness of ESD in influencing waste behavior, and propose directions for future research that can address these identified gaps. By achieving these objectives, this study aims to contribute to the body of knowledge on sustainable education practices and provide actionable insights for educators, policymakers, and institutions seeking to enhance the effectiveness of ESD programs in fostering sustainable behaviors. Review existing research using bibliometric analysis to enhance systematic review transparency, completeness, and quality, comprising three phases: identification, screening for eligibility, and inclusion. Initially, a search of the Scopus database identified 252,981 documents related to environmental awareness. After applying filters for publication age (2013-2023), document type, source, language, and publication stage, 19,981 documents remained. During the screening phase, titles and abstracts were reviewed for relevance to behavior changes, narrowing the selection to 302 articles. Further eligibility assessments reduced this to 183 documents that met criteria such as affiliation with developing countries and discussing topics like environmental education, pro-environmental behavior, and sustainability practices. These articles underwent qualitative content analysis, systematically coding texts, images, audio, and video to identify patterns and trends. Using the VOSviewer tool, co-word analysis was conducted to understand research trends and relationships within the literature, with VOSviewer's distance-based mapping and unique algorithms clarifying key term relationships (Harfadli et al., 2024). The dataset was imported from Scopus for research. Information Systems (RIS) and CSV files allow research trends and networks to be created. VOSViewer generates three types of data map visualizations: network visualization, overlay visualization, and density visualization (McAllister et al., 2022). In network and overlay visualizations, nodes (represented as circles) denote frequently discussed keywords extracted from journal titles and abstracts. The size of the nodes indicates the number of publications linked to these keywords—the larger the node, the greater its significance in the metadata. Edges show the relationship between nodes, with shorter distances indicating stronger keyword associations. Network visualization mapping includes clustering, which groups related keywords and represents them with different colors.

1.2.1. Research trend

A research trend refers to the general direction in which a specific field of study or topic is moving over a period of time(Hong et al., 2016). Research trends can indicate the areas that are gaining popularity, the methodologies being used, the topics that are becoming more significant, and the emerging themes within a particular discipline(Wieczorek et al., 2021).

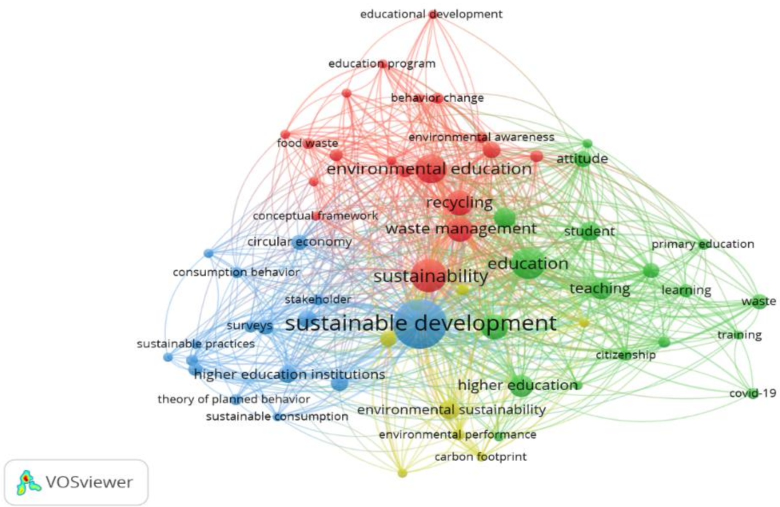


Figure 2. Map of research cluster

The VOSviewer visualization map provided illustrates the research trends and relationships within the field of sustainability and education(Yang & Thoo, 2023). The keyword "Sustainable Development" is at the center of the map, represented by the largest node, indicating its high prominence and central role in the research field. It is closely connected with numerous other keywords, suggesting that sustainable development is a foundational concept linked to various aspects of sustainability research. Similarly, "Sustainability" is another central node, highlighting significant research focus and its strong association with other key concepts, further emphasizing the interconnectedness and importance of these themes within the field.

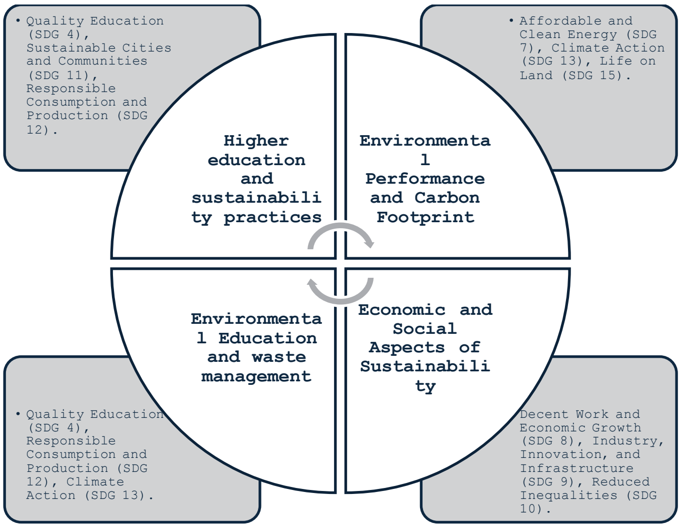


Figure 3. Cluster to Sustainability: Education, Waste Management, and Economic Impacts

The map reveals several distinct clusters, each representing a group of related research topics. These clusters are color-coded to differentiate between various themes.

1. The Red Cluster focuses on Environmental Education and Waste Management, showing a strong research interest in how education promotes environmental awareness and pro-environmental behaviors. Keywords like "behavior change," "environmental awareness," "recycling," and "waste management" are prominent, indicating extensive research on educating individuals about sustainable waste practices and fostering behavioral changes.
2. The Green Cluster emphasizes Higher Education and Sustainability Practices, highlighting the role of universities and colleges in promoting sustainability. Keywords such as "teaching," "learning," "student," and "education" indicate a focus on integrating sustainability into higher education curricula, while terms like "citizenship," "training," and "waste" suggest research on training students and staff in sustainable practices.
3. The Blue Cluster addresses the Economic and Social Aspects of Sustainability, featuring keywords like "circular economy," "consumption behavior," and "stakeholder," emphasizing sustainable consumption

patterns, stakeholder involvement, and economic frameworks supporting sustainability. Keywords associated with higher education institutions in this cluster indicate their influence on sustainable economic practices.

4. Lastly, the Yellow Cluster focuses on Environmental Performance and Carbon Footprint, with keywords like "carbon footprint," "environmental sustainability," and "environmental performance" suggesting research on measuring and improving the environmental performance of institutions. The link with "sustainable consumption" highlights studies on reducing carbon footprints through sustainable consumption behaviors.

1.2.2. Interconnectedness and Interdisciplinary

The dense web of connections among keywords signifies a high level of interdisciplinarity in sustainability research(Mejia et al., 2021). This means that studies often explore the intersections between different areas, such as education, environmental management, economic practices, and social behaviors. Strong connections between nodes such as "environmental education," "sustainability," and "student" highlight the direct impact of educational initiatives on student engagement with sustainability issues.

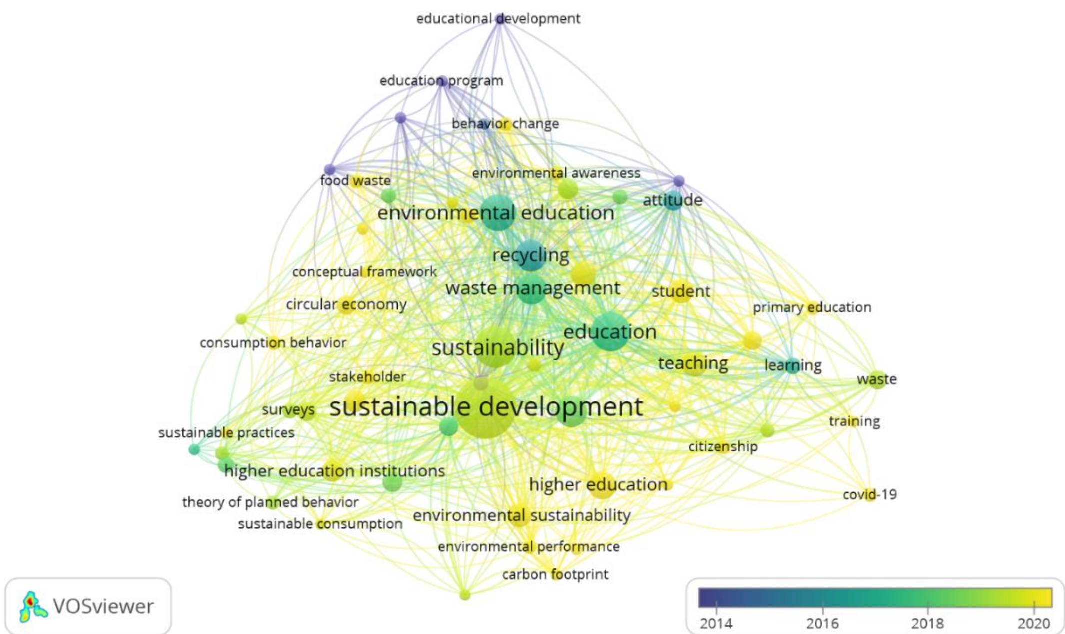


Figure 3. Trend of research year

The data reflects several notable trends in research focus over the years, particularly in the fields of environmental and educational studies. Here's an analysis of the trends by publication year:

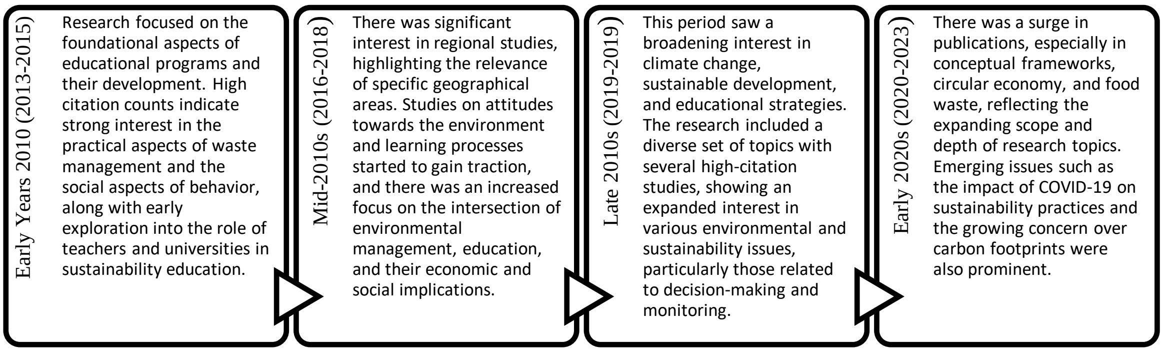


Figure 4. Sustainability Education Research: Trends and Focus Areas

The analysis of research trends over the years highlights several notable shifts in focus within the fields of environmental and educational studies. In the early years, research predominantly centered on developing foundational aspects of educational programs, particularly emphasizing waste management and the social aspects of behavior. During the mid-2010s, there was a significant rise in regional studies, with increased attention on attitudes towards the environment and the intersection of environmental management, education, and their economic and social implications. The late 2010s saw an expanded interest in climate change, sustainable development, and educational strategies, with high-citation studies exploring diverse environmental and sustainability issues, especially in decision-making and monitoring. Finally, in the early 2020s, there was a notable surge in publications on conceptual frameworks, the circular economy, and food waste, reflecting the growing complexity and depth of research topics. Emerging issues such as the impact of COVID-19 on sustainability practices and the heightened concern over carbon footprints also gained prominence. These trends underscore the evolving nature of research priorities in response to global environmental challenges and the increasing integration of sustainability into educational discourse.

1.2.3. Research density

The concept of density in this context likely represents the concentration of research or the intensity of focus within each thematic area. High density in Sustainable Development, with the highest density of 284, underscores its central role in current research trends. Labels such as education, student, and teaching also exhibit high densities, indicating a significant research focus on the educational aspects of sustainability. This trend suggests that researchers increasingly recognize the crucial role education plays in fostering sustainable behaviors and attitudes among students and future generations. While some environmental topics like waste management and recycling show high densities, others like environmental performance and carbon footprint have moderate densities, suggesting diverse but crucial areas of interest. Lower-density labels such as educational development, COVID-19, and sustainable practices represent emerging or specialized research areas, indicating potential growth in future research efforts. This comprehensive exploration reflects how educational strategies can be leveraged to promote sustainability.

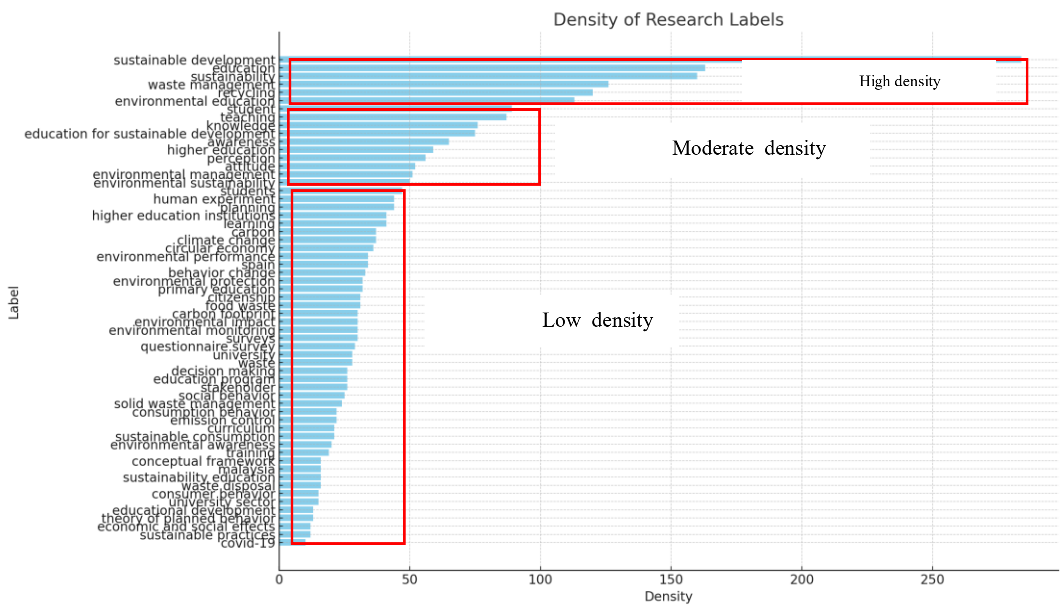


Figure 5. Research density based on labels

On the other hand, environmental topics such as waste management and recycling also show high densities, indicating a strong research emphasis on practical and actionable sustainability practices. This focus aligns with the growing need for effective strategies to manage environmental impacts and promote circular economy principles. In contrast, topics like environmental performance and carbon footprint exhibit moderate densities, suggesting that while these areas are recognized as important, they may not yet be the primary focus of most of the sustainability research. Nonetheless, these moderate densities highlight these areas as crucial but diversified fields that require continued attention and development. Labels with lower densities, such as educational development, COVID-19, and sustainable practices, represent emerging or specialized research areas. The lower density in these labels suggests that they are currently less explored but have significant potential for growth in future research efforts. For instance, the impact of COVID-19 on sustainability practices is a relatively new area of inquiry that is likely to gain more traction as the long-term effects of the pandemic become clearer.

1.2.4. Gap and opportunities of research

The chart highlights the concentration of research efforts across various labels. By examining the lower-density areas, we can identify potential gaps where future research might be valuable. Here are some areas with lower research density that could benefit from increased focus:

Table 1. Gap and opportunities of research.

Label	Density	Gap	Opportunity	Direct interaction with
Sustainable Practices	12	Limited research on specific sustainable practices.	Investigate specific sustainable practices and their implementation in different sectors.	• Circular economy • Higher education institute • Recycling • Student • Sustainable development
Economic and Social Effects	12	Sparse research on the broader economic and social impacts of sustainability initiatives.	Explore how sustainable development affects economic growth, social equity, and community resilience.	• Higher education institution • Sustainable development • Teaching • Consumer behavior

Label	Density	Gap	Opportunity	Direct interaction with
Theory of Planned Behavior	13	Lower focus on theoretical frameworks driving sustainable behavior.	Further study the theory of planned behavior to understand the psychological factors influencing sustainable actions.	• Sustainable development • Environmental education • Sustainable consumption • Student • Consumption behavior • Decision maker
Educational Development	13	Less study on the development of educational programs.	Focus on innovative educational programs and strategies promoting sustainability from early education through higher education.	• Environmental education • Solid waste management • Sustainable development • Student • Recycling
University Sector	15	Limited research on the role of universities in promoting sustainability.	Examine how universities can lead in sustainability practices and influence local communities and policies.	• Higher education institutions • Sustainable development • Student • Stakeholder
Waste Disposal	16	Less concentrated research on waste disposal practices compared to waste management.	Explore innovative waste disposal methods and their environmental impact.	• Sustainable development • Environmental awareness • Environmental education • Waste management • Food waste • Higher education institutions • Student • Stakeholder • Consumption behavior

Analyzing research densities in sustainable practices, economic and social effects, and the Theory of Planned Behavior (TPB) reveals significant insights and opportunities for future research. Despite a moderate level of research activity in sustainable practices, there remains a notable gap in the detailed study of specific sustainable practices and their implementation across different sectors. This gap allows researchers to investigate how these practices can be effectively integrated into various industries, higher education institutions, and recycling initiatives, ultimately contributing to broader sustainable development goals. Similarly, research on economic and social effects shows sparse exploration of how sustainability initiatives impact economic growth, social equity, and community resilience. This underlines the need for studies that assess the wider implications of sustainability efforts, particularly within higher education settings where these impacts can be critically examined and modeled.

TPB, with a slightly higher density of 13, indicates a strong interest in the theoretical underpinnings of sustainable behavior. However, more comprehensive studies on the psychological factors driving these behaviors are still needed. Further research leveraging TPB could provide deeper insights into how attitudes, subjective norms, and perceived behavioral control influence sustainable actions, thereby informing more effective environmental education programs and policy interventions. Addressing these gaps through targeted research can enhance our understanding of sustainable practices, economic and social impacts, and the psychological drivers of sustainable behavior, ultimately supporting the development of robust strategies for promoting sustainability in various contexts. The Educational Development category, with a density of 13, indicates a relatively low focus on developing innovative educational programs and strategies for promoting sustainability from early education through higher education. This presents a significant opportunity to enhance environmental education, solid waste management, and sustainable development initiatives by engaging students and integrating recycling practices. The University Sector, with a density of 15, highlights limited research on the role of universities in promoting sustainability. Universities have the potential to lead sustainability practices, influence local communities, and shape policies, thus requiring deeper investigation into their impact on sustainable development and student engagement. Waste Disposal, with the highest density of 16, suggests that while there is a considerable amount of research in this area, it needs to be more concentrated on innovative waste disposal methods than waste management practices. This gap points to the need to explore new waste disposal techniques and assess their environmental impacts, which can significantly contribute to sustainable development, environmental awareness, and education. Addressing these gaps through targeted research can enhance our understanding of how educational programs, university initiatives, and innovative waste disposal methods can collectively advance sustainability goals, effectively influencing stakeholders, students, and consumption behaviors.

The analysis of research densities and trends over time underscores the evolving priorities within environmental and educational studies. The high density of studies on sustainable development reflects its central role in current research, emphasizing the importance of integrating sustainability into various educational and practical frameworks. High-density areas such as education, student engagement, and teaching highlight a significant focus on the educational dimensions of sustainability, suggesting that educational strategies are pivotal in promoting sustainable behaviors and attitudes. Moderate-density topics like environmental performance and carbon footprint indicate crucial yet less dominant research areas, suggesting that while these topics are important, they require further exploration to match the prominence of other sustainability issues. Lower-density areas, such as educational development, the impact of COVID-19 on sustainability practices, and specific sustainable practices, represent emerging or specialized fields with significant potential for future research. Research in these areas can provide deeper insights into how specific sustainable practices can be implemented across different sectors, how sustainability initiatives impact economic growth and social equity, and how psychological factors influence sustainable behaviors.

Furthermore, the table highlights the need for innovative educational programs and strategies to promote sustainability from early education through higher education. It also points to the potential of universities to lead sustainability practices and influence local communities and policies. Additionally, there is a call for more concentrated research on innovative waste disposal methods compared to waste management practices, emphasizing these methods' environmental impact and sustainability. Addressing these research gaps through targeted studies can enhance our understanding of sustainable practices, economic and social impacts, and the psychological drivers of sustainable behavior. Future research should focus on detailed studies of specific sustainable practices, investigating how these can be effectively implemented across different sectors, including exploring innovative waste disposal methods and their environmental impacts. It is crucial to investigate the psychological factors influencing sustainable behaviors, delving into how attitudes, subjective norms, and perceived behavioral control impact sustainable actions to inform more effective environmental education programs and policy interventions. There is also a significant opportunity to develop and evaluate innovative educational programs and strategies that promote sustainability, integrating these into curricula from early education through higher education and assessing their effectiveness in fostering sustainable behaviors and attitudes. Additionally, research should examine how universities can lead sustainability practices and influence local communities and policies, exploring the impact of university-led sustainability initiatives on local communities and integrating sustainability into their operations and educational programs.

Research on waste management within HEIs has been growing, reflecting the increasing importance of sustainability in educational settings. Studies such as those by Filho and Will (2016) highlight the critical role of HEIs in advancing sustainability initiatives and managing waste effectively within campus environments. Alshuwaikhat and Abubakar (2008) assess current environmental management practices in HEIs, emphasizing the importance of integrated waste management strategies for achieving campus sustainability. Zhang and Li (2018) review the challenges and opportunities in implementing sustainable waste management practices in HEIs, highlighting the growing research and initiatives in this area. Gallo and Anttonen (2014) explore how integrating sustainability into HEI curricula can lead to better waste management practices and overall campus sustainability. Gümüş and Özer (2017) discuss various waste management practices adopted by HEIs globally, underscoring the increasing emphasis on sustainability in educational settings. Additionally, Lukman, Lozano, and Huisingh (2013) identify the drivers and barriers to implementing sustainable waste management systems in universities, contributing to the expanding body of research on this topic. This review synthesizes the existing literature on waste management practices, challenges, and opportunities in HEIs. HEIs, often comparable in size to small municipalities, generate substantial amounts of waste. Research indicates that waste management in these institutions is crucial not only for reducing environmental impact but also for educating and engaging the academic community in sustainable practices (Kumari & Dutta, 2024). Universities serve as microcosms where innovative waste management strategies can be tested and refined before being applied more broadly. Many universities have implemented waste separation and recycling programs as foundational elements of their waste management strategies.

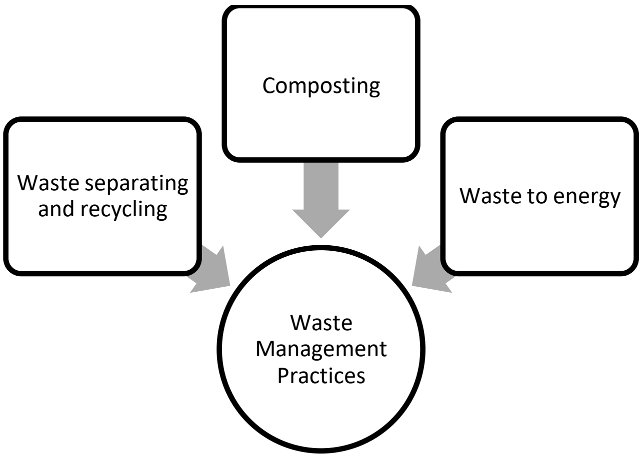


Figure 6. Waste Management in Higher education.

These programs typically involve separating recyclables, compostables, and landfill waste at the source. Studies such as those by Bartelings et al. (2005) highlight the effectiveness of these initiatives in reducing the volume of waste sent to landfills. Composting: Composting organic waste, particularly food waste from cafeterias and dining halls, has become common. Composting reduces waste and produces valuable compost that can be used in campus gardens and landscapes (Fisher, 2013). For example, the University of British Columbia's composting program has significantly reduced its organic waste footprint (UBC Sustainability, 2020). Waste-to-Energy: Some HEIs explore waste-to-energy technologies to convert waste into usable energy. This approach helps reduce the volume of waste and provides a renewable energy source. Institutions like the University of California, Davis have implemented waste-to-energy projects with promising results (UC Davis, 2021).

One of the main challenges in waste management at HEIs is the lack of adequate infrastructure and funding. Establishing comprehensive waste management systems requires significant financial investment, which can be a barrier for many institutions (Susanty, 2016). Community engagement and behavior: Engaging the campus community and changing behaviors are crucial for the success of waste management programs. Research by Ardi and Yanti (2018) indicates that awareness and participation in waste separation and recycling are often low, requiring sustained educational and engagement efforts. Policy and regulation: While some universities have established waste management policies, implementing and enforcing these policies can be inconsistent. Effective waste management requires clear guidelines and rigorously enforced regulations (Nugroho et al., 2019).

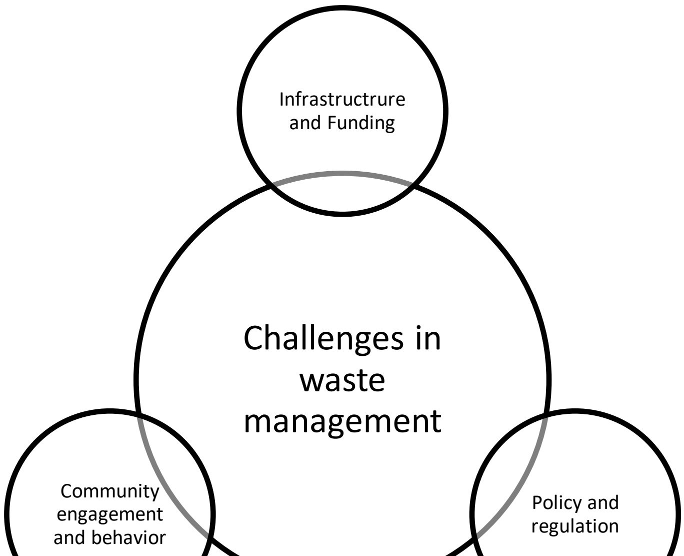


Figure 7. Challenges in waste management in Higher education institutions

Case Studies Universitas Indonesia: Universitas Indonesia has made strides in waste management by implementing waste separation bins and educational campaigns. However, challenges remain in achieving full participation and ensuring proper waste separation (Universitas Indonesia Sustainability Report, 2020).

1.3. Objectives of research

This study emphasizes the importance of involving student pre-service teachers (PSTs) in higher education with sustainable waste management. PsTs are people enrolled in formal education programs and training to become licensed teachers (Mpu et al., 2022). They are currently enrolled in teachers' education programs at colleges, universities, or other institutions, but they still need to graduate from their training or obtain their teaching certifications. By doing this, these programs can encourage PsTs to adopt environmentally conscious behaviours and successfully teach them about the significance of sustainable waste management. This study also emphasizes how crucial it is for universities to launch campaigns that inform people about the ecological damage waste causes to the environment and encourage ecologically conscious behavior. Environmental knowledge (EK) are necessary for the effective implementation of sustainable waste management strategies at higher education institutions, as is individual participation in these programs (Debrah et al., 2021; Fagnani & Guimarães, 2017; Tangwanichagapong et al., 2017; Yusuf & Fajri, 2022). Institutions can help achieve environmental sustainability goals and open the door to a more sustainable future by considering these aspects. PsTs have played an essential part in encouraging sustainable waste management methods, given their future role in educating elementary and high school students. (Brandt et al., 2021; Echegoyen-Sanz & Martín-Ezpeleta, 2021; Tomas et al., 2017). It is ensured that PsTs can teach their students these crucial concepts in an efficient manner by working specifically with students. This highlights the importance of giving PsTs the knowledge, skills, and attitudes needed to support sustainable waste management practices. PsTs can inform students about the significance of sustainable waste management and encourage them to adopt environmentally conscious behaviours by introducing EE into their training programs(Goulgouti et al., 2019; Nousheen et al., 2020; Thu et al., 2021). This observation also highlights how important it is that PsT education programs prioritize EE and make sure future teachers have the abilities and know-how to support environmentally friendly classroom waste management techniques. The views of PsTs towards waste separation and recycling are an important subject of study, as these instructors have a crucial role in influencing future generations' environmental attitudes and behaviors. This is a noticeable gap in the present literature. Understanding them can help create successful projects and programs for EE(Almulhim & Abubakar, 2021; Liao & Li, 2019). Furthermore, as PsTs eventually evolve into teachers, their environmental attitudes and behaviors could be transferred to their students. To ensure that future generations have the information and abilities to support sustainable development, we must look at their intentions toward WSRi.

The specific requirements and objectives of PsTs have yet to be addressed in previous studies, which has resulted in the insufficiency of commitment and participation. (Bock et al., 2021; Torsney et al., 2019).

As potential educators, pre-service teachers in Indonesia are likely to have different factors influencing recycling and waste separation behavior than the general public because of their specific educational background, professional responsibilities, and requirements related to their duties. These variations must be understood to tailor interventions, lesson plans, and policy initiatives that address the different advantages and difficulties that aspiring educators encounter in waste management and ecological sustainability. Implementing successful EE programs and efforts can be challenging due to the lack of research in this field, this further limits our comprehension of the factors influencing their views towards recycling and garbage separation. More study is required to completely understand the attitudes and behaviors of these teachers towards the environment to ensure that future generations have the skills and knowledge necessary to promote sustainable development. (García-González et al., 2020; Minott & Minott, 2022; Nousheen et al., 2020). Its main goals are to assess and describe the factors that affect PsTs' on campus and to analyse the effects of EE, EK, and facilities on WSRIs.

1.4. Scope of this study

This effort aimed to get more insight into how waste separation and recycling intentions on campus are impacted by environmental education, environmental knowledge, and facilities. This campus was selected due to its participation in the green campus program. Malang City is recognized as one of the locations labeled the City of Education. A "green campus" is a university or college campus dedicated to sustainability and environmental concerns (Anthony Jr., 2021). The phrase refers to a range of initiatives and programs designed to improve the environmental impact of campuses and promote ecological responsibility. The UM Green Campus focuses on challenges like reducing waste, conserving water, improving energy efficiency, and promoting environmentally friendly transportation. Mainly this research aims at:

1. To assess the impact of environmental education, knowledge, and facilities on separation and recycling behavior for pre-service teachers in higher education institutions.
2. To pilot the questionnaire to a wider population and compare the results.

These aims focus on understanding how various educational and infrastructural factors influence the recycling and waste separation behaviors of pre-service teachers, and subsequently testing and refining the research tools by broadening the participant base.

1.5. Structure of this study

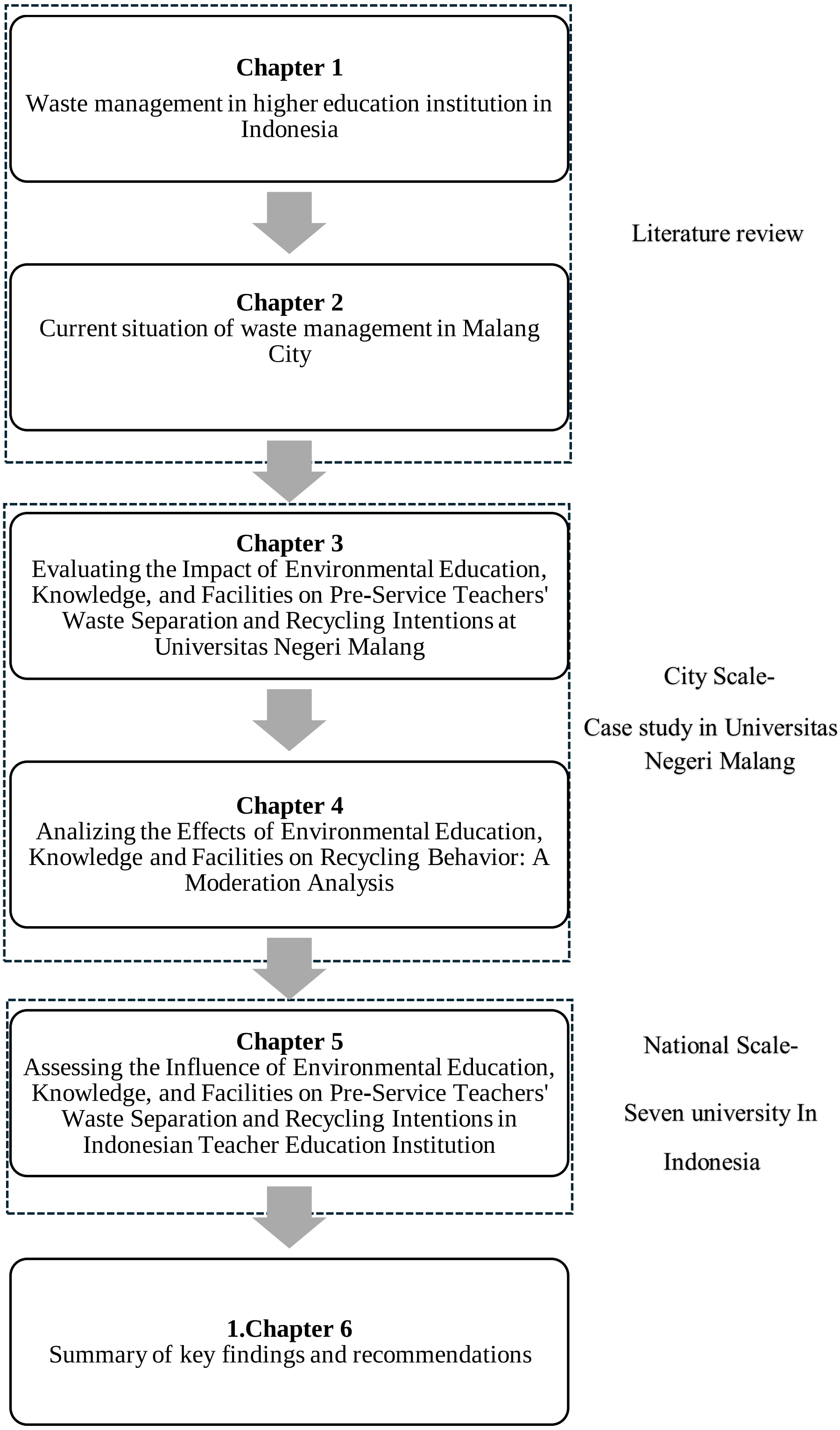


Figure 8. Structure of dissertation.

Chapter 2 Current Situation of The Waste Management In Malang City

2.1. Introduction

In Indonesia, there is a pattern for some areas or cities—particularly those on Java—to become recognized destinations for higher education. Initially, the cities that became favorite places for students to pursue higher education or study in Java were Yogyakarta, Jakarta, Bandung, and Surabaya. However, during the past several years, it has been able to compete with other cities on the island of Java, where Malang City has seen a growth in the number of students enrolled. The City of Malang, East Java, with a geographical size of 110.06 square kilometers, is divided into five districts and 57 sub-districts (BPS et al., 2013). Malang has a permanent population of 867,832 and approximately 300,000 temporary residents, likely due to students and seasonal workers (Malang City Government, 2013). The city's climate is mild, with temperatures between 22.7°C and 25.1°C (BMKG, 2013). In 2013, Malang experienced significant economic growth of 7.57% and had a Human Development Index (HDI) of 77.99, reflecting advancements in life expectancy, education, and per capita income (BPS et al., 2013). The accompanying map illustrates Malang's administrative layout, highlighting key infrastructure such as roads, schools, hospitals, and public facilities and providing a comprehensive snapshot of the city's socio-economic and geographical context.

Data processed from various sources indicate that in 2022, Malang City had approximately 62 public and private universities. Of these, 62, five state and 57 private universities (BPS et al., 2022). In 2022, the number of active students in universities in Malang City amounted to around 330 thousand students, including new and returning students. Students from Malang City's public and private universities are included in this total. These thirty thousand students are specifically enrolled in several significant private universities and five state universities in Malang City. Malang City's reputation as a hub for higher education offers a great chance to raise the standard of living for locals. To the greatest extent possible, the benefits to the local population in Malang City from the presence of students from around the nation must be managed. While the influx of students can have positive impacts, it can also bring about negative effects. Therefore, it is essential to conduct special studies on the positive and adverse impacts of the student presence in Malang City (Malang City Government, 2022).

No	Source of Waste	population	Tons/day
1	Residents of Malang City	898,558	449.28
2	Non-residents (Visitors)	300,000	150.00
3	Roads, Commercial Areas, Markets, and Industries		44.93
4	Others		15.00
	The total waste generated amounts		659.21

Figure 9. The contributions from various sources of waste

Total waste generation in Malang City, contributions from various sources. The data shows that the population of Malang City, which is 898,558 residents, generates approximately 449.28 tons of waste per day, assuming an average waste production of 0.5 kg per person. Additionally, the non-resident population, estimated at 300,000, contributes around 150 tons of waste daily at the same per capita rate. Commercial activities, including streets, markets, and industries, contribute another 44.93 tons of waste per day, calculated as 10% of the total waste generated by the resident population. Other miscellaneous sources account for an additional 15 tons of waste daily, bringing the total waste generated in Malang City to approximately 659.21 tons per day. The figure further details that of the total waste generated, around 492.35 tons per day are transported to temporary disposal sites (TPS). Approximately 464.74 tons per day are transported to final disposal sites (TPA). This data underscores the significant waste management challenge faced by Malang City, necessitating effective waste management strategies and infrastructure to handle the large volumes of waste generated daily (Malang City

Government, 2022).

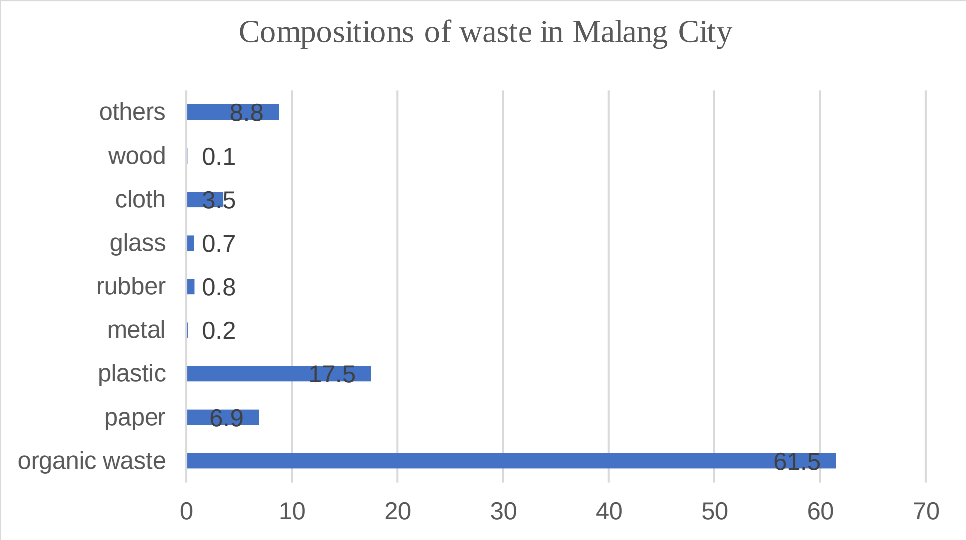


Figure 10. Composition of waste in Malang city

The figure details the waste composition in Malang City, providing a breakdown of daily waste generation by type and quantity. According to the data, Malang City generates 659.21 tons of waste daily. This waste is divided into two main categories: organic (wet) waste and inorganic (dry) waste. Organic waste accounts for 405.41 tons daily, 61.50% of the total waste. In contrast, inorganic waste totals 253.79 tons daily, representing 38.50% of the total waste. The breakdown of inorganic waste includes several subcategories: paper (45.49 tons/day, 6.90%), plastic (115.36 tons/day, 17.50%), metal (1.32 tons/day, 0.20%), rubber/leather (5.27 tons/day, 0.80%), glass (4.61 tons/day, 0.70%), fabric (23.07 tons/day, 3.50%), wood (0.66 tons/day, 0.10%), and other materials (58.01 tons/day, 8.80%). This composition indicates that much of Malang City's waste is recyclable, particularly the large amounts of plastic and paper. The high percentage of organic waste suggests opportunities for composting and biogas production initiatives, which could reduce the burden on landfills and create sustainable waste management solutions (Malang City Government, 2022). To achieve environmental sustainability and improve Malang City's waste management system, it is essential to implement efficient waste separation, recycling initiatives, and organic waste processing. A review of Malang City's waste management system. The figure 11 outlines the waste management flow in Malang City as per Local Regulation 10/2010. It divides the waste management process into three main stages: Collection, Transportation, and Landfill Operations.

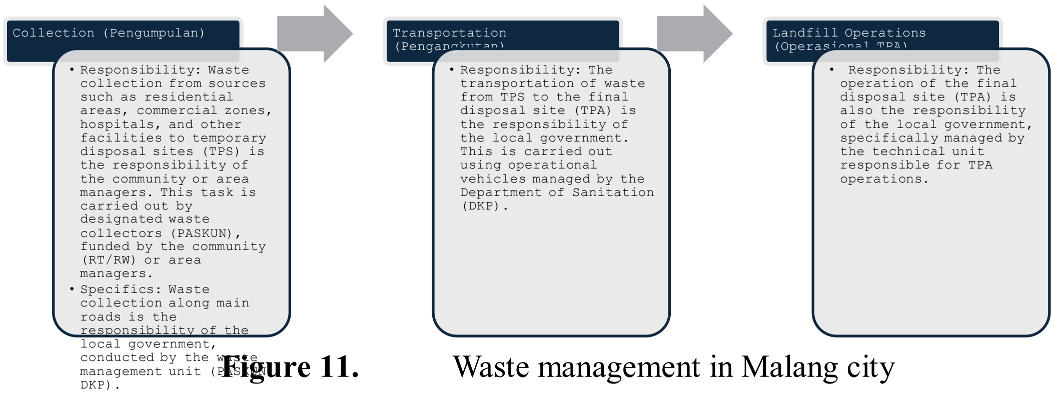


Figure 11. Waste management in Malang city

The waste management system in Malang City, regulated by Local Regulation 10/2010, involves a structured process divided into three critical stages: collection, transportation, and landfill operations. The first stage, waste collection, requires community involvement and funding for waste generated from residential, commercial, and healthcare facilities (Kurniawan et al., 2023). Community and area managers are responsible for this collection, with the local government taking over collection duties along main roads. In the second stage, waste must be transported from interim to permanent disposal locations. The local government manages this duty and uses Department of Sanitation-provided specialized operating vehicles (DKP). The final stage is the landfill operation (TPA), managed by the local government's technical unit. This structured approach ensures that waste management responsibilities are delineated among the community, local government, and technical units, aiming for an efficient and organized waste management system in Malang City.

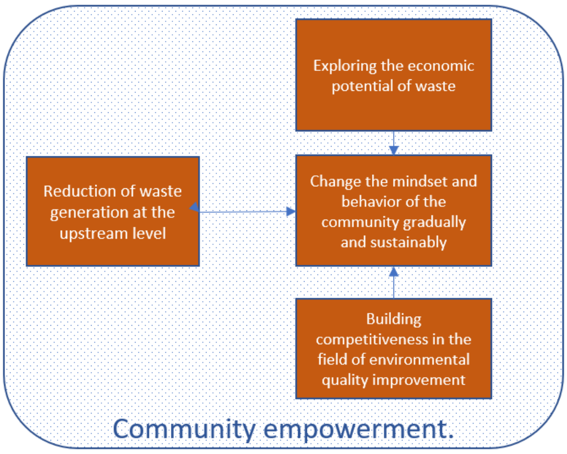


Figure 12. Key focus of Malang City Government in managing waste.

Figure 12 outlines the key focus areas of the Malang City Government in managing waste, highlighting their strategic initiatives and community empowerment efforts. The government aims to reduce waste generation at the source, including households, businesses, and institutions, focusing on minimizing waste before it enters the collection and disposal system. A significant effort is directed towards gradually and sustainably changing the public's mindset and behavior towards waste through educational campaigns and community programs to encourage more responsible waste practices. Additionally, the government seeks to create a competitive environment for improving environmental quality by incentivizing businesses and communities to adopt better waste management practices and compete in achieving sustainability goals. Another focus area is to tap into the economic potential of processed waste, treating waste as a resource to develop economic opportunities through recycling and other waste processing activities. Central to their strategy is community empowerment, involving citizens in waste management processes, including separating waste into organic and inorganic categories at the source to facilitate recycling and composting.

Overall, the Malang City Government's approach to waste management integrates strategic initiatives with community involvement, aiming for sustainable practices and economic benefits from waste processing.

2.2. Waste management movement in higher education in Malang and Global

Waste management is a critical environmental and public health issue, especially in densely populated regions. HEIs in Indonesia, home to large student populations and diverse activities, are significant waste generators. The movement towards effective waste management in Indonesian HEIs has gained momentum in recent years, driven by the need to promote sustainability and environmental stewardship(Sulistiani et al., 2024).

2.2.1. Current practices and initiatives

Many universities in Indonesia have implemented waste separation programs to separate organic and inorganic waste. For instance, Universitas Indonesia (UI) has a comprehensive waste management system that includes waste separation at the source and extensive recycling efforts, aiming to reduce the volume of waste sent to landfills and promote recycling and composting practices (UI GreenMetric, 2021). Several universities have adopted the "Green Campus" initiative, which includes comprehensive waste management strategies. Institutions like Universitas Negeri Malang (UM) and Institut Teknologi Bandung (ITB) have integrated waste reduction, recycling, and educational campaigns into their campus sustainability programs, often involving collaboration with students, faculty, and staff to promote a culture of environmental responsibility (UM Green Campus Initiative, 2022; ITB et al., 2021).

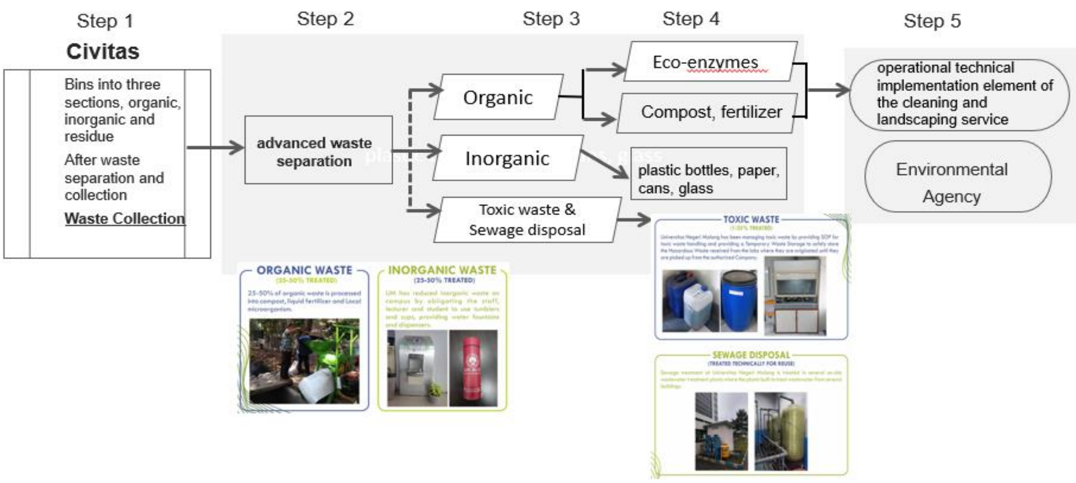


Figure 13. The Waste Management process at Universitas Negeri Malang

The figure 13 illustrates the waste management process at Universitas Negeri Malang, detailing the flow from initial waste collection to final processing and collaboration with the Environmental Agency. Initially, waste is separated into three categories: organic, inorganic, and residue. After segregation, the waste is collected for further processing. The collected waste undergoes advanced separation techniques to distinguish between organic and inorganic materials. Organic waste, which can decompose naturally, is directed towards composting and fertilizer production. Inorganic waste, including recyclable materials like plastic bottles, paper, cans, and glass, is managed through recycling initiatives. Toxic waste and sewage are separated for specialized disposal. Organic waste is treated with eco-enzymes to enhance composting and produce high-quality fertilizer. Toxic waste is managed with proper disposal methods, and sewage is treated thoroughly for reuse. The final processed products, such as compost and recycled materials, are used as part of campus cleaning and landscaping services. The university collaborates with the Environmental Agency to ensure that waste management practices align with environmental regulations and standards. The diagram emphasizes a structured and comprehensive approach to waste management, highlighting the university's commitment to sustainability and environmental responsibility. Additional details include processing 25-50% of organic waste into compost or liquid fertilizer and the management of 25-50% of inorganic waste through recycling. Toxic waste is handled with specific protocols to prevent environmental contamination, and sewage is treated to meet safety standards and reused where possible.

HEIs have been proactive in conducting educational campaigns to raise awareness about waste management, regularly organizing workshops, seminars, and campaigns focusing on the 3Rs (Reduce, Reuse, Recycle) to educate the campus community on the importance of waste separation and sustainable practices (Alshuwaikhat & Abubakar, 2008).

Table 2. Current practices and challenges of waste management in Indonesia

Name of University	Practises	Challenges
Universitas Brawijaya	**Green Campus Program:** The program includes Zero Waste Day Ozone Layer Protection Food Waste management and Tree planting Car free day **Number of students : 59.635**	Residents feel uncomfortable about the environmental hygiene and the lack of the type of trash. According to the number of plants within the population of Brawijaya University that it is still less in number. Dumpster area is also seen less extensive.
Universitas Negeri Malang	**Green campus Program** car free day, one million trees program, food security by planting sweet potatoes on campus Bike sharing, **Number of students : 33.632**	awareness of sorting waste in the provided place is still low, many use private transportation of motor vehicles rather than cycling or walking.
Universitas Muhammadiyah Malang	**Green campus Program** Reduce parking area by building multi-storey parking lots. Provide sterile and safe ready-to-drink water taps at several points in the campus area. Operating electric cars for on-campus public transportation Construction of integrated TPS for waste management. Construction of Micro Hydro Power Plant (PLTMH), Solar Panel, Biogas. **Number of student :35.204**	The cost of establishing recycling facilities, hiring additional staff for waste management, and running educational campaigns

Table 2 presents a detailed comparison of sustainable campus programs and the associated challenges at three prominent universities in Malang, Indonesia: Universitas Brawijaya, Universitas Negeri Malang, and Universitas Muhammadiyah Malang. Universitas Brawijaya, with a student population 59,635, has implemented a comprehensive Green Campus Program that includes initiatives such as Zero Waste Day, Ozone Layer Protection, Food Waste Management, Tree Planting, and Car-Free Day. Despite these efforts, the university faces significant challenges, including residents' discomfort with environmental hygiene and needing more trash management. There is also a notable disparity between the number of plants on campus and the large student population, making the dumpster areas appear less extensive and well-managed. Universitas Negeri Malang, hosting 33,632 students, also promotes a Green Campus Program featuring activities like Car-Free Day, the One Million Trees Program, food security initiatives by planting sweet potatoes on campus, and a bike-sharing system. However, the university must improve with low student awareness regarding waste sorting in designated areas.

Additionally, many students prefer using motor vehicles over cycling or walking, undermining the bike-sharing initiative and contributing to higher carbon emissions on campus. Universitas Muhammadiyah Malang, with 35,204 students, has made significant strides in its Green Campus Program by reducing parking areas through the construction of multi-story parking lots, providing safe and sterile ready-to-drink water taps at various campus points, and operating electric cars for on-campus public transportation. Furthermore, the university has invested in constructing integrated TPS (Temporary Disposal Sites) for waste management and renewable energy projects such as Micro Hydro Power Plants (PLTMH), Solar Panels, and Biogas. Despite these advancements, the university faces substantial financial challenges. The costs associated with establishing and maintaining recycling facilities, hiring additional staff for waste management, and running continuous educational campaigns to promote environmental awareness are significant hurdles. These universities' sustainable initiatives reflect a broader commitment to environmental responsibility and sustainability in higher education institutions in Indonesia. Universitas Brawijaya's focus on waste management and environmental protection through activities like Zero Waste Day and Ozone Layer Protection highlights the importance of comprehensive programs in fostering a green campus culture. Universitas Negeri Malang's initiatives, particularly the One Million Trees Program and bike-sharing, emphasize the critical role of community involvement and behavior change in achieving sustainability goals. The efforts by Universitas Muhammadiyah Malang to integrate renewable energy sources and enhance waste management infrastructure demonstrate the university's dedication to long-term sustainable development.

However, the challenges these institutions face underline the complexities of implementing sustainable practices on a large scale. Universitas Brawijaya's issues with environmental hygiene and waste management infrastructure point to the need for more effective waste management strategies and increased green spaces. Universitas Negeri Malang's low student awareness about waste sorting and reliance on motor vehicles indicates more robust educational campaigns and incentives to encourage eco-friendly transportation alternatives. The financial constraints at Universitas Muhammadiyah Malang highlight the need for sustainable funding models and partnerships to support environmental initiatives.

Additionally, universities are hubs for research and innovation in waste management, with institutions like Universitas Airlangga (UNAIR) and Universitas Diponegoro (UNDIP) exploring new technologies and methods for efficient waste processing and recycling, including biogas production from organic waste and recycling technologies for plastics and paper (UNAIR Research Report, 2022; UNDIP Innovation Journal, 2021). However, one of the significant challenges is the need for adequate infrastructure and funding for comprehensive waste management systems, as many HEIs struggle with the initial costs of setting up waste separation facilities and maintaining recycling programs (Smyth et al., 2010). Changing the behavior and mindset of the campus community towards waste management remains a challenge, as consistent participation in waste separation and recycling programs varies despite awareness campaigns (Kollmuss & Agyeman, 2002). Additionally, there is a need for stronger policies and regulations at the institutional level to enforce waste management practices, as some universities have adopted robust policies. In contrast, others need clearer guidelines and enforcement mechanisms (Zhang & Li, 2018).

Table 3. Current practices and challenges of waste management in HEIs

	Practices	Challenges
ASIA	Waste Separation: Universities in Asia, such as the National University of Singapore (NUS) and the University of Hong Kong (HKU), have implemented waste separation programs. Recycling Initiatives: Recycling programs are being adopted, though they vary in scale and effectiveness. Green Campus Initiatives: Many universities have broader sustainability programs that include waste management as a key component.	Infrastructure: Lack of adequate waste management infrastructure is a significant issue in many Asian universities. Awareness and Engagement: There is a need for greater awareness and engagement in sustainable waste practices among students and staff. Policy and Enforcement: Weak enforcement of waste management policies can undermine efforts.

	Practices	Challenges
United States & Europe	Comprehensive Recycling Programs: Many universities in the United States and Europe have well-established recycling programs. Institutions like Stanford University and the University of Cambridge have extensive waste separation and recycling initiatives. Composting: Composting of organic waste is a common practice. Universities often have on-site composting facilities. Zero Waste Goals: Some universities aim for zero waste, implementing policies to minimize waste generation and maximize recycling and composting. The University of California system has set ambitious zero waste goals.	Cost and Funding: Implementing and maintaining comprehensive waste management systems can be expensive. Behavioral Change: Encouraging consistent participation in waste separation and recycling requires ongoing education and engagement. Regulatory Compliance: Navigating and complying with complex waste management regulations can be challenging.
Japan	Practices: Japanese universities such as the University of Tokyo and Kyoto University have implemented comprehensive waste management systems, emphasizing waste reduction and recycling.	Challenges: Cultural habits related to waste disposal can be difficult to change. High costs associated with advanced recycling technologies.

2.2.2. Comparison and challenges

Globally, HEIs generally have more developed infrastructure for waste management, including advanced recycling and composting facilities. In contrast, infrastructure in Asia varies widely, with some universities having advanced systems while others lack basic waste management infrastructure (Smyth et al., 2010; Zhang & Li, 2018). Regulatory frameworks and enforcement mechanisms are stronger globally, supporting effective waste management. Conversely, while policies exist in Asia, enforcement can be inconsistent, reducing the program's effectiveness (Alshuwaikhat & Abubakar, 2008). Cultural and behavioral aspects also differ; globally, there are higher levels of awareness and engagement in sustainability practices, whereas, in Asia, significant cultural and behavioral changes are needed to improve participation in waste management programs (Kollmuss & Agyeman, 2002). Funding is another point of divergence; globally, HEIs typically have greater access to funding and resources for waste management initiatives, while in Asia, funding constraints often impact the implementation and maintenance of effective systems (Zhang & Li, 2018). Additionally, universities in the US and Europe have led the research and innovation in waste management technologies. There is an increasing focus on research and innovation in Asia, but the region still needs to catch up in developing and deploying new technologies (UNAIR Research Report, 2022).

Chapter 3 Evaluating the Impact of Environmental Education, Knowledge, and Facilities on Pre-Service Teachers' Waste Separation and Recycling Intentions at Universitas Negeri Malang

3.1. Introduction

An individual's intention is the root of their motivation or their intentional decision to engage in a particular behavior. Action, on the other hand, explains how such behavior is put into practice. The vital role of purpose as a factor in behavior is consistent with TPB's theoretical framework. Those who have strong intentions to do so show a greater willingness to separate and recycle waste. This idea includes all the many aspects of decision-making, mindsets, and actions ensuring the effective processing, recycling, and reuse of recyclable materials into the production cycle and their separation from the general waste process. WSRIs can include activities such as separating and classifying recyclables, using recycling bins or containers, participating in recycling activities and programs, and contributing funds to these campaigns. Nevertheless, intention by itself cannot ensure that behavior will follow. In addition, external constraints, conflicting goals, or a lack of resources might make it more difficult for intentions to become behaviors (Cantú et al., 2021). Estrada-Vidal (Estrada-Vidal & Tójar-Hurtado, 2017) Have proposed employing education, especially environmental education(EE), to address these issues. EE is designed to make people more conscious of environmental issues, inspire them to take action, and educate them with both the knowledge and skills needed to make responsible choices(Schild, 2016). By fostering environmental literacy as well as appropriate behavior, EE can significantly contribute to lowering levels of environmental ignorance and irresponsibility(Fang et al., 2022). This type of organization is due to its enormous potential to support sustainable development. These practices can play a critical role in reducing waste and promoting sustainability. It also highlights how important it is for organizations to create and carry out initiatives that promote recycling, reuse, and waste reduction, in addition to informing employees and students about the significance of sustainable waste management practices(Abu Qdais et al., 2019; Hegab et al., 2023). To effectively implement these sustainable waste management strategies in higher education institutions, stakeholders' awareness and proficiency with environmental knowledge are needed (Hendrarso, 2021). Achieving efficient and sustainable waste management requires engaging people and encouraging environmental responsibility (Pandit et al., 2021).

This chapter emphasizes the importance of involving pre-service teachers (PsTs) in higher education to promote sustainable waste management. PsTs, currently training to become licensed teachers, can be equipped with the knowledge and motivation to adopt and teach environmentally responsible behaviors through their education(Mpu et al., 2022). A significant gap in the literature is the limited research on PsTs' attitudes toward waste separation and recycling (WSRi). As future educators, their behavior will influence students, making understanding their intentions toward WSR crucial. This research focuses on the factors affecting PsTs' WSRi behaviors, particularly in Indonesia, where their educational backgrounds and responsibilities may shape their attitudes differently(Bock et al., 2021; Torsney et al., 2019). The study aims to identify the factors influencing PsTs' WSR intentions and examine how environmental education, knowledge, and facilities impact these behaviors on campus.

3.2. Material and method

3.3. Study area

Pre-service teachers are the subject of the study at Universitas Negeri Malang (UM), one of the teacher educational institutions in eastern Java Island, Indonesia, in March 2022. This campus was selected because it participates in the green campus program; a university or college campus committed to sustainability and environmental awareness is called a "green campus" (Anthony Jr., 2021). Malang City is recognized as one of the regions that is termed the City of Education. The expression alludes to several initiatives and plans aimed at reducing the environmental impact of campuses and promoting ecological responsibility. UM Green campus focuses on concerns associated with activities like reducing trash, conserving water, using less energy, and promoting eco-friendly transportation.

3.4. Theory of planned behavior

The Theory of Planned Behaviour (TPB) is a social psychological model designed to explain human behavior and predict the likelihood of people engaging in specific behaviors (Chen, 2016; Nousheen et al., 2020; Yusuf & Fajri, 2022). TPB, extensively utilized in domains like consumer behavior, environmental behavior, and health behavior, was created by Icek Ajzen in the 1980s. According to TPB, perceptions of behavioral control, attitudes, and subjective norms all influence behavior. Attitudes concern an individual's positive or negative assessment of work-related stress factors. In contrast, subjective norms relate to the perceived impact of social pressure and expectations from important people, like family, friends, or professionals (Ajzen, 2020a; Ajzen & Driver, 1991; Davis et al., 2002). When considering internal and external limitations, an individual's perceived ease or difficulty in engaging in behavior is perceived behavioral control(Ajzen, 2020b; Ajzen & Driver, 1991).

TPB is a valid indicator of behavior that has passed comprehensive testing and validation in much empirical research. It has been used in various settings, such as anticipating environmental and health-related behaviors like recycling, energy saving, and behaviors related to physical activity(Linder et al., 2022; Perski et al., 2022; Yuriev et al., 2020). TPB has also been used to guide the development of interventions to change behaviors and promote sustainability(Boca & Saraçlı, 2019; Bock et al., 2021; Tenkasi & Zhang, 2018). To sum up, this comprehensive theory offers a thorough framework for understanding and predicting WSRi in humans. TPB has been proven to be a significant behavior indicator and is widely used in various sectors. It can be applied to create interventions that promote sustainable behavior and help create a more sustainable future. Here, of the results and propose the following hypotheses:

- **H1**: PsTs attitudes (ATT) positively influences the WSRIs.
- **H2**: Subjective norms (SN) influence PsTs WSRIs.
- **H3**: Perceived behavioral control (PBC) influences PsTs WSRIs.
- **H4**: Behavioral intention (BHV) influences PsTs's behavior.

- **H5**: PBC influences PsTs Behavior.

3.5. Environmental knowledge

EK is the term used to describe an individual's understanding of environmental issues and how they influence the natural world and the well-being of humanity (Muafi, 2022) and it is seen as essential in fostering ecological awareness, attitudes, and practices that result in sustainable development. Studies have demonstrated that environmental attitudes and behaviors and EK have a favorable relationship. (P. Liu et al., 2020; Zheng et al., 2018). Higher EK individuals are more likely to participate in recycling programs and energy conservation, among other environmentally friendly activities. EK additionally has the potential to boost environmental literacy and encourage people to take action to protect the environment. It can be obtained in some ways, such as through direct environmental experience, formal education, and informal education. Therefore, the following hypothesis:

- **H6**: PsTs EK has a positive influence on their WSRIs.
- **H7**: PsTs EK has a positive influence on their ATT to WSRIs.

3.6. Environmental education

To enable people to make informed decisions, take action to preserve the environment, and promote sustainability, environmental education (EE) refers to learning about the environment and improving environmental awareness, knowledge, attitudes, and behaviors (Marpa, 2020). EE is addressed by several international environmental agreements and efforts and is seen as a crucial element of sustainable development. EE effectively promotes environmental awareness, knowledge, and behavior [42, 43]. Studies show that Environmental Education (EE) can improve people's understanding of the environment, change their attitudes and behaviours, and encourage them to embrace environmentally responsible practices [44–46].

Furthermore, EE encourages intergenerational justice and ensures that the next generation has the skills and knowledge to make wise environmental decisions. With the belief that educated decision-makers who understand environmental challenges can make choices that improve both the present and future generations(Mensah, 2019). EE can be provided in a number of ways, such as through environmental communication campaigns, community participation initiatives, and formal and informal education (Grigoroglou & Kounani, 2016; Zikargae et al., 2022). EE that is provided through colleges, universities, and schools is referred to as formal education (Williams Middleton et al., 2020), On the other hand, programs and activities provided at parks, museums, and nature centers indicate how informal education is given. Environmental communication campaigns and community engagement initiatives aim to include people and enhance environmental knowledge, awareness, and behavior. Therefore, the developed the hypothesis are as follows:

- **H8**: EE has a positive influence on PsTs EK.
- **H9**: EE has a positive influence on PsTs environmental ATT.

3.7. Facilities

Facilities (FAC), whose availability and shape may impact individuals' choices and behaviors, are critical in building human WSRIs (Shi et al., 2021). (Widayanti et al., 2020). This has significant implications for a number of disciplines, such as environmental psychology, urban planning, and architecture. According to studies [53–55], facilities can influence behavior in various ways. For instance, the structure and design of a facility affect how simple it is to accomplish specific functions and obtain access to specific areas and activities. Additionally, social cues from facilities—such as signs and other visual cues—that promote or inhibit particular behaviors can impact WSRIs. Additionally, they provide settings that encourage or prohibit particular behaviors. Therefore, we propose the following hypothesis:

- **H10**: Perceived satisfaction of facility influences PsTs' WSRIs.

We developed the theoretical model displayed in Figure 11 based on the empirical evidence and theories stated above.

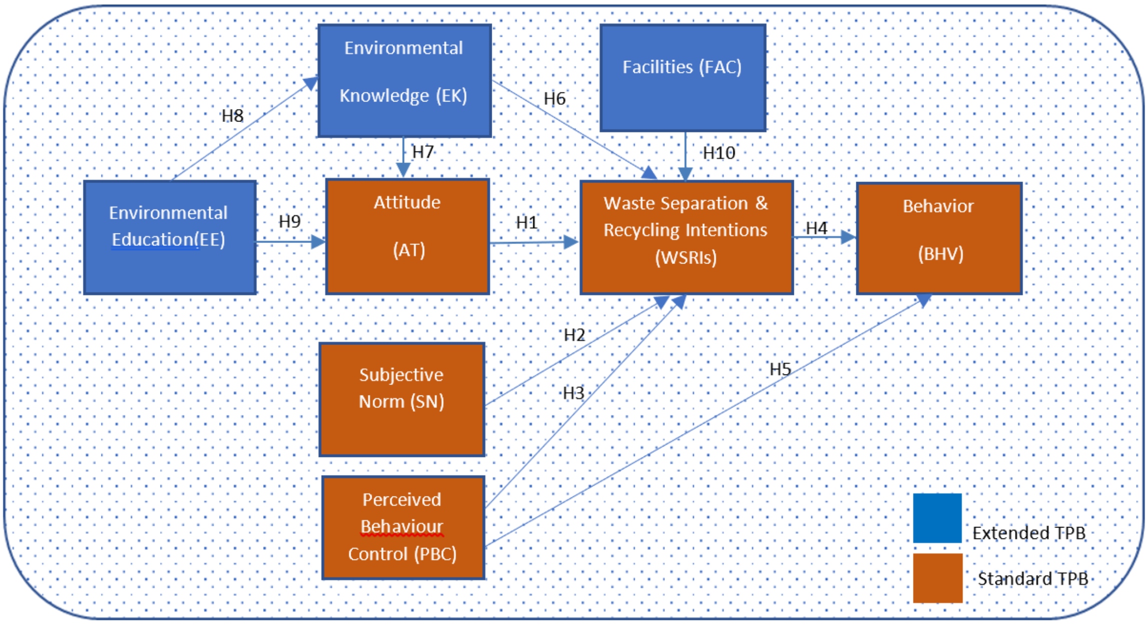


Figure 14. Developed the theoretical model.

3.8. Questionnaire design

The survey had seven measures that evaluated the respondents' interest in participating in WSRIs on campus in addition to independent factors such as facilities (FAC), perceived behavioural control (PBC), attitude (ATT), environmental education (EE), environmental knowledge (EK), and subjective norms (SN). To collect data rapidly and achieve a high response rate, the primary author advised three undergraduate courses (N=30) enrolled in a statistics and data analysis course to undertake a pilot study prior to the survey. The findings showed that the Bartlett's test was significant at $p < 0.001$ and the Kaiser-Meyer-Olkin was 0.945, indicating that the questionnaire data was suitable for factor analysis and that the questions were based on Francis' recommendations and WSRIs (Lubke & Muthén, 2004). Responses were evaluated on a seven-point Likert scale, ranging from" strongly disagree" to "strongly agree", with corresponding coding values of 1 to 7, respectively. A rating of 4 was given to "neither agree nor disagree" [51]. Following Ajzen's guidance, each TPB construct has numerous statement-like components (Ajzen & Driver, 1991) except the demographic information. Questions and their reference are presented in the table 4.

Table 4. Items for each measure.

Constructs	Items	Reference
Attitude (ATT)	Waste separation on campus is reasonable. Waste separation on campus is beneficial. Recycling is useful. Recycling is responsible. Recycling is sensible.	Liang et Al (2021); Zhang et al (2021)
Subjective Norm (SN)	My relatives believe, I should separate waste on campus. My peers believe that I should separate waste on campus. My acquaintances believe I recycle materials. I will recycle materials.	Thakkar JJ (2020)(Ghani et al., 2013)
Perceived Behavior Control (PBC)	I engaged in recycling behavior in the last four weeks. I have engaged in recycling behaviors on campus.	Liang et Al (2021)(Tonglet et al., 2004)
Environmental Education (EE)	I would like the university to include environmental education in the curriculum. I am very interested in environmental issues. I have taken courses on the environment at the university. Environmental education is one of the most important issues facing society today.	Self-Referenced Boca & Saraçlı, 2019; Bock et. al. (2021)
Environmental Knowledge (EK)	I believe environmental issues can be addressed with technology. Separating waste with the intention of developing virtuous behavior is important. Separating waste with the intention of improving the environment is important.	Boca & Saraçlı, (2019)Wu et al (2019) (Wang et al., 2021; Zsóka et al., 2013)
Facilities (FAC)	There are waste sorting facilities on campus. There are waste separation symbols on the bins on campus. The waste sorting bins have sufficient capacity. There is sufficient equipment and containers on campus enable waste sorting.	Janmaimool (2019)(Stoeva & Alriksson, 2017)
Intention to Separate and Recycle (ISR)	I intend to sort plastic waste at disposal in my daily routine. I intend to separate my trash when on campus in the next three months. I intend to separate plastic and food waste while on campus.	Wu et Al (2019)(Wang et al., 2021)

	I tend to recycle my campus waste in my everyday life.	
Behavior (BHV)	I have been consistently recycling recyclable materials. I have been regularly separating my waste.	Thakkar JJ (2020)(Ghani et al., 2013)

3.9. Sampling methodology and data collection

Respondents to this study are students from seven various faculties at UM who are enrolled in the teaching and education program. The target population was divided into two clusters employing cluster random sampling as the methodological framework. Participants from the science and social sciences faculties were chosen randomly from each cluster. When directly sampling individuals would be too costly or challenging, this sampling method is appropriate. A randomization table or random number generator ensures that all individuals in the population have an equal probability of being chosen and removes any potential biases or preferences. Due to limitations caused by the coronavirus epidemic, information was gathered using an online survey. To determine the validity of the questionnaire and provide an ethical statement at the beginning, a pilot survey was first administered using social media platforms, emphasizing consent and ethics. 532 questionnaires were sent out, and 530 were returned, yielding an 89.7% response rate. The answers to this questionnaire will be kept private, and the data will be examined as a whole rather than separately.

Figure 15. Map of Universitas Negeri Malang at east Java, Indonesia

3.10. Statistical analysis

SPSS 26.0 and SPPS AMOS 26.0 were employed in this study to describe and analyze the survey data. Contained of five phases: The research hypotheses and conceptual models are developed through (1) a thorough analysis of the relevant literature and the identification of factors that influence WSRIs; (2) the design of a questionnaire based on the hypotheses and expert opinions, followed by the formal administration of the survey; and (3) the evaluation of data validity and reliability. The Composite Reliability (CR) of all observed variables and Cronbach's alpha (α) of the construct items were calculated to assess the construct's reliability. Factor loading and average variance extracted (AVE) were used to evaluate the construct's convergent validity, and Harman's one-factor test was employed to determine common method bias in the data(Liang et al., 2021); (4) Structural analysis of the hypotheses and the structural equation model's path; (5) recommendations based on the results are presented.

3.11. Result

3.11.1. Descriptive demographic statistics

Along with responding to the PsTs, 530 participants filled out the self-administered questionnaire. Table 5 demonstrates a gender disparity, with 71% of participants female and 29% male. The sample population was made up of over 70% of rural residents. Most respondents (76%) were residents and had monthly salaries under IDR 1,000,000 (IDR is the Indonesian monetary unit, abbreviated as Rupiah). Below is a summary of the respondents' demographics.

Variables		Frequency	Percentage (%)
Sex	Female	380	71
	Male	152	29
Place of origin	Rural	355	67
	Urban	177	33
Residence status	Local	411	77
	Newcomer	121	23
Monthly income	<IDR.1.000.000, -	420	79
	>IDR.1.000.000, -	110	21
Faculty	Natural Science	244	46
	Social Science	286	54

Table 5. Demographic statistics.

3.11.2. Confirmatory factors analysis (CFA)

Before developing the model, we conducted a CFA to assess the dataset's reliability for hypothesis testing. The CFA was carried out using the observed variable data from the questionnaire. The validity and dependability of the variable constructs are assessed using Cronbach's Alpha, Average Variance Extracted (AVE), and Construct Reliability (CR). Reliability and validity tests were conducted to validate this extended model's constructs, as shown in Table 6. The table presents validation metrics for the constructs used in the model, each evaluated based on the number of items included, Cronbach's Alpha, Composite Reliability (CR), and Average Variance Extracted (AVE). Attitude (ATT), consisting of 5 items, has a Cronbach Alpha of 0.95, CR of 0.95, and AVE of 0.79, indicating excellent reliability and validity. Subjective Norms (SN), with 4 items, has a Cronbach Alpha of 0.91, CR of 0.91, and AVE of 0.72, demonstrating strong internal consistency and convergent validity. Perceived Behavioral Control (PBC), with two items, has a Cronbach Alpha of 0.87, CR of 0.87, and AVE of 0.77, indicating good reliability. Environmental Education (EE), including 4 items, has a Cronbach Alpha of 0.90, CR of 0.89, and AVE of 0.67, suggesting good reliability and validity. Environmental Knowledge (EK), comprising three items, has a Cronbach Alpha of 0.84, CR of 0.87, and AVE of 0.69, indicating satisfactory reliability and validity. Facilities (FAC), with four items, have a Cronbach Alpha of 0.91, CR of 0.90, and AVE of 0.70, reflecting high reliability and validity. Intent to Separate and Recycle (ISR), including 4 items, has a Cronbach Alpha of 0.89, CR of 0.89, and AVE of 0.67, indicating good reliability and validity. Behavior (BHV), with two items, has a Cronbach Alpha of 0.76, CR of 0.78, and AVE of 0.65, showing acceptable reliability and validity. The high Cronbach Alpha values across all constructs indicate excellent internal consistency, while the CR and AVE values confirm the constructs' reliability and convergent validity. These metrics validate the robustness of the extended TPB model, supporting its application in understanding and enhancing waste separation and recycling behaviors in educational settings.

Table 6. Validation of constructs for the model developed.

Construct	Number of Items	Cronbach's Alpha	CR	AVE
Attitude (ATT)	5	0.95	0.95	0.79
Subjective Norms (SN)	4	0.91	0.91	0.72
Perceived Behavioral Control (PBC)	2	0.87	0.87	0.77
Environmental Education (EE)	4	0.90	0.89	0.67
Environmental Knowledge (EK)	3	0.84	0.87	0.69
Facilities (FAC)	4	0.91	0.90	0.70
Intent to Separate and Recycle (ISR)	4	0.89	0.89	0.67
Behavior (BHV)	2	0.76	0.78	0.65

3.11.3. Structural model hypothesis testing

This study integrated factor and path analysis with SEM AMOS 26.0 as a data analysis tool to model intricate interactions between variables. SEM is employed because the hypothetical model has numerous routes and intricate connections between latent variables (Khairi et al., 2021). To attain this, the link between EE, EK, and FAC regarding the intention to separate and recycle waste had to be evaluated for configural and metric invariance. The former was verified using Acceptance Goodness of Fit (GoF) values in the unconstrained model. On the other hand, an analysis was conducted on the variation in chi-square values between the restricted and unconstrained models (Mansolf et al., 2020). The research model was examined during the tests for discriminant and convergent validity of each construct, and the hypothesis was evaluated to assess the structural model in the data analysis process. The model fit indices results are shown in Table 7, where all indices fulfill the required criteria, and the differences are statistically significant at the 0.01 level, indicating a satisfactory fit.

Table 7. Model fit indices.

Models	Model Fit Indexes				
Model Fit Indexes	CFI	AGFI	GFI	NFI	RMSEA
TPB Extended	0.976	0.901	0.924	0.953	0.043

(CFI: Comparative fit index, GFI: Goodness-of-fit index, AGFI: Adjusted goodness-of-fit; RMSEA: Root means square error of approximation; NFI: Normed fit index.)

The results of the hypothesis testing are shown in Figure 16 with the path coefficients.

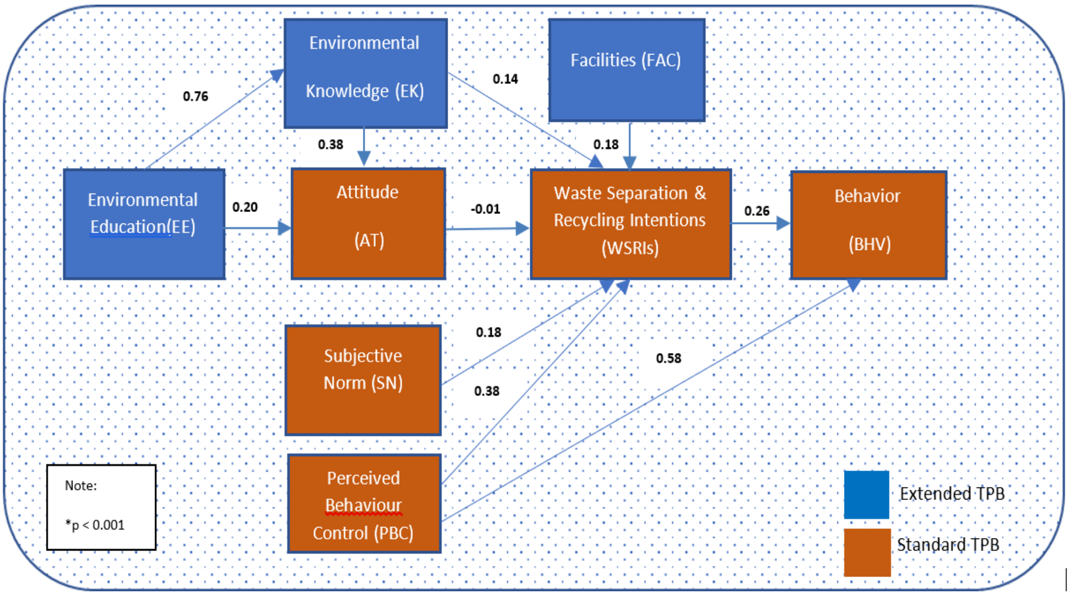


Figure 16. Result of SEM of waste separation and recycling behavior.

All initial TPB hypotheses were significant except for H1, which was rejected due to the negative correlation between attitude (b = -0.01) and WSRIs. On the other hand, PBC (b = 0.38) was positively correlated with WSRIs, supporting hypotheses H2 and H3. Furthermore, there was no apparent relationship between SN and WSRIs. Moreover, BHV was positively correlated with both WSRIs (b = 0.27) and PBC (b = 0.58), supporting H4 and H5. According to the extended TPB model, all of the constructs included in the original TPB model showed substantial beneficial connections. Most notably, EE supported H8 and H9 by positively correlating with ATT (b = 0.39) and EK (b = 0.77). Furthermore, WSRi positively correlates with EK (B=0.32) and FAC (b=0.18), supporting H6 and H7. To summarize, every hypothesis was validated except for ATT's impact on WSRIs.

Table 8. SEM results of extended TPB model

Path	Coefficient	Direct Effect	Indirect Effect	Total Effect
AT --> ISR	-0.12	-0.12		-0.120
SN --> ISR	0.248	0.248		0.248
PBC --> ISR	0.309	0.309		0.309
ISR --> BHV	0.249	0.249		0.249
PBC --> BHV	0.59	0.59	0.077	0.667
EK -->ISR	0.2	0.2	-0.047	0.153
EK --> AT	0.39	0.39		0.390
EE --> EK	0.793	0.793		0.793
EE --> AT	0.224	0.224	0.309	0.533
FAC --> ISR	0.226	0.226		0.226
EE --> ISR	0.095		0.095	0.095
EE --> BHV	0.024		0.024	0.024
FAC --> ISR	0.056		0.056	0.056
SN --> BHV	0.062		0.062	0.062
EK --> BHV	0.038		0.038	0.038
AT --> BHV	-0.03		-0.03	-0.030

3.12. Discussion

The factors impacting pre-service teachers' intentions toward waste separation and recycling were investigated using the expanded TPB. Consistent with previous studies, the model integrates attitudes, subjective norms, perceived behavioral controls, environmental education, environmental knowledge, and facilities. Remarkably, attitudes were not a significant predictor of waste separation and recycling intentions in this study. This finding runs counter to earlier studies' findings that attitudes have a beneficial influence on the intention to separate and recycle, as the original TPB stated (Razali et al., 2020; Sheau-Ting et al., 2016).

The literature analysis revealed contrary findings regarding the connection between intention and attitude. While some researchers indicate no significant correlations, others (Janmaimool & Khajohnmanee, 2019) suggest an important association. (Bechler et al., 2021). When an individual's attitudes towards an object or behavior don't always correspond with their intentions or actual behaviors, it's referred to as the "attitude being unrelated to intention" phenomenon (Itzchakov et al., 2018). Research in social psychology has shown that various factors, such as cultural background, personal views, and social standards, can influence an individual's attitudes and intentions. Furthermore, studies have revealed differences between intentions and attitudes, showing that intentions do not always accurately predict behavior (Jung et al., 2020). For example, someone may be enthusiastic about working out but must be physically active regularly. In a similar vein, someone may feel negatively about smoking but smoke because of things like addiction or peer pressure. This indicates that attitudes are not necessarily reliable indicators of behavior and are, instead, complicated constructions impacted by a variety of factors.

According to the findings of this research, the most significant predictor of an individual's WSRIs is their level of environmental education, indicating that an increased desire to act is correlated with an improved understanding of environmental issues and mitigation techniques. Furthermore, according to P. Liu et al. (2020), there is a favourable correlation between environmental education, environmental knowledge, and attitude. It was observed, nonetheless, that WSRIs were more significantly impacted by environmental knowledge than by attitude. Raising pre-service teachers' (PsTs) environmental knowledge will likely increase their consciousness and encourage them to adopt more ecologically friendly goals. There is a significant correlation between environmental knowledge (EK), attitude (ATT), WSRIs, and environmental education (EE). The hypothesis that increasing environmental knowledge might have a favorable impact on behavior is further supported by the substantial correlation between EE and EK and the beneficial effect of EE on pro-environmental attitudes (Liao & Li, 2019). Prior research has indicated that EE courses on waste management raise awareness of the issue (Debrah et al., 2021; Owojori et al., 2022), Inspiring others to participate in recycling and waste separation. The study's perceived behavioral control (PBC) supports a meta-analysis of research using the theory of planned behavior (TPB) that concluded perceived behavioral control is a strong predictor of intentions and actual behavior. According to Lee and Lina Kim's (2018) investigation, people are more likely to engage in behavior when they feel they have greater control over it. Students who have high perceived control over their study habits and time management are more likely to plan to participate in successful study behaviors (Dunn et al., 2018). PBC greatly influences intentions and behavior, especially in teacher education contexts. Regarding environmental practices, people who believe they can recycle are more likely to plan to do so (Z. Liu et al., 2021).

3.13. Conclusions

To sum up, the development of WSRIs depends crucially on environmental knowledge, perceived behavioral control, and environmental education. These aspects should be considered when creating and carrying out waste management initiatives and programs, particularly in HEI contexts like teacher education institutes. The SEM results support the theory that environmental education plays a major role in influencing future teachers' intentions toward sustainable waste management techniques. This emphasizes how crucial it is to include environmental education in teacher training programs to encourage sustainable practices and foster a more environmentally conscious society. To improve environmental education, perceived behavioral control, and environmental knowledge in influencing PsTs towards WSRIs, the following policy proposals are put forth in light of the SEM findings: First and foremost, teacher preparation programs must incorporate environmental education. This entails implementing sustainable waste management techniques to provide PsTs with the required information and cultivate a positive belief in carrying out a certain behavior. Second, cooperation between schools and environmental organizations is crucial to offer PsTs comprehensive environmental education programs and resources. This cooperative endeavour can potentially increase the reach and influence of environmental education programs. Thirdly, it is essential to consistently monitor and evaluate the effectiveness and influence of environmental education initiatives on PsTs' behaviors about WSRIs. This continuous evaluation ensures that educational initiatives are always improved and aligned with changing demands. This study highlights the importance of inclusive and effective environmental education programs for all people. By implementing these regulations, pre-service teachers will be better prepared to implement sustainable waste management techniques by gaining valuable skills and positive behaviors. In the end, this can help create a society that is more sustainable and conscious of the environment.

Chapter 4 The Effects of Environmental Education, Knowledge and Facilities on Recycling Behavior: A Moderation Analysis

4.1. Introduction

The escalating concerns about environmental sustainability and waste management have heightened the focus on recycling behaviors, particularly within HEIs. As centers of knowledge and innovation, HEIs are uniquely positioned to influence sustainable practices and instill environmental consciousness among students. This study aims to investigate the effects of environmental education, knowledge, and facilities on recycling behavior among students, employing a moderation analysis to uncover the intricacies of these relationships.

Environmental education has been widely recognized as pivotal in promoting sustainable behaviors. Educational programs can significantly enhance environmental awareness and foster pro-environmental behaviors by providing students with a comprehensive understanding of environmental issues and the importance of recycling (Tilbury, 1995). However, the effectiveness of environmental education in altering behavior also depends on the level of environmental knowledge individuals possess. Higher levels of knowledge can translate into greater awareness of the consequences of waste and the benefits of recycling, thereby reinforcing sustainable practices (Kollmuss & Agyeman, 2002). Facilities, such as recycling bins and composting stations, play a crucial role in facilitating recycling behavior. The availability and accessibility of these facilities can significantly influence the likelihood of individuals engaging in recycling activities. Previous research has indicated that well-placed and easily accessible recycling facilities on campus are associated with higher rates of recycling participation among students (Oskamp et al., 1991). Despite the acknowledged importance of these factors, there is a need for a deeper understanding of how they interact to influence recycling behavior. This study employs a moderation analysis to examine how environmental knowledge, and the availability of recycling facilities may moderate the relationship between environmental education and recycling behavior. By exploring these moderating effects, the study aims to provide a more nuanced understanding of the factors that drive recycling behavior in HEIs and offer insights into how educational institutions can enhance their waste management strategies.

4.2. Research design

This study employs a quantitative research design using a survey methodology to gather data on the effects of environmental education, environmental knowledge, and facilities on recycling behavior among students in HEIs. The research utilizes structural equation modeling (SEM) to analyze the relationships between these variables and to perform moderation analysis.

1. H9: Environmental Education (EE) moderates the relationship between intent to separation and recycling and behavior (BHV)
2. H10: Environmental knowledge (EK) moderates the relationship between intent to separate and recycle (ISR) and recycling behavior (BHV).
3. H12: Facilities (FAC) moderate the relationship between intent to separate and recycle (ISR) and recycling behavior (BHV).
4. H13: Facilities (FAC) moderate the relationship between attitude (AT) and recycling behavior (BHV).
5. H14: Environmental education (EE) moderates the relationship between attitude (AT) and recycling behavior (BHV).H15: Environmental knowledge (EK) moderates the relationship between attitude (AT) and recycling behavior (BHV).

These hypotheses aim to provide a comprehensive understanding of how environmental education, knowledge, and facilities influence recycling behavior directly and through interactions among these factors.

4.3. Sampling methodology and data collection

The participants in this study are undergraduate students enrolled in various programs across multiple HEIs in Indonesia. A sample size of 530 students was selected using stratified random sampling to ensure representation from different faculties and departments. Prior to the main survey, a pilot study was conducted with 30 undergraduate students to test the reliability and validity of the questionnaire.

A structured questionnaire was developed to measure the following constructs:

1. Environmental Education (EE): Assessed using a 4-item scale measuring students' exposure to environmental education programs and courses.
2. Environmental Knowledge (EK): Measured using a 3-item scale evaluating students' knowledge of environmental issues and recycling practices.
3. Facilities (FAC): Assessed using a 4-item scale regarding the availability and accessibility of recycling facilities on campus.
4. Attitude (AT): Measured using a 5-item scale evaluating students' attitudes towards recycling.
5. Subjective Norms (SN): Assessed using a 4-item scale measuring the perceived social pressure to engage in recycling.
6. Perceived Behavioral Control (PBC): Measured using a 2-item scale assessing students' perceived ease or difficulty in performing recycling behaviors.
7. Intent to Separate and Recycle (ISR): Assessed using a 4-item scale evaluating students' intention to engage in recycling.
8. Recycling Behavior (BHV): Measured using a 2-item scale assessing actual recycling behavior.

All items were rated on a seven-point Likert scale ranging from "strongly disagree" to "strongly agree".

The questionnaire was distributed online via email and social media platforms. Participation was voluntary, and informed consent was obtained from all participants. Data collection occurred over a period of four weeks.

4.4. Moderation analysis

Moderation analysis will be performed using the PROCESS macro in SPSS to explore how environmental knowledge and facilities influence the relationship between environmental education and recycling behavior. Interaction terms will be created, and the significance of these terms will be tested to determine moderation effects. By employing these methods, the study aims to comprehensively understand the factors influencing recycling behavior in HEIs and offer practical recommendations for enhancing waste management practices through targeted educational interventions and facility improvements.

Data analysis was conducted in several steps:

1. Descriptive Statistics: Calculated for all variables to understand the basic characteristics of the data.
2. Reliability and Validity Testing: Performed using Cronbach's Alpha for internal consistency and confirmatory factor analysis (CFA) for construct validity.
3. Structural Equation Modeling (SEM): Employed to test the hypothesized relationships between environmental education, environmental knowledge, facilities, and recycling behavior.
4. Moderation Analysis:
5. Conducted using the PROCESS macro in SPSS to examine whether environmental knowledge and facilities moderate the relationship between environmental education and recycling behavior.

4.4.1. Descriptive Statistics

Descriptive statistics will include means, standard deviations, and frequency distributions for all constructs. These statistics will provide an overview of the data and help identify any anomalies or patterns.

4.4.2. Reliability and Validity

Cronbach's Alpha was used to assess the internal consistency of the scales, with a value of 0.70 or higher being considered acceptable. To verify the constructvalidity of the measurement model, CFA was conducted. The fit indices reported include the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA), ensuring the robustness and accuracy of the measurement constructs.

Table 9. Reliability and Validity

Test	Result
Harman’s one factor test-standard method bias	33.94%
Confirmatory Factor Analysis (CFA)	KMO = 0.945 MSA > 0.5
Cronbach Alpha	0.960

4.4.3. Structural Equation Modeling (SEM)

SEM will be used to test the direct and indirect effects of environmental education, environmental knowledge, and facilities on recycling behavior. The following steps will be involved:

1. Measurement Model: Assessed to confirm that the observed variables adequately measure the latent constructs.
2. Structural Model: Tested to examine the hypothesized relationships between constructs.

4.5. Results

The results of the study are presented below, focusing on the relationships between environmental education (EE), environmental knowledge (EK), facilities (FAC), attitudes (AT), subjective norms (SN), perceived behavioral control (PBC), intention to separate and recycle (ISR), and recycling behavior (BHV). The results are based on the Structural Equation Modeling (SEM) and moderation analyses.

The moderation analysis examined the moderating effects of EK, FAC, and EE on the relationships between ISR and BHV, and AT and BHV.

1. EK as Moderator between ISR and BHV: The interaction term (ISR x EK) was significant ($\beta = 0.0827$, $p < 0.01$), indicating that environmental knowledge moderates the relationship between intention to separate and

recycle and recycling behavior. The relationship is stronger when environmental knowledge is high.

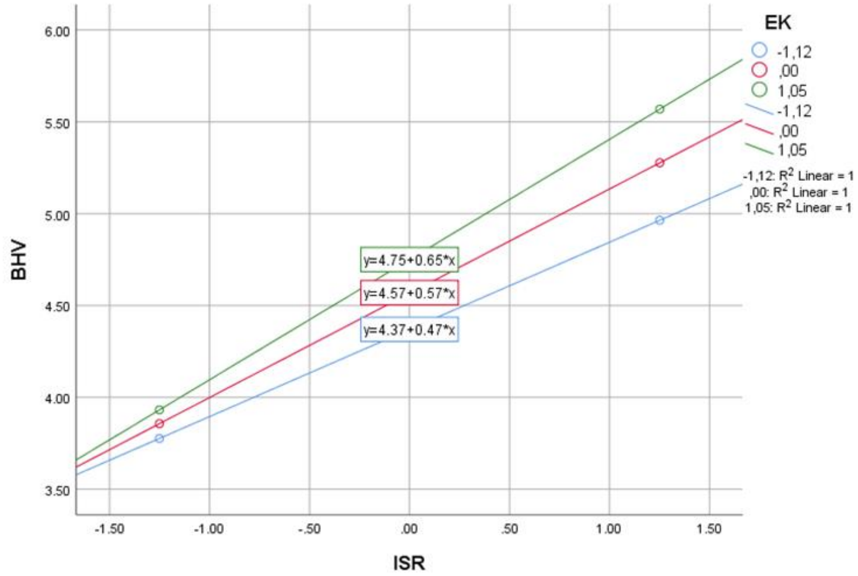


Figure 17. EK as Moderator between ISR and BHV

2. FAC as Moderator between ISR and BHV: The interaction term (ISR x FAC) was not significant (β = 0.0106, $p > 0.05$), indicating that facilities do not significantly moderate the relationship between intention to separate and recycle and recycling behavior.

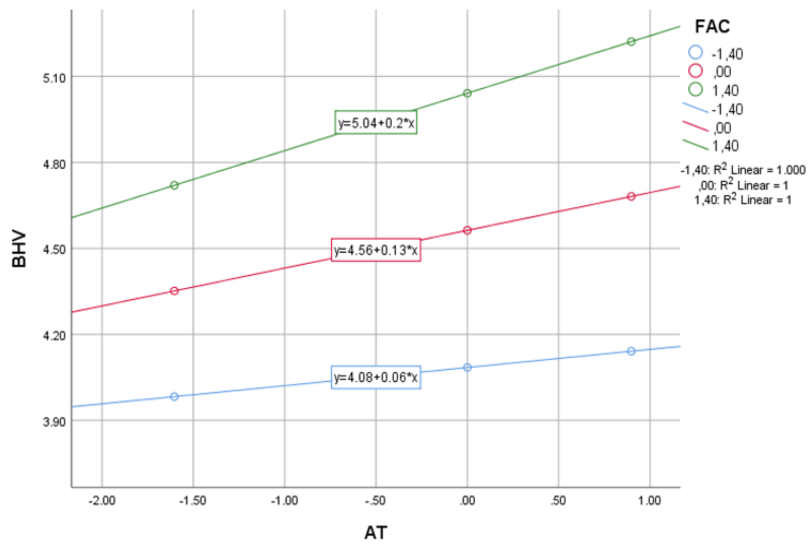


Figure 18. FAC as Moderator between ISR and BHV

3. FAC as Moderator between AT and BHV: The interaction term (AT x FAC) was significant (β = 0.049, $p < 0.05$), indicating that facilities moderate the relationship between attitude and recycling behavior. The relationship is stronger when facilities are adequate.

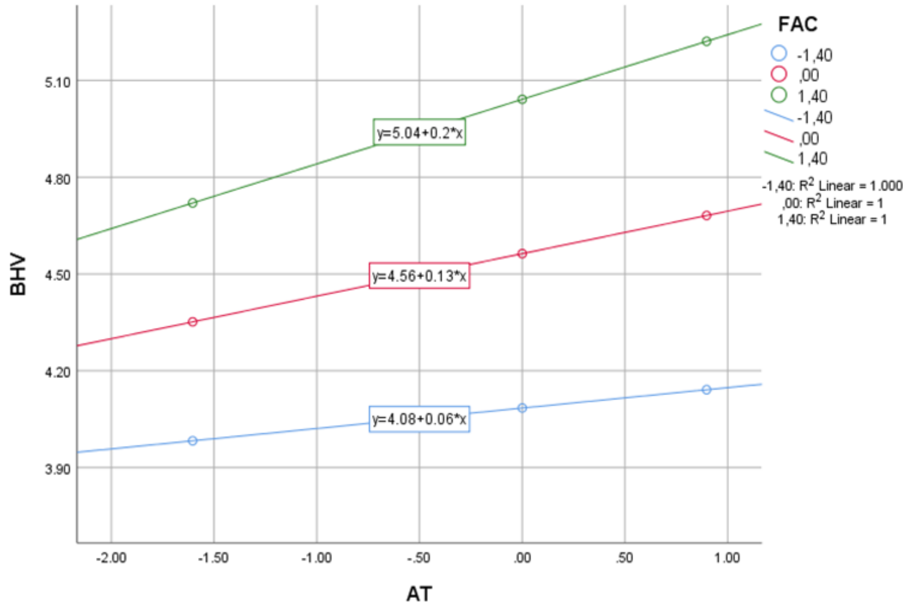


Figure 19. FAC as Moderator between AT and BHV

4. EE as Moderator between AT and BHV: The interaction term (AT x EE) was significant (β = 0.0853, $p < 0.01$), indicating that environmental education moderates the relationship between attitude and recycling behavior. The relationship is stronger when environmental education is high.

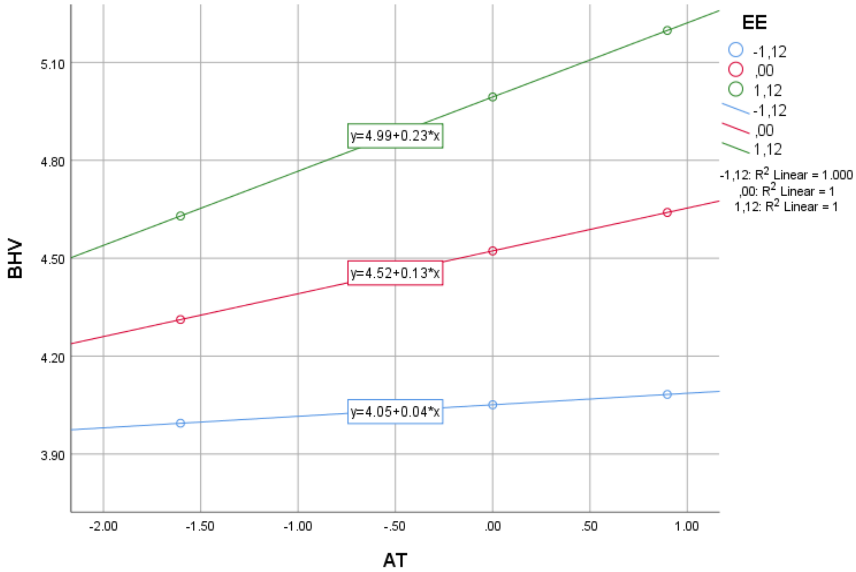


Figure 20. EE as Moderator between AT and BHV

5. EK as Moderator between AT and BHV: The interaction term (AT x EK) was significant (β = 0.0760, $p < 0.01$), indicating that environmental knowledge moderates the relationship between attitude and recycling behavior. The relationship is stronger when environmental knowledge is high.

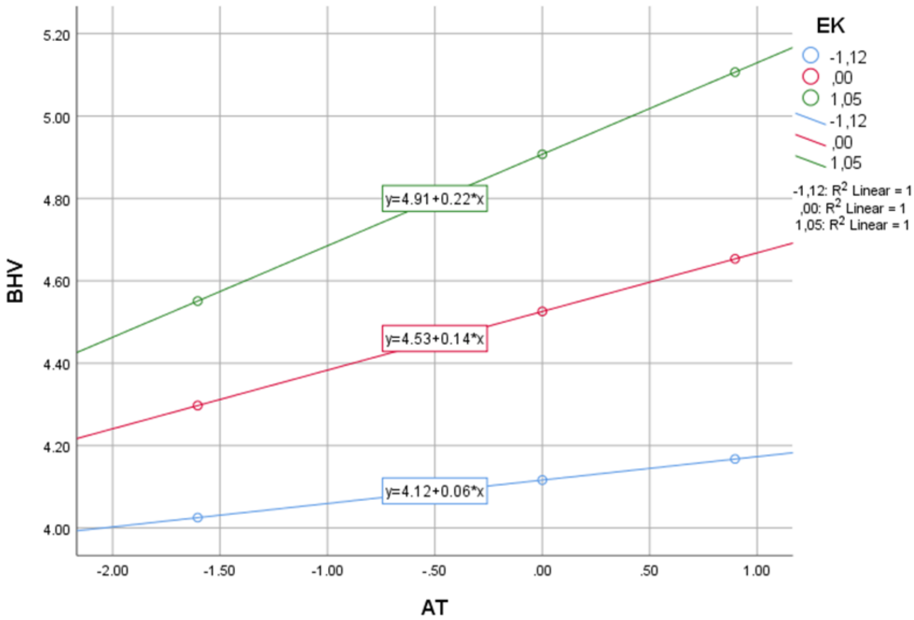


Figure 21. EK as Moderator between AT and BHV

4.6. Discussion

The moderation analyses provided additional insights into how environmental education (EE) and environmental knowledge (EK) influence the relationships between attitudes, intentions, and behaviors. EE and EK strengthened the link between attitudes and recycling behavior, with significant interaction effects ($\beta = 0.0853$ for EE and $\beta = 0.0760$ for EK). This indicates that higher levels of environmental education and knowledge directly impact attitudes and behaviors and amplify the effectiveness of positive attitudes toward recycling. These findings highlight the critical role of continuous education and awareness programs in fostering a more environmentally conscious student population. The presence of robust environmental education programs helps develop a deeper understanding of and commitment to sustainability among students. This educational foundation ensures that students are aware of environmental issues and equipped with the necessary knowledge and skills to engage in pro-environmental behaviors.

Furthermore, the significant interaction effects suggest that when students receive high-quality environmental education and possess substantial environmental knowledge, their positive attitudes toward recycling are more likely to translate into actual recycling behavior. This underscores the importance of instilling positive attitudes and providing the educational tools and knowledge necessary to support and sustain these attitudes.

In essence, the moderation effects of EE and EK imply that educational interventions can play a pivotal role in enhancing the efficacy of sustainability initiatives. By continuously integrating environmental education into the curriculum and promoting environmental knowledge, educational institutions can create a supportive environment that encourages and sustains positive recycling behaviors. This approach ensures that promoting sustainable practices goes beyond mere awareness and attitudes, fostering actionable and long-lasting environmental stewardship among students. These findings reinforce the need for ongoing investment in educational programs focusing on environmental issues, ensuring that students are well-informed and motivated to participate in sustainability efforts.

4.7. **Conclusion**

In conclusion, this study provides robust evidence that environmental education, knowledge, and facilities play crucial roles in shaping recycling behaviors among pre-service teachers. By addressing these factors, HEIs can effectively promote sustainable practices and contribute to broader environmental goals. Future research should explore additional variables and contextual factors influencing recycling behaviors, ensuring that sustainability initiatives are comprehensive and impactful. The results of this study have several implications for policy and practice within HEIs. Firstly, integrating environmental education into teacher training programs is essential to cultivate a generation of educators who can lead sustainability initiatives. Secondly, enhancing the availability and accessibility of recycling facilities on campus can significantly boost recycling behaviors.

Chapter 5 Assessing the Influence of Environmental Education, Knowledge, and Facilities on Pre-Service Teachers' Waste Separation and Recycling Intentions in Indonesian Teacher Education Institution

5.1. Introduction

The Sustainable Development Goals of the United Nations have had a significant impact on higher education institutions and their engagement in waste management over the past ten years (Leal Filho et al., 2019; Nhamo & Mjimba 2020). These institutions must prioritize sustainable waste management practices because they have the potential to support sustainable development and are essential for reducing waste and advancing sustainability (Journeault et al., 2021). Additionally, it highlights how important it is for educational institutions to create and carry out programs that encourage recycling, reuse, and minimizing waste and teach staff and students the importance of sustainable waste management practices(Ebrahimi and North, 2017; Hegab et al. 2023).

Teacher-education institutions play an important role in promoting environmental education by training and equipping educators, nurturing environmentally literate teachers, integrating environmental content into the curriculum, building partnerships, setting examples through sustainable practices, offering professional development opportunities, advocating policy change, and empowering students to become active agents of change (Karrow et al., 2016; Almeida et al., 2018). These efforts have played an important role in fostering a more environmentally aware and responsible society. As part of this movement, students play a crucial role in driving change and adopting sustainable behaviors (Horng et al. 2022). However, students respond differently to sustainability initiatives (Kim et al. 2018; Whitley et al. 2018). Education for environmental sustainability, awareness, and individual participation in sustainable waste management programs are necessary to implement sustainable waste management practices in higher education institutions successfully (Fagnani and Guimarães 2017; Debrah et al. 2021). By understanding which initiatives have successfully driven sustainable behaviors, institutions can refine their strategies and focus on what works best. Measuring behavioral change helps us understand which interventions are more effective for specific demographics or groups of students.

Understanding this behavior is crucial given the possible environmental, economic, and social effects of WSRi. Intention describes an individual's conscious decision-making or underlying motive to engage in a specific behavior. Conversely, action refers to the tangible enactment or execution of said behavior. TPB's theoretical foundation aligns with the value of intention as a behavior determinant (Ajzen 1991). As a result, those who planned to separate and recycle their waste had more of an urge to carry out this action. WSRi may involve separating recyclables, utilizing recycling bins or containers, participating in recycling programs and projects, and contributing money to support these activities. But behavior doesn't always follow purpose alone. Other issues like lack of resources, competing objectives, or external restraints can make it more difficult to translate intentions into actions. (Cantú et al. 2021).

By considering these things, organizations may help achieve environmental sustainability goals and open the door to a more sustainable future. PsTs will play a significant role in teaching elementary and high school students in the future, so they must support sustainable waste management techniques(Brandt et al. 2021; Echegoyen-Sanz and Martín-Ezpeleta 2021). Working promptly with the PsTs ensured they could efficiently teach their pupils valuable lessons. This highlights the importance of giving PsTs the knowledge, skills, and mindsets to support sustainable waste management. Incorporating environmental education (EE) and improving facilities in the context of environmental education refers to the resources, infrastructure, and physical spaces that support and enhance learning experiences. These facilities can be within formal educational institutions, such as schools and universities, or community-based centers or outdoor learning spaces in their training programs. They can then encourage students to adopt environmentally conscious behaviours by providing them with further information on the significance of sustainable waste management(Goulgouti et al. 2019; Nousheen et al. 2020).

Furthermore, it underscores the necessity of prioritizing EE within PsTs training programs to ensure that prospective educators are equipped with the knowledge and skills required to promote sustainable classroom waste management practices. In assessing PsTs' attitudes toward waste separation and recycling, which is a significant research area, a notable gap exists in the literature. This gap is particularly noteworthy as these educators wield substantial influence over future generations' environmental attitudes and behaviors. A deeper understanding of these factors can provide valuable insights for developing successful EE projects and programs (Hayes et al. 2019; Christian et al. 2021). PsTs are the educators of future generations; therefore, their attitudes and behaviors concerning the environment are likely to influence their students.

The dearth of studies in this area is concerning as it suggests that EE facilities and programs targeting PsTs may be insufficient or likely less successful in promoting sustainable behavior. Previous research has demonstrated a lack of interest and commitment, as these studies did not address the specific needs and objectives of PsTs (Tran Ho et al. 2022; Winter et al. 2022). Designing efficient EE programs and infrastructure can be challenging due to the research gap in this field, which limits our understanding of the variables that impact the intention to separate and recycle waste. The lack of research underscores the need for additional studies since it is crucial to comprehend teachers' intentions and actions concerning the environment, ensuring that future generations possess the knowledge and skills necessary to support sustainable development (Menabò et al. 2022; Venn et al. 2022). The main objectives of this study were to examine the relationship between EE, EK, and ISR facilities on campus and identify and explain the factors influencing PsTs' WSRi on campus.

5.2. Material and method

5.3. Study area and data collection

Participants in this research are students from seven teacher-education institutes spread throughout six Indonesian islands, and they made up the sample for this study. A random sample of clusters was selected, encompassing all members within the chosen clusters. Cluster random sampling proves beneficial when direct sampling of individuals is impractical or costly (Henry 2009). By ensuring that every member of the population has an equal chance of being selected, a random number generator or table for randomization eliminates any potential bias or preference (Lavrakas et al. 2019). Using a social media platform, a pilot survey was first conducted to assess the efficacy of the questionnaire and provide an ethical description from the onset, with a particular emphasis on informed consent and ethics. This questionnaire's contents will be kept confidential, and the data will be examined collectively rather than separately. A sum of 505 surveys were handed out, of which 400 were collected, resulting in a response rate of 79.7%. The geographical areas outlined earlier are illustrated in Figure 22 as the research sites.

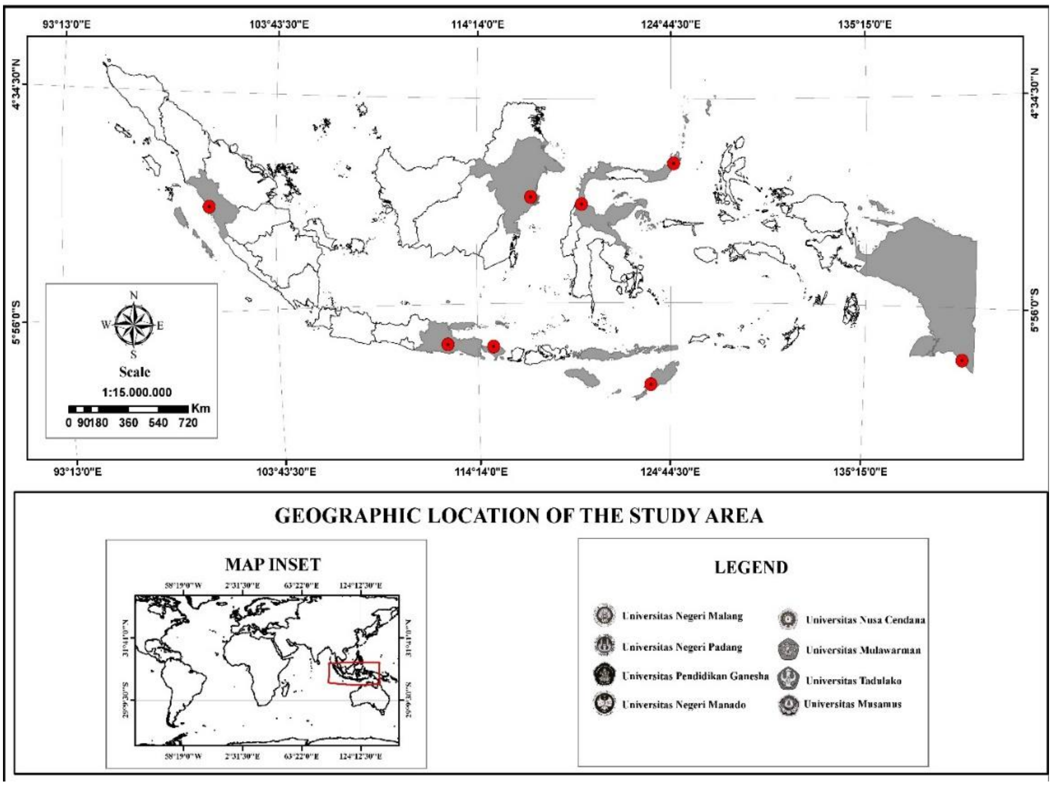


Figure 22. Geographic location of the study area

5.4. Statistical analysis

The acquired data were analyzed using the partial least squares (PLS) method of structural equation modeling (SEM). To build a PLS route model, the Smart PLS program provides a user-friendly interface. There are three stages of data analysis, namely outer model evaluation, inner model evaluation, path analysis, mediation/indirect influence testing and multi group comparisons(Memon et al., 2021). This study investigates the relationship between the influence of EE, EK, FAC, ATT, SN, PBC, BHV and WSRi shown in Fig. 20.

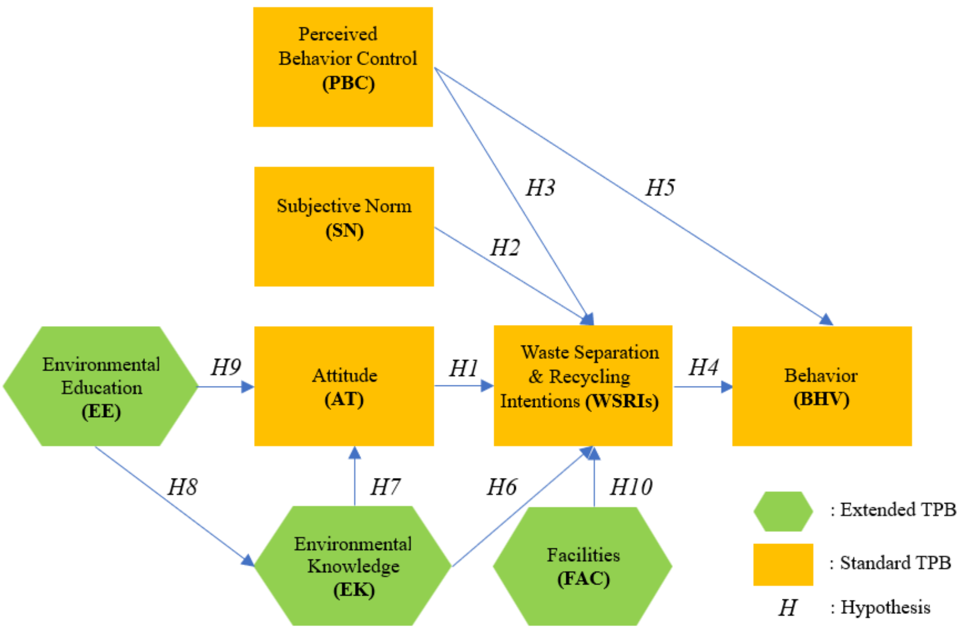


Figure 23. Initial theoretical path model.

5.5. Result

5.5.1. Respondent demographic information

As shown in table 10, 275 respondents (68%) were female, and the remainder (32%) were male. More than 60% of respondents were from rural areas. Most respondents had resident status (60%) and received monthly incomes of less than IDR 1,000,000 (83%). Sustainable education is influenced by socio-economic and cultural practices (Maraoli 2021). A summary of the respondents' demographics is presented in table 10.

Table 10. Data respondents

Categories	Frequency (n)	Percentage (%)
Gender		
Female	275	68
Male	128	32
Place of Origin		
Rural	253	63
Urban	150	37
Residence Status		
Local	243	60
Newcomer	160	40
Current Residence		
Own House	159	39
Rent House	30	7
Dormitory	175	43
Official Residence	4	1
Others	35	9
Monthly Revenue		
< IDR 1.000.0000.-	334	83
IDR 1.000.000 - IDR 2.000.000	50	12
>IDR 2.000.000	19	5

Note: IDR is the abbreviation for Rupiah, which is the monetary unit of Indonesia.

5.5.2. Evaluation of measurement and structural models

To determine the reliability and validity of the data, the evaluation measurement model is the first process in the PLS-SEM technique. Measurement models should reflect their validity and reliability values, which support the inclusion of these models in path model (Dijkstra and Henseler 2015). Ensuring indicator reliability, composite reliability, convergent validity (Average Variance Extracted/AVE), and discriminant validity an essential requirement for carrying out these checks (Baharum et al. 2023). Tables 3 and 4 display the reliability and validity of the measurements derived from the assessment of reflective measurement models.

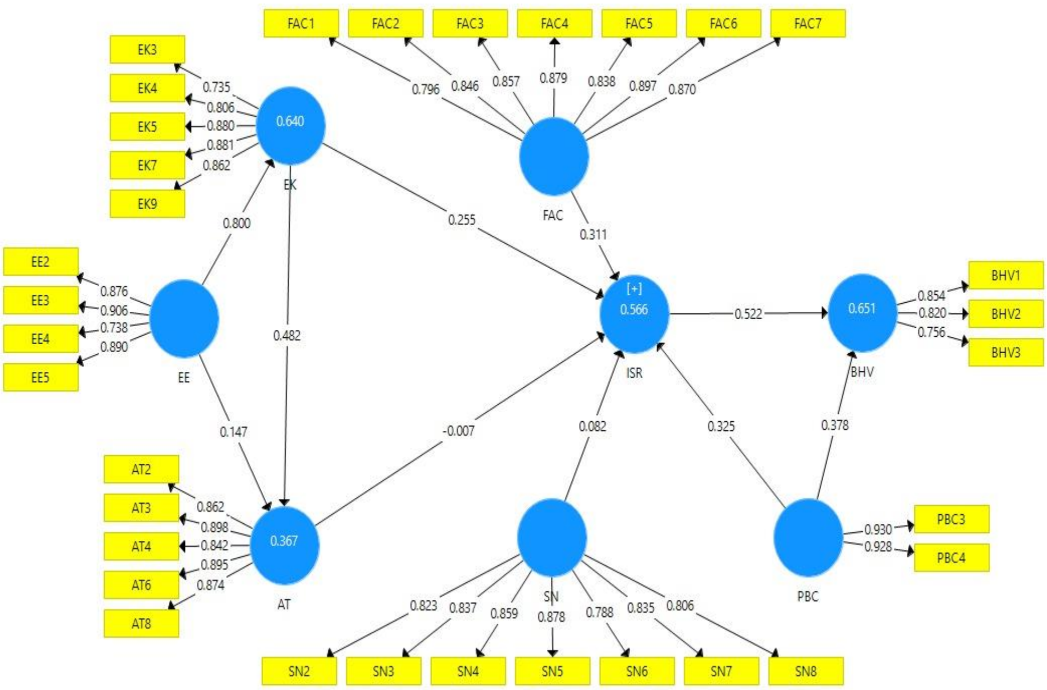
Table 11. Reflective Measurement Models Results Summary

Latent Variables	Items Code	Factor Loadings	Cronbach's Alpha	CR	AVE	Discriminant Validity
Attitude (AT)	AT2	0.862				
	AT3	0.898				
	AT4	0.842	0.923	0.942	0.765	Yes
	AT6	0.894				
	AT8	0.874				
Behaviour (BHV)	BHV1	0.854				
	BHV2	0.820	0.739	0.852	0.658	Yes
	BHV3	0.756				
Environmental Education (EE)	EE2	0.876				
	EE3	0.906	0.875	0.915	0.731	Yes
	EE4	0.738				
	EE5	0.890				
Environmental Knowledge (EK)	EK3	0.735				
	EK4	0.806				
	EK5	0.880	0.890	0.920	0.697	Yes
	EK7	0.881				
	EK9	0.862				
Facilities (FAC)	FAC1	0.796				
	FAC2	0.846				
	FAC3	0.857				
	FAC4	0.879	0.938	0.950	0.731	Yes
	FAC5	0.838				
	FAC6	0.897				
	FAC7	0.870				
Waste Separation & Recycling Intention (ISR)	ISR1	0.831				
	ISR2	0.848				
	ISR3	0.832				
	ISR4	0.832	0.934	0.947	0.718	Yes
	ISR5	0.873				
	ISR6	0.876				
	ISR7	0.837				

Latent Variables	Items Code	Factor Loadings	Cronbach's Alpha	CR	AVE	Discriminant Validity
Perceived Behavioral Control (PBC)	PBC3	0.930	0.842	0.927	0.864	Yes
	PBC4	0.928				
Subjective Norm (SN)	SN2	0.823	0.926	0.941	0.694	Yes
	SN3	0.837				
	SN4	0.859				
	SN5	0.878				
	SN6	0.788				
	SN7	0.835				
	SN8	0.806				

Referring to Table 11, the outer loading for each reflective construct exceeded the criterion value of 0.708. PBC exhibited the highest external loading and reliability (0.930 and 0.9842, respectively), followed by EE_3 (0.906 and 0.875), AT_3 (0.898 and 0.923), FAC_6 (0.897 and 0.938), and EK (0.881 and 0.890). All constructs surpassed the values considered acceptable for outer loadings, reliability, and validity, as indicated by other reliability loadings and values exceeding 0.60.

Figure 24. PLS SEM Model



The Partial Least Square Structural Equation Modeling (PLS-SEM) diagram represents latent variables (LVs) as blue circles, which symbolize unobservable constructs inferred from observed indicators, or measured variables (MVs), depicted in yellow boxes (e.g., EK3, EK4). The associated factor loadings next to the MVs denote the strength of their relationship with the LVs. The directional arrows between the LVs, accompanied by numerical values, represent path coefficients, indicating the magnitude and direction of the hypothesized causal relationships. The key latent variables identified are EK, SN, ISR, PBC, and BHV. The model elucidates several causal pathways, such as the influence of EK on EE, AT, and ISR, as well as the subsequent impacts of EE on AT and ISR's mediating effects on BHV and PBC. This structural model is a rigorous framework for testing theoretical hypotheses and examining the complex interrelationships among various constructs, ultimately contributing to a deeper understanding of their influences on specified outcomes.

Table 12. Discriminant Validity Assessment (HTMT Criterion)

Predictors	AT	BHV	EE	EK	FAC	ISR	PBC	SN
AT	-	-	-	-	-	-	-	-
BHV	0.558	-	-	-	-	-	-	-
EE	0.587	0.698	-	-	-	-	-	-
EK	0.654	0.789	0.898	-	-	-	-	-
FAC	0.337	0.754	0.486	0.530	-	-	-	-
ISR	0.374	0.890	0.565	0.604	0.656	-	-	-
PBC	0.232	0.874	0.263	0.370	0.517	0.670	-	-
SN	0.543	0.750	0.495	0.615	0.475	0.586	0.658	-

Convergent validity at the construct level is ascertained using the average variance extracted (AVE). The construct communality equivalent for this metric is 42. PBC (0.864), AT (0.765), EK (0.731), FAC (0.731), and WSRi (0.718) all exhibit AVE values significantly higher than the reference values. This indicates that the measurement of these five constructs demonstrates a robust level of convergent validity. Indicator reliability, composite reliability, convergent validity (AVE2), and discriminant validity (assessed using the Fornell-Larcker criterion and the heterotrait-monotrait ratio (HTMT) of the measurement models for constructs with reflective measures were examined (García-Machado et al. 2020). The HTMT criterion, as depicted in Table 12, was employed to assess discriminant validity, and measure the distinctiveness of a construct from others, while acknowledging phenomena not represented by other constructs in the model. Since all values were below 0.9 and 0.85, the model satisfied these criteria.

5.5.3. Hypothesis testing results

The analysis is conducted by contrasting the empirical "t" value with the critical value. The coefficient is considered statistically significant, with a specified chance of error, if the former number is greater than the latter, which is known as the significance level (Gold 2017). When comparing the hypotheses in this scenario, 8 out of 10 were accepted with a 99% confidence level, and one was accepted with a 95% confidence level.

Table 13. Hypothesis Testing

Hypothesis	Path Coefficient	T-value (bootstrap)	Decision
H1. Pre-service Teacher' attitudes positively influence the WSRi.	-0.007	0.153	Rejected
H2: Subjective norms influence Pre-service Teacher' WSRi.	0.082	1.426	Rejected
H3: Perceived behavioral control influences Pre-Service Teacher' WSRi.	0.325	6.556	Supported
H4: ISR influences Pre-service Teacher' behavior	0.522	11.44	Supported

Hypothesis	Path Coefficient	T-value (bootstrap)	Decision
H5: Perceived behavior control influences Pre-service Teacher' behavior.	0.378	7.203	Supported
H6: Pre-service Teacher' environmental knowledge has a positive influence on their WSRi.	0.255	5.417	Supported
H7: Pre-service Teacher' environmental knowledge has a positive influence on their attitude to WSRi.	0.482	6.433	Supported
H8: Environmental education has a positive influence on Pre-service Teachers' environmental knowledge.	0.8	27.197	Supported
H9: Environmental education has a positive influence on Pre-service Teacher' attitude.	0.147	1.824	Supported
H10: Perceived satisfaction of facilities influences Pre-service Teacher' WSRi.	0.311	6.327	Supported

The objectives of PLS-SEM include finding significant path coefficients in the structural model, as well as identifying significant and appropriate effects (Becker et al. 2023). Therefore, it's crucial to consider both the indirect impacts produced by mediating constructs and the direct effects of one construct on another. To achieve this, the total effect, which is the sum of all direct and indirect effects, is measured. Table 6 provides a summary of the findings, showing that at least 95% of the overall effects in the model are significant. It's important to note that despite the presence of other structures, the interactions AT-BHV, AT-WSRi, SN-BHV, and SN-WSRi remained classified as Not Significant. The success of environmental education is influenced by behavior, experience, skills, and social challenges and practices, so that it can create sustainable education (Boojh 2022).

Table 14. Results of the Tests for Significance of the Total Effects

Path	Total Effect	Standard Error	t values	P Values	Significant level	Confidence Intervals Lower bound	Upper bound
AT-> BHV	-0.004	0.024	0.153	0.439	NS	-0.042	0.035
AT-> ISR	-0.007	0.045	0.153	0.439	NS	-0.084	0.066
EE -> AT	0.532	0.052	10.28	0	SIG	0.455	0.625
EE-> BHV	0.105	0.025	4.231	0	SIG	0.066	0.148
EE -> EK	0.8	0.029	27.197	0	SIG	0.751	0.847
EE -> ISR	0.2	0.04	5.064	0	SIG	0.136	0.271
EK -> AT	0.482	0.075	6.433	0	SIG	0.348	0.592
EK-> BHV	0.131	0.028	4.686	0	SIG	0.087	0.18
EK -> ISR	0.252	0.044	5.66	0	SIG	0.177	0.325
FAC-> BHV	0.162	0.031	5.293	0	SIG	0.114	0.213
FAC-> ISR	0.311	0.049	6.327	0	SIG	0.227	0.391
ISR-> BHV	0.522	0.046	11.44	0	SIG	0.446	0.591
PBC-> BHV	0.548	0.045	12.149	0	SIG	0.471	0.618
PBC-> ISR	0.325	0.05	6.556	0	SIG	0.234	0.4
SN-> BHV	0.043	0.03	1.41	0.08	NS	-0.004	0.094
SN->ISR	0.082	0.057	1.426	0.077	NS	-0.007	0.176

Note: SIG = Significant at p 0.05, NS = Not Significant. Bootstrap.

5.5.4. Moderation using multi-group analysis

Measurement and structural invariances were tested by looking at configural invariances and metric invariances. Configural invariances were confirmed by looking at acceptable Goodnes of Fit (GoF) values in the unconstrained model. Metric invariances are assessed by looking at the results of the difference in chi-squared values that are not statistically significant ($p > 0.05$) ($\Delta\chi2/\Delta df < \pm1.96$)

between the unconstrained model and the constrained model. In the table below, the GoF values of all items EXCEPT monthly revenue have met the sig value and the difference between the models is small ($\Delta\chi2/\Delta df < \pm1.96$).

Table 15. Model GoF

Models	Goodness of Fit					Model Diferences			
	X2	df	X2/df	TLI	CFI	Δχ2	df	Δχ2/Δdf	Sig
Gender									
Unconstrained	210,602	152	1,386	0,964	0,977				
Metric (Constrained)	220,438	160	1,378	0,965	0,976	9,837	8	0,008	0,277
Place of Origin									
Unconstrained	232,987	152	1,533	0,951	0,969				
Metric (Constrained)	239,718	160	1,498	0,954	0,969	6,73	8	0,035	0,566
Residence Status									
Unconstrained	213,387	152	1,404	0,963	0,976				
Metric (Constrained)	221,305	160	1,383	0,965	0,976	7,919	8	0,021	0,441
Current Residence									
Unconstrained	233,682	152	1,537	0,951	0,969				
Metric (Constrained)	245,875	160	1,537	0,951	0,968	12,193	8	0	0,143
Monthly Revenue									
Unconstrained	213,387	152	1,64	0,942	0,963				
Metric (Constrained)	221,305	160	1,706	0,936	0,958	23,668	8	0,066	0,003

Structural Invariances

After testing measurement invariances, structural invariances are tested to determine whether group differences cause significant differences in the results of path analysis. This is done by looking at the level of significance in the model difference between unconstrained and constrained models ($P < 0.05$). If there is a significant difference, the effect of a stronger or weaker group relationship can be seen further in the regression weight value of each relationship.

In the table 16 below are the sig values in the relationships of all paths and their respective determinants between groups. From the table, there are several moderators that are significant (labeled in blue).

Table 16. Sig Values in the relationships of all paths

TPB Model	Sig.					
	Gender	Place of Origin	Residence Status	Current Residence	Monthly revenue	KPL
AT --> ISR	0,565	0,038	0,484	0,369	0,049	0,295
ISR --> BHV	0,434	0,317	0,038	0,614	0,957	0,164
PBC --> BHV	0,429	0,737	0,216	0,28	0,457	0,848
SN --> ISR	0,768	0,66	0,003	0,007	0,72	0,342
PBC --> ISR	0,887	0,764	0,153	0	0,938	0,03
EK -->ISR	0,012	0,73	0,629	0,057	0,011	0,108
EE --> EK	0,242	0,721	0,382	0,519	0,015	0,87
EK --> AT	0,152	0,343	0,102	0,217	0,995	0,314
EE --> AT	0,846	0,256	0,581	0,675	0,814	0,391
FAC --> ISR	0,013	0,319	0,515	0,314	0,027	0,896

Then the more dominant relationship between groups was examined as follows:

Table 17. Relationships between groups.

TPB Model	Sig.					
	Gender	Place of Origin	Residence Status	Current Residence	Monthly revenue	KPL
AT --> ISR	0,565	0,038	0,484	0,369	0,049	0,295
Regression weight		rural 0,122			Less than 0,056	
		Urban -0,038			More than -0,165	
ISR --> BHV	0,434	0,317	0,038	0,614	0,957	0,164
Regression weight			newcomer 0,473			
			local 0,773			
PBC --> BHV	0,429	0,737	0,216	0,28	0,457	0,848
SN --> ISR	0,768	0,66	0,003	0,007	0,72	0,342
			newcomer 0,3	Own house -0,074		
			local -0,004	Rent house 0,219		
PBC --> ISR	0,887	0,764	0,153	0	0,938	0,03
						have 0,088
						have not -0,212
EK -->ISR	0,012	0,73	0,629	0,057	0,011	0,108
	male 0,086				less than 0,282	
	female 0,443				more than 0,684	
EE --> EK	0,242	0,721	0,382	0,519	0,015	0,87
					less than 0,595	
					more than 0,841	
EK --> AT	0,152	0,343	0,102	0,217	0,995	0,314
EE --> AT	0,846	0,256	0,581	0,675	0,814	0,391
FAC --> ISR	0,013	0,319	0,515	0,314	0,027	0,896
	male 0,376				less than 0,232	
	female 0,097				more than -0,113	

The results show that the AT-ISR relationship has a greater influence on the rural group and income less than IDR 1,000,000. The ISR-BHV relationship has a greater influence on the local group. The SN-ISR relationship has a greater influence on the newcomer and rent house groups. The PBC-ISR relationship has a greater influence on the group that has done teaching practices. The EE-EK relationship has a greater influence on groups with incomes greater than IDR 1,000,000. And the FAC-ISR relationship has a greater influence on the male group and income less than IDR 1,000,000.

5.6. Discussion

This study aimed to investigate the variables that influence WSRi among PsTs, as predicted by the extended TPB. The analysis began by identifying the components contributing to the construct of WSRi, which were already present in the TPB literature. These components included EE, EK, FAC, and demographic factors such as gender, education levels, and income. The initial theoretical model was constructed using these components. Structural equation analysis was conducted using PLS-SEM modeling with SmartPLS version 3.2.7 to confirm the correlations between these exogenous and endogenous variables of sustainable consumption behavior. Of the ten hypotheses initially proposed, eight were confirmed to be significant, while the other two, not considered significant, were eliminated due to path values far below the permitted thresholds. This allows us to conclude that EK is influenced by EE ($t = 27.197$), specifically related to sustainability topics, BHV ($t = 11.440$), and PBC ($t = 7.203$) among PsTs and their BHV. PBC influences WSRi ($t = 6.556$), which is positively related to BHV on campus.

In addition, three new hypotheses were developed and confirmed, establishing important causal relationships in the model: EE is related to AT conditions ($t = 6.433$). Similarly, the existing FAC influenced the WSRi ($t = 6.327$), and EK ($t = 5.417$) also contributed to this intention. All hypotheses were confirmed and validated at a significant level of $p < 0.05$. With a statistical power of 80%, the R2 value for the final proposed model is 0.566. EE is important for creating environmentally caring behavior and attitudes by values. Sustainable education requires a fundamental change in outlook, including changes to curriculum, learning, policies, and facilities to align EE with student needs and behavior.

Unexpectedly, PsTs AT (t = 0.153) and SN (t = 1.426) did not predict the WSRi. Nevertheless, EE (t = 1.824) was not associated with AT. The relationship between AT and WSRi has been the subject of contradictory insights in previous research; although some researchers have suggested a strong association, others have found no significant association. When someone's attitudes towards an object or behavior don't always match their intentions or real behaviors, it's referred to as an AT unconnected to intention. Additionally, research has shown that attitudes do not necessarily predict behavior and that there are differences between attitudes and intents. For instance, an individual may enjoy working out but not exercise regularly. Comparably, someone may smoke despite having a negative perception of the habit because of addiction or peer pressure. This implies that intentions and attitudes are multifaceted, variable constructs subject to various influences. Experience, laws, campaigns, and particular projects impact EE more.

Nevertheless, SN indirectly influences WSRi by affecting a person's AT and PBC. Instead, SN operates through the mediation of attitude and perceived behavioral control, the other two factors in the Theory of Planned Behavior. The strength of this influence can vary, depending on individual differences and the importance that individuals place on others' opinions. Furthermore, although EE can effectively increase knowledge and awareness, it only sometimes leads to significant changes in AT towards the environment. Several factors could explain why EE might only sometimes be directly associated with AT change, such as pre-existing AT and the diversity of learners' social and cultural influences. This study found that EE was the strongest predictor of an individual's WSRi, indicating that those with a deeper understanding of environmental concerns and mitigation strategies were more inclined to act.

Furthermore, the results revealed positive associations between EE, EK, and AT. However, EK had a more substantial influence on WSRi than AT. Enhancing the EK of PsTs will likely enhance their awareness and motivate them to adopt environmentally friendly attitudes. EE is a significant predictor of EK, AT, and

WSRi. EE and EK are highly correlated, and EE positively affects pro-environmental AT. EE significantly affects BHV, which can lead to changes and increase the number of individuals participating in WSRi. Several learning models can be implemented to improve sustainable education and EE, namely inquiry-based learning, experiential learning, service learning, place-based learning, and culturally sustained learning.

5.7. Conclusion

In conclusion, the research confirmed several noteworthy relationships within the model. First and foremost, it underscored the pivotal role of EE in predicting EK, BHV, and, ultimately, WSRi among PsTs, emphasizing the need for a profound understanding of environmental issues and solutions, as it can substantially enhance individuals' willingness to participate in recycling initiatives.

Furthermore, the study revealed that EK had a more substantial impact on WSRi than AT, implying that knowledge about environmental matters significantly drives recycling behavior. Additionally, accessible recycling facilities on campus emerged as a key determinant influencing PsTs' intention to separate and recycle waste, emphasizing the importance of infrastructure in promoting sustainable behaviors. However, the research also highlighted that AT and SN did not directly predict WSRi among PsTs, aligning with previous findings that AT and intentions may not always translate into corresponding behaviors. Nevertheless, SN was found to indirectly influence behavioral intention by shaping AT and PBC, aligning with the fundamental principles of TPB. Ultimately, this study contributes to understanding the factors influencing waste separation and recycling intentions and behaviors among pre-service teachers, stressing the role of environmental education, knowledge, facilities, and subjective norms. It also underscores the intricate nature of attitudes and intentions, suggesting that effective interventions to promote recycling should adopt a comprehensive approach addressing various influencing factors.

Chapter 6 Summary of Key Findings, Recommendations and Limitations

6.1. Summary of key findings

Research one concluded that crucial factors such as environmental education, perceived behavioral control, and environmental knowledge are critical in fostering waste separation and recycling intentions (WSRi). These factors should be integral to waste management programs and initiatives, especially in HEIs. Structural Equation Modeling (SEM) results substantiate that environmental education significantly shapes future teachers' intentions toward sustainable waste management practices.

The implications of this finding suggest that integrating environmental education into teacher training programs is essential for cultivating environmentally conscious future educators. Enhancing the scope and impact of environmental education through collaboration with environmental organizations can further bolster these efforts. Additionally, there is a need for ongoing monitoring and evaluation to align educational efforts with evolving needs, ensuring continuous improvement in promoting sustainable behaviors. Further research on inclusive and successful environmental education initiatives for all individuals is necessary. Studies should also aim to understand how these initiatives equip pre-service teachers with vital skills and perspectives for sustainable waste management practices.

Research in the Indonesian context indicates that EE is crucial in predicting environmental knowledge (EK), behavioral intentions (BHV), and, ultimately, waste separation and recycling intentions (WSRi) among pre-service teachers (PsTs), underscores the necessity of a profound understanding of environmental issues to enhance participation in recycling initiatives. EK substantially impacts WSRi more than attitudes (AT), highlighting that knowledge about environmental matters significantly drives recycling behavior. Accessible recycling facilities on campus are key determinants influencing PsTs' intention to separate and recycle waste, indicating the importance of infrastructure in promoting sustainable behaviors. AT and SN do not directly predict WSRi but indirectly influence behavioral intention by shaping attitudes and perceived behavioral control (PBC), which aligns with the fundamental principles of the Theory of Planned Behavior (TPB).

6.2. Recommendations

Effective interventions to promote recycling should adopt a comprehensive approach addressing various influencing factors, including environmental education, knowledge, facilities, and subjective norms. The implications of these findings emphasize the role of environmental education and knowledge in promoting sustainable practices, highlight the need for accessible recycling facilities to support sustainable behaviors and suggest a multifaceted approach to address the complexity of attitudes and intentions towards recycling. Future research directions include adding new variables, such as socio-cultural or environmental influences on the intention to sort and recycle waste and conducting further interventions and studies to understand and enhance the impact of these variables on recycling behavior.

Both conclusions emphasize environmental education, perceived behavioral control, and environmental knowledge shaping waste separation and recycling intentions among pre-service teachers. They highlight the importance of infrastructure and collaborative efforts in promoting sustainable waste management practices and call for comprehensive and ongoing educational interventions to cultivate sustainable behaviors. However, conclusion research two provides a more detailed analysis of the indirect influence of attitudes and subjective norms on WSRi, aligning with the Theory of Planned Behavior (TPB). At the same time, Conclusion one offers specific policy recommendations, such as integrating environmental education into curricula and collaborating with environmental organizations, along with the need for regular monitoring and evaluation. Additionally, Conclusion Research Two stresses the complexity of attitudes and intentions and the need for a comprehensive approach. In contrast, Conclusion One focuses on practical policy recommendations and the significance of continuous assessment.

6.3. Limitations

Even with the insightful information this study offered, a number of limitations should be noted: Sample Size and Generalisability: Mainly, pre-service teachers from a few Indonesian higher education institutions made up the study's sample. The results must, therefore, be more broadly applicable to students in different fields or pre-service instructors in other nations. To improve the generalisability of the findings, larger and more varied samples should be used in future research. Intersectional Architecture: A cross-sectional design was used in the study to collect data at a certain moment in time. This method restricts the capacity to determine causality between the variables under study. Longitudinal studies offer a more comprehensive picture of how environmental education, knowledge, and facilities affect recycling behaviors over time. Self-Reported Data: The data was collected through self-reported questionnaires, subject to social desirability and recall biases. Participants may have over-reported socially desirable behaviors or under-reported undesirable ones. Combining self-reports and observational methods could provide a more accurate assessment of recycling behaviors.

Other Notable Limitations: Measurement of Constructs: While the constructs of environmental education, knowledge, and facilities were measured using validated scales, there may still be nuances and dimensions that were not captured. Future research should consider using mixed methods to gain deeper insights into these variables. Context-Specific Factors: The study was conducted within Indonesian higher education institutions' cultural and institutional contexts. Cultural attitudes towards the environment, institutional policies, and local infrastructure may have influenced the findings. Comparative studies across cultural and institutional contexts are needed to validate and extend these findings. Limited Moderating Variables: The study focused on environmental education, knowledge, and facilities as moderating variables. Other potential moderators, such as socio-economic status, personal values, and environmental attitudes, were not examined. Including a broader range of moderating variables in future research could provide a more comprehensive understanding of the factors influencing recycling behaviors. Specificity of Constructs: The constructs of attitude, subjective norms, perceived behavioral control, environmental education, and environmental knowledge were broadly defined. Future research could benefit from examining more specific aspects of these constructs, such as the types of environmental education programs or specific elements of perceived behavioral control. External Factors: The study did not account for external factors such as government policies, community recycling programs, and media influence that could also impact recycling behaviors. Considering these external influences in future studies would provide a more holistic view of the factors affecting recycling behavior.

References

Abu Qdais, H., Saadeh, O., Al-Widyan, M., Al-tal, R., & Abu-Dalo, M. (2019). Environmental sustainability features in large university campuses: Jordan University of Science and Technology (JUST) as a model of green university. *International Journal of Sustainability in Higher Education*, *20*(2), 214–228.

Ajzen, I. (2020a). The theory of planned behavior: Frequently asked questions. *Human Behavior and Emerging Technologies*, *2*(4), 314–324.

Ajzen, I. (2020b). The theory of planned behavior: Frequently asked questions. *Human Behavior and Emerging Technologies*, *2*(4), 314–324.

Ajzen, I., & Driver, B. L. (1991). Prediction of leisure participation from behavioral, normative, and control beliefs: An application of the theory of planned behavior. *Leisure Sciences*, *13*(3), 185–204.

Almulhim, A. I., & Abubakar, I. R. (2021). Understanding public environmental awareness and attitudes toward circular economy transition in Saudi Arabia. *Sustainability*, *13*(18), 10157.

Anthony Jnr, B. (2021). Green campus paradigms for sustainability attainment in higher education institutions–a comparative study. *Journal of Science and Technology Policy Management*, *12*(1), 117–148.

Bahçelioğlu, E., Buğdaycı, E. S., Doğan, N. B., Şimşek, N., Kaya, S. Ö., & Alp, E. (2020). Integrated solid waste management strategy of a large campus: A comprehensive study on METU campus, Turkey. *Journal of Cleaner Production*, *265*, 121715.

Bashir, M. J., Jun, Y. Z., Yi, L. J., Abushammala, M. F., Amr, S. S. A., & Pratt, L. M. (2020). Appraisal of student’s awareness and practices on waste management and recycling in the Malaysian University’s student hostel area. *Journal of Material Cycles and Waste Management*, *22*, 916–927.

Bechler, C. J., Tormala, Z. L., & Rucker, D. D. (2021). The Attitude–Behavior Relationship Revisited. *Psychological Science*, *32*(8), 1285–1297. https://doi.org/10.1177/0956797621995206

Boca, G., & Saraçlı, S. (2019). Environmental Education and Student’s Perception, for Sustainability. *Sustainability*, *11*(6), 1553. https://doi.org/10.3390/su11061553

Bock, D., Harms, U., & Mahler, D. (2021). Examining the dimensionality of pre-service teachers’ enthusiasm for teaching by combining frameworks of educational science and organizational psychology. *Plos One*, *16*(11), e0259888.

Brandt, J.-O., Barth, M., Merritt, E., & Hale, A. (2021). A matter of connection: The 4 Cs of learning in pre-service teacher education for sustainability. *Journal of Cleaner Production*, *279*, 123749.

Budihardjo, M. A., Humaira, N. G., Putri, S. A., Ramadan, B. S., Syafrudin, S., & Yohana, E. (2021). Sustainable solid waste management strategies for higher education institutions: Diponegoro university, indonesia case study. *Sustainability*, *13*(23), 13242.

Buehler, R., & Dill, J. (2016). Bikeway networks: A review of effects on cycling. *Transport Reviews*, *36*(1), 9–27.

Cantú, A., Aguiñaga, E., & Scheel, C. (2021). Learning from failure and success: The challenges for circular economy implementation in SMEs in an emerging economy. *Sustainability*, *13*(3), 1529.

Chen, M.-F. (2016). Extending the theory of planned behavior model to explain people's energy savings and carbon reduction behavioral intentions to mitigate climate change in Taiwan–moral obligation matters. *Journal of Cleaner Production*, *112*, 1746–1753.

Davis, L. E., Ajzen, I., Saunders, J., & Williams, T. (2002). The decision of African American students to complete high school: An application of the theory of planned behavior. *Journal of Educational Psychology*, *94*(4), 810.

Debrah, J. K., Vidal, D. G., & Dinis, M. A. P. (2021). Raising Awareness on Solid Waste Management through Formal Education for Sustainability: A Developing Countries Evidence Review. *Recycling*, *6*(1), 6. https://doi.org/10.3390/recycling6010006

Digdowiseiso, K. (2020). The development of higher education in Indonesia. *International Journal of Scientific & Technology Research*, *9*(2).

Dunn, R., Hattie, J., & Bowles, T. (2018). Using the Theory of Planned Behavior to explore teachers' intentions to engage in ongoing teacher professional learning. *Studies in Educational Evaluation*, *59*, 288–294.

Echegoyen-Sanz, Y., & Martín-Ezpeleta, A. (2021). A holistic approach to education for sustainability: Ecofeminism as a tool to enhance sustainability attitudes in pre-service teachers. *Journal of Teacher Education for Sustainability*, *23*(1), 5–21.

ElHaffar, G., Durif, F., & Dubé, L. (2020). Towards closing the attitude-intention-behavior gap in green consumption: A narrative review of the literature and an overview of future research directions. *Journal of Cleaner Production*, *275*, 122556.

Estrada-Vidal, L. I., & Tójar-Hurtado, J.-C. (2017). College student knowledge and attitudes related to Sustainability Education and environmental health. *Procedia-Social and Behavioral Sciences*, *237*, 386–392.

Fagnani, E., & Guimarães, J. R. (2017). Waste management plan for higher education institutions in developing countries: The Continuous Improvement Cycle model. *Journal of Cleaner Production*, *147*, 108–118.

Fang, W.-T., Hassan, A., & LePage, B. A. (2022). Environmental Literacy. In *The Living Environmental Education: Sound Science Toward a Cleaner, Safer, and Healthier Future* (pp. 93–126). Springer.

García-González, E., Jiménez-Fontana, R., & Azcárate, P. (2020). Education for sustainability and the sustainable development goals: Pre-service teachers' perceptions and knowledge. *Sustainability*, *12*(18), 7741.

Ghani, W. A. W. A. K., Rusli, I. F., Biak, D. R. A., & Idris, A. (2013). An application of the theory of planned behaviour to study the influencing factors of participation in source separation of food waste. *Waste Management*, *33*(5), 1276–1281.

Goulgouti, A., Plakitsi, A., & Stylos, G. (2019). Environmental literacy: Evaluating knowledge, affect, and behavior of pre-service teachers in Greece. *Interdisciplinary Journal of Environmental and Science Education*, *15*(1), e02202.

Grigoroglou, G., & Kounani, A. (2016). *Environmental summer camp in a Greek Island*. 3–8.

Guo, D., Wang, X., Feng, T., & Han, S. (2022). Factors Influencing the Waste Separation Behaviors of Urban Residents in Shaanxi Province during the 14th National Games of China. *International Journal of Environmental Research and Public Health*, *19*(7), 4191. https://doi.org/10.3390/ijerph19074191

Harfadli, M. M., Ramadan, B. S., Rachman, I., & Matsumoto, T. (2024). Challenges and characteristics of the informal waste sector in developing countries: An overview. *Journal of Material Cycles and Waste Management*, *26*(3), 1294–1309.

Hegab, H., Shaban, I., Jamil, M., & Khanna, N. (2023). Toward sustainable future: Strategies, indicators, and challenges for implementing sustainable production systems. *Sustainable Materials and Technologies*, *36*, e00617.

Hendrarso, P. (2021). 3R based waste management in Jakarta higher education institutions: An application of environmental education to create sustainable campus. *Technium Soc. Sci. J.*, *20*, 1.

Hong, Y., Yao, Q., Yang, Y., Feng, J., Wu, S., Ji, W., Yao, L., & Liu, Z. (2016). Knowledge structure and theme trends analysis on general practitioner research: A Co-word perspective. *BMC Family Practice*, *17*, 1–15.

Itzchakov, G., Uziel, L., & Wood, W. (2018). When attitudes and habits don't correspond: Self-control depletion increases persuasion but not behavior. *Journal of Experimental Social Psychology*, *75*, 1–10.

Janmaimool, P., & Khajohnmanee, S. (2019). Roles of environmental system knowledge in promoting university students' environmental attitudes and pro-environmental behaviors. *Sustainability*, *11*(16), 4270.

Jin, N., Lee, S., & Lee, H. (2015). The effect of experience quality on perceived value, satisfaction, image and behavioral intention of water park patrons:

New versus repeat visitors. *International Journal of Tourism Research*, *17*(1), 82–95.

Johnson, S. R., & Stage, F. K. (2018). Academic engagement and student success: Do high-impact practices mean higher graduation rates? *The Journal of Higher Education*, *89*(5), 753–781.

Jung, H. J., Choi, Y. J., & Oh, K. W. (2020). Influencing factors of Chinese consumers' purchase intention to sustainable apparel products: Exploring consumer "attitude–behavioral intention" gap. *Sustainability*, *12*(5), 1770.

Khairi, M. I., Susanti, D., & Sukono, S. (2021). Study on Structural Equation Modeling for Analyzing Data. *International Journal of Ethno-Sciences and Education Research*, *1*(3), 52–60.

Kopnina, H. (2020). Education for the future? Critical evaluation of education for sustainable development goals. *The Journal of Environmental Education*, *51*(4), 280–291.

Kubota, R., Horita, M., & Tasaki, T. (2020). Integration of community-based waste bank programs with the municipal solid-waste-management policy in Makassar, Indonesia. *Journal of Material Cycles and Waste Management*, *22*(3), 928–937.

Kumari, A., & Dutta, S. (2024). Importance of Education and Community Engagement for Effective Waste Management Techniques. In *Exploring Waste Management in Sustainable Development Contexts* (pp. 53–70). IGI Global.

Kurniawan, T. A., Meidiana, C., Othman, M. H. D., Goh, H. H., & Chew, K. W. (2023). Strengthening waste recycling industry in Malang (Indonesia): Lessons from waste management in the era of Industry 4.0. *Journal of Cleaner Production*, *382*, 135296.

Kusumawanto, A., & Setyowati, M. (2020). Green Engineering for Waste Management System in University—A Case Study of Universitas Gadjah Mada, Indonesia. *Green Engineering for Campus Sustainability*, 145–161.

Leal Filho, W., Shiel, C., Paço, A., Mifsud, M., Ávila, L. V., Brandli, L. L., Molthan-Hill, P., Pace, P., Azeiteiro, U. M., & Vargas, V. R. (2019). Sustainable Development Goals and sustainability teaching at universities: Falling behind or getting ahead of the pack? *Journal of Cleaner Production*, *232*, 285–294.

Lee, S. J., & Lina Kim, H. (2018). Roles of perceived behavioral control and self-efficacy to volunteer tourists' intended participation via theory of planned behavior. *International Journal of Tourism Research*, *20*(2), 182–190.

Liang, T.-P., Lin, Y.-L., Shiau, W.-L., & Chen, S.-F. (2021). Investigating common method bias via an EEG study of the flow experience in website design. *Journal of Electronic Commerce Research*, *22*(4), 305–321.

Liao, C., & Li, H. (2019). Environmental Education, Knowledge, and High School Students' Intention toward Separation of Solid Waste on Campus.

International Journal of Environmental Research and Public Health, *16*(9), 1659. https://doi.org/10.3390/ijerph16091659

Linder, N., Giusti, M., Samuelsson, K., & Barthel, S. (2022). Pro-environmental habits: An underexplored research agenda in sustainability science. *Ambio*, 1–11.

Liu, P., Teng, M., & Han, C. (2020). How does environmental knowledge translate into pro-environmental behaviors?: The mediating role of environmental attitudes and behavioral intentions. *Science of The Total Environment*, *728*, 138126. https://doi.org/10.1016/j.scitotenv.2020.138126

Liu, Z., Yang, J. Z., Clark, S. S., & Shelly, M. A. (2021). Recycling as a planned behavior: The moderating role of perceived behavioral control. *Environment, Development and Sustainability*, 1–16.

Lubke, G. H., & Muthén, B. O. (2004). Applying multigroup confirmatory factor models for continuous outcomes to Likert scale data complicates meaningful group comparisons. *Structural Equation Modeling*, *11*(4), 514–534.

Mahardika, S., & Pratamo, N. B. A. (2024). The Problem of Plastic Waste, A Comparison of the Systems in Indonesia and the Netherlands: The Urgency of State Intervention and Legal Instruments. *Environmental Pollution Journal*, *4*(1), 933–948.

Mansolf, M., Jorgensen, T. D., & Enders, C. K. (2020). A multiple imputation score test for model modification in structural equation models. *Psychological Methods*, *25*(4), 393.

Marpa, E. P. (2020). Navigating Environmental Education Practices to Promote Environmental Awareness and Education. *Online Submission*, *2*(1), 45–57.

McAllister, J. T., Lennertz, L., & Atencio Mojica, Z. (2022). Mapping a discipline: A guide to using VOSviewer for bibliometric and visual analysis. *Science & Technology Libraries*, *41*(3), 319–348.

Mejia, C., Wu, M., Zhang, Y., & Kajikawa, Y. (2021). Exploring topics in bibliometric research through citation networks and semantic analysis. *Frontiers in Research Metrics and Analytics*, *6*, 742311.

Memon, M. A., Ramayah, T., Cheah, J.-H., Ting, H., Chuah, F., & Cham, T. H. (2021). PLS-SEM statistical programs: A review. *Journal of Applied Structural Equation Modeling*, *5*(1), 1–14.

Menon, S., & Suresh, M. (2020). Synergizing education, research, campus operations, and community engagements towards sustainability in higher education: A literature review. *International Journal of Sustainability in Higher Education*, *21*(5), 1015–1051.

Mensah, J. (2019). Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review. *Cogent Social Sciences*, *5*(1), 1653531.

Miller, D., Merrilees, B., & Coghlan, A. (2015). Sustainable urban tourism: Understanding and developing visitor pro-environmental behaviours. *Journal of Sustainable Tourism*, *23*(1), 26–46.

Minott, D., & Minott, G. (2022). In pursuit of a sustainable future for Jamaica: Values, critical consciousness, and the pre-service teacher. *Environmental Education Research*, 1–12.

Moustairas, I., Vardopoulos, I., Kavouras, S., Salvati, L., & Zorpas, A. (2022). Exploring factors that affect public acceptance of establishing an urban environmental education and recycling center. *Sustainable Chemistry and Pharmacy*, *25*, 100605.

Mpu, Y. N., Hackmack, K., & Roy, I. (2022). Teacher Educator Reflections on Preparing First Year Pre-Service Teachers for School-Based Work Integrated Learning in An Online Learning Environment. *Research in Social Sciences and Technology*, *7*(3), 18–35.

Muafi, M. (2022). The effect of environmental awareness and environmental knowledge on green behavior mediated by the employee's wellbeing. *International Journal of Business Ecosystem & Strategy (2687-2293)*, *4*(2), 50–60.

Murray, J. (2018). Student-led action for sustainability in higher education: A literature review. *International Journal of Sustainability in Higher Education*, *19*(6), 1095–1110.

Nhamo, G., & Mjimba, V. (2020). *Sustainable development goals and institutions of higher education*. Springer.

Nousheen, A., Zai, S. A. Y., Waseem, M., & Khan, S. A. (2020). Education for sustainable development (ESD): Effects of sustainability education on pre-service teachers' attitude towards sustainable development (SD). *Journal of Cleaner Production*, *250*, 119537.

Nyblade, L., Stockton, M. A., Giger, K., Bond, V., Ekstrand, M. L., Lean, R. M., Mitchell, E. M., Nelson, L. R. E., Sapag, J. C., & Siraprapasiri, T. (2019). Stigma in health facilities: Why it matters and how we can change it. *BMC Medicine*, *17*, 1–15.

Oh, J., & Hettiarachchi, H. (2020). Collective action in waste management: A comparative study of recycling and recovery initiatives from Brazil, Indonesia, and Nigeria using the institutional analysis and development framework. *Recycling*, *5*(1), 4.

Owojori, O. M., Mulaudzi, R., & Edokpayi, J. N. (2022). Student's Knowledge, Attitude, and Perception (KAP) to Solid Waste Management: A Survey towards a More Circular Economy from a Rural-Based Tertiary Institution in South Africa. *Sustainability*, *14*(3). https://doi.org/10.3390/su14031310

Pandit, A., Nakagawa, Y., Timilsina, R. R., Kotani, K., & Saijo, T. (2021). Taking the perspectives of future generations as an effective method for achieving sustainable waste management. *Sustainable Production and Consumption*, *27*, 1526–1536.

Perski, O., Keller, J., Kale, D., Asare, B. Y.-A., Schneider, V., Powell, D., Naughton, F., Ten Hoor, G., Verboon, P., & Kwasnicka, D. (2022). Understanding health behaviours in context: A systematic review and meta-analysis of Ecological Momentary Assessment studies of five key health behaviours. *Health Psychology Review*, *16*(4), 576–601.

Purcell, W. M., Henriksen, H., & Spengler, J. D. (2019). Universities as the engine of transformational sustainability toward delivering the sustainable development goals:"Living labs" for sustainability. *International Journal of Sustainability in Higher Education*, *20*(8), 1343–1357.

Ramaswamy, M., Marciniuk, D. D., Csonka, V., Colò, L., & Saso, L. (2021). Reimagining internationalization in higher education through the United Nations sustainable development goals for the betterment of society. *Journal of Studies in International Education*, *25*(4), 388–406.

Ramdan, H. B., Shams, S., Imteaz, M. A., Ahsan, A., & Honda, T. (2023). Addressing sustainability through waste management: A perspective from higher education institutions in Southeast Asia. *Journal of Material Cycles and Waste Management*, *25*(2), 873–885.

Razali, F., Daud, D., Weng-Wai, C., & Anthony Jiram, W. R. (2020). Waste separation at source behaviour among Malaysian households: The Theory of Planned Behaviour with moral norm. *Journal of Cleaner Production*, *271*, 122025. https://doi.org/10.1016/j.jclepro.2020.122025

Rimantho, D., Hidayah, N. Y., Herzanita, A., & Sandi, A. (2021). Failure Risk Model of Sustainable Solid Waste Management at The University in Indonesia using Dynamic System Approach. *F1000Research*, *10*, 976.

Schild, R. (2016). Environmental citizenship: What can political theory contribute to environmental education practice? *The Journal of Environmental Education*, *47*(1), 19–34.

Serge Kubanza, N., & Simatele, M. D. (2020). Sustainable solid waste management in developing countries: A study of institutional strengthening for solid waste management in Johannesburg, South Africa. *Journal of Environmental Planning and Management*, *63*(2), 175–188.

Sheau-Ting, L., Sin-Yee, T., & Weng-Wai, C. (2016). Preferred Attributes of Waste Separation Behaviour: An Empirical Study. *Procedia Engineering*, *145*, 738–745. https://doi.org/10.1016/j.proeng.2016.04.094

Shi, J., Xu, K., Si, H., Song, L., & Duan, K. (2021). Investigating intention and behaviour towards sorting household waste in Chinese rural and urban–rural integration areas. *Journal of Cleaner Production*, *298*, 126827.

Stoeva, K., & Alriksson, S. (2017). Influence of recycling programmes on waste separation behaviour. *Waste Management*, *68*, 732–741.

Sulistiani, D., Hasanah, S. M., Cholifah, N., & Sholihah, I. H. (2024). Implementation of green public procurement in higher education institutions. *Journal of Law and Sustainable Development*, *12*(4), e3517–e3517.

Tangwanichagapong, S., Nitivattananon, V., Mohanty, B., & Visvanathan, C. (2017). Greening of a campus through waste management initiatives: Experience from a higher education institution in Thailand. *International Journal of Sustainability in Higher Education*.

Tenkasi, R. R. V., & Zhang, L. (2018). A Test of the Theory of Planned Behavior: Influencing Behavioral Change to go "Green"☆ Both authors contributed equally. The ordering of authors is alphabetical. In *Research in organizational change and development* (Vol. 26, pp. 127–165). Emerald Publishing Limited.

Thu, P. T. B., Dang, L. A., Le, T. M. H., & Le, T. H. (2021). Determining Factors Affecting Teacher's Behavioral Intention of Using Information Technology in Lecturing –Case Study of Economic Universities in Vietnam. In Dr. C.-C. Kuo (Ed.), *New Innovations in Economics, Business and Management Vol. 1* (pp. 25–36). Book Publisher International (a part of SCIENCEDOMAIN International). https://doi.org/10.9734/bpi/niebm/v1/13638D

Tomas, L., Girgenti, S., & Jackson, C. (2017). Pre-service teachers' attitudes toward education for sustainability and its relevance to their learning: Implications for pedagogical practice. *Environmental Education Research*, *23*(3), 324–347.

Tonglet, M., Phillips, P. S., & Read, A. D. (2004). Using the Theory of Planned Behaviour to investigate the determinants of recycling behaviour: A case study from Brixworth, UK. *Resources, Conservation and Recycling*, *41*(3), 191–214.

Torrijos, V., Dopico, D. C., & Soto, M. (2021). Integration of food waste composting and vegetable gardens in a university campus. *Journal of Cleaner Production*, *315*, 128175.

Torsney, B. M., Lombardi, D., & Ponnock, A. (2019). The role of values in pre-service teachers' intentions for professional engagement. *Educational Psychology*, *39*(1), 19–37.

Wang, K., Lu, J., & Liu, H. (2021). Residents' waste source separation behaviours in Shanghai, China. *Journal of Material Cycles and Waste Management*, *23*(3), 937–949. https://doi.org/10.1007/s10163-021-01179-7

Wen, J., Kozak, M., Yang, S., & Liu, F. (2021). COVID-19: Potential effects on Chinese citizens' lifestyle and travel. *Tourism Review*, *76*(1), 74–87.

Widayanti, A. W., Green, J. A., Heydon, S., & Norris, P. (2020). Health-seeking behavior of people in Indonesia: A narrative review. *Journal of Epidemiology and Global Health*, *10*(1), 6.

Wieczorek, O., Unger, S., Riebling, J., Erhard, L., Koß, C., & Heiberger, R. (2021). Mapping the field of psychology: Trends in research topics 1995–2015. *Scientometrics*, *126*(12), 9699–9731.

Williams Middleton, K., Padilla-Melendez, A., Lockett, N., Quesada-Pallarès, C., & Jack, S. (2020). The university as an entrepreneurial learning space: The role of socialized learning in developing entrepreneurial competence. *International Journal of Entrepreneurial Behavior & Research*, *26*(5), 887–909.

Yuriev, A., Dahmen, M., Paillé, P., Boiral, O., & Guillaumie, L. (2020). Pro-environmental behaviors through the lens of the theory of planned behavior: A scoping review. *Resources, Conservation and Recycling*, *155*, 104660. https://doi.org/10.1016/j.resconrec.2019.104660

Yusuf, R., & Fajri, I. (2022). Differences in behavior, engagement and environmental knowledge on waste management for science and social students through the campus program. *Heliyon*, *8*(2), e08912.

Zheng, Q., Xu, A., Kong, D., Deng, H., & Lin, Q. (2018). Correlation between the environmental knowledge, environmental attitude, and behavioral intention of tourists for ecotourism in China. *Applied Ecology and Environmental Research*, *16*(1), 51–62.

Zikargae, M. H., Woldearegay, A. G., & Skjerdal, T. (2022). Empowering rural society through non-formal environmental education: An empirical study of environment and forest development community projects in Ethiopia. *Heliyon*, *8*(3), e09127.

Zsóka, Á., Szerényi, Z. M., Széchy, A., & Kocsis, T. (2013). Greening due to environmental education? Environmental knowledge, attitudes, consumer behavior and everyday pro-environmental activities of Hungarian high school and university students. *Journal of Cleaner Production*, *48*, 126–138.

Ajzen, I. (1991). The theory of planned behavior. Organizational behavior and human decision processes, 50, 179–211.

Alam, M. (2023). Environmental Education and Non-governmental Organizations. In: The Palgrave Encyclopedia of Urban and Regional Futures. 495–502., https://doi.org/10.1007/978-3-030-51812-7_333-1.

Al-Mamary, Y.H.S. and Alraja, M.M. (2022). Understanding entrepreneurship intention and behavior in the light of TPB model from the digital entrepreneurship perspective. International Journal of Information Management Data Insights, 2, 100106, https://doi.org/10.1016/J.JJIMEI.2022.100106.

Almeida, S.C., Moore, D. and Barnes, M. (2018). Teacher identities as key to environmental education for sustainability implementation: A study from Australia. Australian Journal of Environmental Education, 34, 228–243, https://doi.org/10.1017/aee.2018.40.

Ardoin, N.M., Bowers, A.W. and Gaillard, E. (2020). Environmental education outcomes for conservation: A systematic review. Biological Conservation, 241, 108224, https://doi.org/10.1016/J.BIOCON.2019.108224.

Bagastyo, A.Y., Anggrainy, A.D. and Liang, M.S.M.W.H. (2023). Assessment of attitude and participation level among the households and local merchants toward single-use plastic waste management: A case study in Balikpapan Municipality, Indonesia. Case Studies in Chemical and Environmental Engineering, 7, 100361, https://doi.org/https://doi.org/10.1016/j.cscee.2023.100361.

Baharum, H., Ismail, A., Awang, Z., McKenna, L., Ibrahim, R., Mohamed, Z. and Hassan, N.H. (2023). Validating an instrument for measuring newly graduated nurses' adaptation. International journal of environmental research and public health, 20, 2860, https://doi.org/10.3390/ijerph20042860.

Becker, J.-M., Cheah, J.-H., Gholamzade, R., Ringle, C.M. and Sarstedt, M. (2023). PLS-SEM's most wanted guidance. International Journal of Contemporary Hospitality Management, 35, 321–346, https://doi.org/10.1108/IJCHM-04-2022-0474.

Brandt, J.-O., Barth, M., Merritt, E. and Hale, A. (2021). A matter of connection: The 4 Cs of learning in pre-service teacher education for sustainability. Journal of Cleaner Production, 279, 123749, https://doi.org/10.1016/j.jclepro.2020.123749.

Cantú, A., Aguiñaga, E. and Scheel, C. (2021). Learning from failure and success: The challenges for circular economy implementation in SMEs in an emerging economy. Sustainability, 13, 1529, https://doi.org/10.3390/su13031529.

Chen, L. and Gao, M. 2020. A new learning interaction rule for municipal household waste classification behavior based on multi-agent-based simulation. Journal of Cleaner Production, 271, 122654, https://doi.org/10.1016/j.jclepro.2020.122654.

Chen, W., Cao, C., Fang, X. and Kang, Z. (2019). Expanding the theory of planned behaviour to reveal urban residents' pro-environment travel behaviour. Atmosphere, 10, 467, https://doi.org/10.3390/atmos10080467.

Christian, K.B., Kelly, A.M. and Bugallo, M.F. (2021). NGSS-based teacher professional development to implement engineering practices in STEM instruction. International Journal of STEM Education, 8, 1–18, https://doi.org/10.1186/s40594-021-00284-1.

Cullinane, A. and Erduran, S. (2023). Nature of science in preservice science teacher education–Case studies of Irish pre-service science teachers. Journal of Science Teacher Education, 34, 201–223, https://doi.org/10.1080/1046560X.2022.2042978.

Debrah, J.K., Vidal, D.G. and Dinis, M.A.P. (2021). Raising awareness on solid waste management through formal education for sustainability: A developing countries evidence review. Recycling, 6, 6, https://doi.org/10.3390/recycling6010006.

Delaroche, M. (2020). Adoption of conservation practices: what have we learned from two decades of social-psychological approaches? Current Opinion in Environmental Sustainability, 45, 25–35, https://doi.org/10.1016/j.cosust.2020.08.004.

Dijkstra, T.K. and Henseler, J. (2015). Consistent partial least squares path modeling. MIS quarterly, 39, 297–316.

Dopelt, K., Radon, P. and Davidovitch, N. (2019). Environmental effects of the livestock industry: The relationship between knowledge, attitudes, and behavior among students in israel. International journal of environmental research and public health, 16, 1359, https://doi.org/10.3390/ijerph16081359.

Ebrahimi, K. and North, L.A. (2017). Effective strategies for enhancing waste management at university campuses. International Journal of Sustainability in Higher Education, 18, 1123–1141, https://doi.org/10.1108/IJSHE-01-2016-0017.

Echegoyen-Sanz, Y. and Martín-Ezpeleta, A. (2021). A holistic approach to education for sustainability: Ecofeminism as a tool to enhance sustainability attitudes in pre-service teachers. Journal of Teacher Education for Sustainability, 23, 5–21, https://doi.org/10.2478/jtes-2021-0002.

Fagnani, E. and Guimarães, J.R. (2017). Waste management plan for higher education institutions in developing countries: The Continuous Improvement Cycle model. Journal of Cleaner Production, 147, 108–118, https://doi.org/10.1016/j.jclepro.2017.01.080.

Faize, F.A. and Akhtar, M. (2020). Addressing environmental knowledge and environmental attitude in undergraduate students through scientific argumentation. Journal of Cleaner Production, 252, 119928, https://doi.org/10.1016/j.jclepro.2019.119928.

Farrukh, M., Ansari, N., Raza, A., Wu, Y. and Wang, H. (2022). Fostering employee's pro-environmental behavior through green transformational leadership, green human resource management and environmental knowledge. Technological Forecasting and Social Change, 179, 121643, https://doi.org/10.1016/j.techfore.2022.121643.

Ferguson, T., Roofe, C. and Cook, L.D. (2021). Teachers' perspectives on sustainable development: the implications for education for sustainable development. Environmental Education Research, 27, 1343–1359, https://doi.org/10.1080/13504622.2021.1921113.

García-Machado, J.J., Figueroa-García, E.C. and Jachowicz, A. (2020). Sustainable consumption behaviour in Poland through a PLS-SEM model. Perspectives on Consumer Behaviour: Theoretical Aspects and Practical Applications, 147–172, https://doi.org/10.1007/978-3-030-47380-8_7.

Gkargkavouzi, A., Halkos, G. and Matsiori, S. (2019). Environmental behavior in a private-sphere context: Integrating theories of planned behavior and value belief norm, self-identity and habit. Resources, Conservation and Recycling, 148, 145–156, https://doi.org/10.1016/j.resconrec.2019.01.039.

Gold, D. 2017. Statistical tests and substantive significance. In: The Significance Test Controversy. 172–181.

Goulgouti, A., Plakitsi, A. and Stylos, G. (2019). Environmental literacy: Evaluating knowledge, affect, and behavior of pre-service teachers in Greece. Interdisciplinary Journal of Environmental and Science Education, 15, e02202, https://doi.org/10.29333/ijese/6287.

Hayes, K.N., Wheaton, M. and Tucker, D. (2019). Understanding teacher instructional change: The case of integrating NGSS and stewardship in professional development. Environmental Education Research, 25, 115–134, https://doi.org/10.1080/13504622.2017.1396289.

Hegab, H., Shaban, I., Jamil, M. and Khanna, N. (2023). Toward sustainable future: Strategies, indicators, and challenges for implementing sustainable production systems. Sustainable Materials and Technologies, 36, e00617, https://doi.org/10.1016/j.susmat.2023.e00617.

Henry, G.T. 2009. Practical sampling. The SAGE handbook of applied social research methods, 2, 77–105.

Horng, J.-S., Liu, C.-H., Chou, S.-F., Yu, T.-Y., Fang, Y.-P. and Huang, Y.-C. (2022). Student's perceptions of sharing platforms and digital learning for sustainable behaviour and value changes. Journal of Hospitality, Leisure, Sport & Tourism Education, 31, 100380, https://doi.org/10.1016/j.jhlste.2022.100380.

Janmaimool, P. and Khajohnmanee, S. (2019). Roles of environmental system knowledge in promoting university students' environmental attitudes and pro-environmental behaviors. Sustainability, 11, 4270, https://doi.org/10.3390/su11164270.

Journeault, M., Perron, A. and Vallières, L. (2021). The collaborative roles of stakeholders in supporting the adoption of sustainability in SMEs. Journal of environmental management, 287, 112349, https://doi.org/10.1016/j.jenvman.2021.112349.

Kanada, M., Norman, P., Kaida, N. and Carver, S. (2023). Linking environmental knowledge, attitude, and behavior with place: a case study for strategic environmental education planning in Saint Lucia. Environmental Education Research, 29, 929–950, https://doi.org/10.1080/13504622.2022.2074376.

Karrow, D.D., Di Giuseppe, M., Elliott, P., Gwekwerere, Y. and Inwood, H. (2016). Canadian Perspectives on Initial Teacher Environmental Education Praxis.

Kim, A.A., Sadatsafavi, H., Medal, L. and Ostergren, M.J. (2018). Impact of communication sources for achieving campus sustainability. Resources, Conservation and Recycling, 139, 366–376, https://doi.org/10.1016/j.resconrec.2018.08.024.

Knickmeyer, D. (2020). Social factors influencing household waste separation: A literature review on good practices to improve the recycling performance of urban areas. Journal of cleaner production, 245, 118605, https://doi.org/10.1016/j.jclepro.2019.118605.

Kopnina, H. (2020). Education for the future? Critical evaluation of education for sustainable development goals. The Journal of Environmental Education, 51, 280–291, https://doi.org/10.1080/00958964.2019.1710444.

Kurokawa, H., Igei, K., Kitsuki, A., Kurita, K., Managi, S., Nakamuro, M. and Sakano, A. (2023). Improvement impact of nudges incorporated in environmental education on students' environmental knowledge, attitudes, and behaviors. Journal of Environmental Management, 325, 116612, https://doi.org/10.1016/j.jenvman.2022.116612.

Lavrakas, P.J., Traugott, M.W., Kennedy, C., Holbrook, A.L., de Leeuw, E.D. and West, B.T. (2019). Experimental Methods in Survey Research: Techniques That Combine Random Sampling with Random Assignment.

Leal Filho, W., Shiel, C., et al. (2019). Sustainable Development Goals and sustainability teaching at universities: Falling behind or getting ahead of the pack? Journal of Cleaner Production, 232, 285–294, https://doi.org/10.1016/j.jclepro.2019.05.309.

Legrain, P., Becerra-Labrador, T., Lafont, L. and Escalié, G. (2021). Designing and implementing a sustainable cooperative learning in physical education: A pre-service teachers' socialization issue. Sustainability, 13, 657, https://doi.org/10.3390/su13020657.

Liang, T.-P., Lin, Y.-L., Shiau, W.-L. and Chen, S.-F. (2021). Investigating common method bias via an EEG study of the flow experience in website design. Journal of Electronic Commerce Research, 22, 305–321.

Liao, C. and Li, H. (2019). Environmental education, knowledge, and high school students' intention toward separation of solid waste on campus. International journal of environmental research and public health, 16, 1659, https://doi.org/10.3390/ijerph16091659.

Lim, W.M. and Weissmann, M.A. (2023). Toward a theory of behavioral control. Journal of Strategic Marketing, 31, 185–211, https://doi.org/10.1080/0965254X.2021.1890190.

Menabò, L., Skrzypiec, G., Sansavini, A., Brighi, A. and Guarini, A. (2022). Distance education among Italian teachers: Differences and experiences. Education and Information Technologies, 27, 9263–9292, https://doi.org/10.1007/s10639-022-11008-5.

Nhamo, G. and Mjimba, V. (2020). Sustainable Development Goals and Institutions of Higher Education, https://doi.org/10.1007/978-3-030-26157-3.

Nousheen, A., Zai, S.A.Y., Waseem, M. and Khan, S.A. (2020). Education for sustainable development (ESD): Effects of sustainability education on pre-service teachers' attitude towards sustainable development (SD). Journal of Cleaner Production, 250, 119537, https://doi.org/10.1016/j.jclepro.2019.119537.

Opoku, A. and Egbu, C. (2018). Students' perspectives on the relevance of sustainability literacy in a postgraduate built environment program. International Journal of Construction Education …, https://doi.org/10.1080/15578771.2017.1286417.

Parajuly, K., Fitzpatrick, C., Muldoon, O. and Kuehr, R. (2020). Behavioral change for the circular economy: A review with focus on electronic waste management in the EU. Resources, Conservation & Recycling: X, 6, 100035, https://doi.org/10.1016/j.rcrx.2020.100035.

Perski, O., Keller, J., et al. (2022). Understanding health behaviours in context: A systematic review and meta-analysis of ecological momentary assessment studies of five key health behaviours. Health psychology review, 16, 576–601, https://doi.org/10.1080/17437199.2022.2112258.

Risien, J., Hoke, K., Storksdieck, M., Davis, C. and Klein, E. (2023). A dynamic framework for making sense of partnerships between universities and informal education providers. Evaluation and Program Planning, 102328, https://doi.org/10.1016/j.evalprogplan.2023.102328.

Ruiz Bravo, D. (2023). Shaping Social Practices and Behaviors to Implement Community-Based Organic Waste Management Strategies.

Sok, J., Borges, J.R., Schmidt, P. and Ajzen, I. (2021). Farmer behaviour as reasoned action: a critical review of research with the theory of planned behaviour. Journal of Agricultural Economics, 72, 388–412, https://doi.org/10.1111/1477-9552.12408.

Stoeva, K. and Alriksson, S. (2017). Influence of recycling programmes on waste separation behaviour. Waste Management, 68, 732–741, https://doi.org/10.1016/j.wasman.2017.06.005.

Tcymbal, A., Demetriou, Y., et al. (2020). Effects of the built environment on physical activity: a systematic review of longitudinal studies taking sex/gender into account. Environmental health and preventive medicine, 25, 1–25, https://doi.org/10.1186/s12199-020-00915-z.

Tran Ho, U., Lepage, B.A. and Fang, W.-T. (2022). Environmental education in pre-school teacher training programs in Vietnam: situations and challenges. Journal of Early Childhood Teacher Education, 1–20, https://doi.org/10.1080/10901027.2022.2136552.

Venn, R., Perez, P. and Vandenbussche, V. (2022). Competencies of sustainability professionals: an empirical study on key competencies for sustainability. Sustainability, 14, 4916, https://doi.org/10.3390/su14094916.

Wang, Q.-C., Chang, R., Xu, Q., Liu, X., Jian, I.Y., Ma, Y.-T. and Wang, Y.-X. (2021). The impact of personality traits on household energy conservation behavioral intentions–An empirical study based on theory of planned behavior in Xi'an. Sustainable Energy Technologies and Assessments, 43, 100949, https://doi.org/10.1016/j.seta.2020.100949.

Whitley, C.T., Takahashi, B., Zwickle, A., Besley, J.C. and Lertpratchya, A.P. (2018). Sustainability behaviors among college students: An application of the VBN theory. Environmental education research, 24, 245–262, https://doi.org/10.1080/13504622.2016.1250151.

Winter, V., Kranz, J. and Möller, A. (2022). Climate change education challenges from two different perspectives of change agents: Perceptions of school students and pre-service teachers. Sustainability, 14, 6081, https://doi.org/10.3390/su14106081.

Wu, L., Zhu, Y. and Zhai, J. (2022). Understanding Waste Management Behavior Among University Students in China: Environmental Knowledge, Personal Norms, and the Theory of Planned Behavior. Frontiers in Psychology, 12, https://doi.org/10.3389/FPSYG.2021.771723/FULL.

Xiao, H.-L., Jin, C.-Y., Zhang, G.-D. and Zhang, C.-Q. (2023). Applying the temporal self-regulation theory to understand sugar-sweetened beverage consumption among Chinese college students. Health Psychology and Behavioral Medicine, 11, 2208213, https://doi.org/10.1080/21642850.2023.2208213.

Yadav, S. (2023). Cultivating Sustainable Behavior and Critical Consciousness Towards the Environment: Environmental Education for Sustainability. The Impact of Climate Change and Sustainability Standards on the Insurance Market, 333–348, https://doi.org/10.1002/9781394167944.ch21.

Zeng, Z., Zhong, W. and Naz, S. (2023). Can Environmental Knowledge and Risk Perception Make a Difference? The Role of Environmental Concern and Pro-Environmental Behavior in Fostering Sustainable Consumption Behavior. Sustainability, 15, 4791, https://doi.org/10.3390/su15064791.

Zhang, B., Lai, K., Wang, B. and Wang, Z. (2019). From intention to action: How do personal attitudes, facilities accessibility, and government stimulus matter for household waste separation? Journal of Environmental Management, 233, 447–458, https://doi.org/https://doi.org/10.1016/j.jenvman.2018.12.059.

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“May this work honor Him and the wonderful family He has blessed me with”.

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