Uncertain Supply Chain Management 11 (2023) 1001–1008

Contents lists available at GrowingScience

Uncertain Supply Chain Management

homepage: www.GrowingScience.com/uscm

Predicting supply chain management of e-waste recycling behavior using an extended theory of planned behavior model

Adi Suryanto[a*], Nurliah Nurdin[a], Andriansyah[b], Neneng Sri Rahayu[a] and Erna Irawati[a]

[a]*Politeknik STIA LAN, Jakarta, Indonesia*
[b]*Universitas Muhammadiyah Jakarta, Indonesia*

A B S T R A C T

Article history:
Received October 2, 2022
Received in revised format March 18, 2023
Accepted April 20 2023
Available online
April 27 2023

Keywords:
E-waste
Recycling behavior
Theory of Planned Behavior
Supply chain management

This study aims to examine the supply chain management perspective of subjective norms, attitude, perceived behavioral control, and intention on e-waste recycling behavior, and the mediating role of intention in the relationship between the factors of extended theory of planned behavior and e-waste recycling behavior. The research sample was students at some universities in Jakarta, Indonesia with data collected through an online questionnaire. The results of the analysis show that subjective norms, attitudes, perceived behavioral control, and intentions have significant effects on e-waste recycling behavior. In addition, intention can mediate the relationship between attitude and perceived behavioral control on e-waste recycling behavior. The implication highlighted the importance of the role of subjective norms, attitude, perceived behavioral control, and intention in influencing one's e-waste recycling behavior. Therefore, public awareness can pay attention to the factors of extended theory of planned behavior in helping to increase the awareness of e-waste recycling. From a theoretical point of view, the findings show that the Theory of Planned Behavior is a useful theoretical framework for understanding the behavior of e-waste recycling. Practically speaking, significant findings about the role of subjective norms, attitudes, perceived behavioral controls, and intentions in influencing e-waste recycling behavior can inform policies and programs aimed at promoting more responsible e-waste management.

1. Introduction

Electronic waste (e-waste) is a serious concern worldwide due to the increasing number of electronic devices being disposed of every year. Improper disposal of e-waste not only poses risks to human health and the environment, but also results in the loss of valuable resources. Conversely, e-waste recycling can help reduce these negative impacts and create economic opportunities. E-waste management from a supply chain perspective requires a coordinated effort from all stakeholders. A supply chain perspective highlights the need for effective collection, safe transportation, efficient recycling, and proper disposal of e-waste (Cruz-Sotelo et al., 2017). Governments, manufacturers, and other stakeholders must work together to create a sustainable e-waste management system that complies with safety and environmental standards. One of the important determinants of e-waste recycling behavior is the perception of environmental responsibility. People who believe they have an individual responsibility to protect the environment are more likely to engage in e-waste recycling than those who do not share this perception (Keshavarz & Karami, 2016: Saphores et al., 2012). In a supply chain perspective, some factors influencing the recycling behavior of individuals of e-waste include knowledge and awareness about the recycling process and the environmental impact of e-waste. Keshavarz and Karami (2016) found that people who are aware of the negative impact of e-waste on the environment and human health are more likely to recycle their e-waste. Likewise, Islam et al. (2021) found that providing education and information programs to the public about e-waste recycling can increase recycling behavior. In addition, social norms and peer pressure can also be effective in promoting e-waste recycling behavior. Otto et al. (2018) show that social norms and peer pressure can be used to encourage people to recycle their e-waste. Several factors

* Corresponding author
E-mail address asuryanto.lanri@gmail.com (A. Suryanto)

doi: 10.5267/j.uscm.2023.4.022

have been shown to be determinants of e-waste recycling behavior including e-waste recycling facilities, and effective strategies such as financial incentives and social norms can influence e-waste recycling behavior. Previous studies have shown that the factors of extended Theory of Planned Behavior (TPB) can affect e-waste recycling behavior. One theory that can be used to understand the relationship between subjective factors and e-waste recycling behavior is the Theory of Planned Behavior (TPB) (Wang et al., 2019; Aboelmaged, 2021). Based on the Theory of Planned Behavior (TPB), these three factors have a significant influence on e-waste recycling behavior. Subjective norms are related to social expectations that encourage or inhibit behavior, attitudes are related to individual evaluation of the behavior, while perceived behavioral control is related to an individual's ability to control behavior (Goh et al., 2017).

To increase the awareness of e-waste recycling behavior, it is necessary to understand the subjective factors that influence it, such as social norms, attitudes, and self-control (Nduneseokwu et al., 2017). By understanding these factors, we can develop strategies or programs that can increase the awareness of e-waste recycling behavior and improve the quality of e-waste in Indonesia as a whole. In the context of E-waste, Theory of Planned Behavior can be used to understand subjective factors that influence e-waste recycling behavior (Aboelmaged, 2021). By understanding these factors, strategies or programs can be developed that can increase the awareness of e-waste recycling behavior. Therefore, this study aims to examine the effect of subjective norms, attitudes, and perceived behavioral control on e-waste recycling behavior. This study will also examine the role of intention as a mediator between subjective norms, attitudes, and perceived behavioral control over e-waste recycling behavior. As a contribution, this research is needed to identify the most effective strategies to promote the recycling behavior of individuals' e-waste and increase the effectiveness of e-waste management.

2. Literature Review

Subjective norms are individual views of social expectations associated with certain behaviors (Van Tonder et al., 2023). Ajzen (1991) found that subjective norms can affect one's e-waste recycling intentions and behavior. Ajzen (1991) showed that individuals tend to have higher intentions to perform certain behaviors if they feel that the behavior is accepted and supported by their social environment. Armitage & Conner (2001) found that subjective norms affect an individual's e-waste recycling behavior. Armitage and Conner (2001) emphasized that individuals tend to be more motivated to recycle e-waste if they feel that their social environment supports this e-waste recycling behavior. Individuals also tend to have higher e-waste recycling motivation if they feel supported by their social environment, such as family, friends, and teachers. Moreover, a positive attitude towards e-waste recycling and e-waste can increase the motivation and effectiveness of e-waste recycling behavior (Christohel, 1990). Fishbein and Ajzen (1975) found that an individual's attitude toward a certain behavior influences their intention to perform that behavior. In the context of e-waste recycling, a positive attitude towards e-waste recycling can increase individuals' intention to recycle e-waste. Ajzen (1991) found that attitude also influences one's e-waste recycling behavior. Ajzen (1991) emphasized that individuals tend to have more effective e-waste recycling behavior if they have a positive attitude towards e-waste recycling. In terms of extended TPB constructs, Perceived Behavioral Control (PBC) can help increase individuals' intention to recycle e-waste by providing positive support, motivation, and inspiration (Koshta et al., 2022). Studies have shown that PBC is a critical predictor of recycling behavior (White & Hyde, 2012; Ajzen, 1991). Koshta (2022) found that PBC was a significant factor in determining the intention to recycle e-waste. In addition, the application of interesting and interactive e-waste recycling methods and the use of effective e-waste recycling technology can help increase individuals' perceived behavioral control over e-waste recycling. Individuals will have a strong intention to recycle e-waste and have more effective e-waste recycling behavior in achieving their e-waste recycling goals.

In order to increase the awareness of e-waste recycling behavior in Indonesia, it is important to consider the subjective norms factor. Perceived behavioral control can help individuals feel supported and accepted by their social environment in e-waste recycling, for example by providing moral support and providing positive expectations (De Vries et al., 1988). Individuals will be more motivated and have more effective e-waste recycling behavior in achieving their e-waste recycling goals. In addition, intention is an important factor that influences one's e-waste recycling behavior. In the context of the Theory of Planned Behavior (TPB), subjective norms, attitude, and perceived behavioral control can affect the intention to carry out e-waste recycling behavior, which in turn influences e-waste recycling behavior (Ajzen & Madden, 1986; La Barbera & Ajzen, 2021). Armitage & Conner (2001) showed that intention mediates the relationship between subjective norms, attitude, and perceived behavioral control of e-waste recycling behavior. This means that when someone has positive subjective norms, a positive attitude towards e-waste recycling, and high perceived behavioral control, they will have a strong intention to learn, which in turn will increase the awareness of e-waste recycling behavior. Dixit Badgaiyan (2016) found that intention mediates the relationship between subjective norms, attitude, and perceived behavioral control on one's motivation to recycle e-waste. Accordingly, the following hypotheses were proposed:

H_1: *Subjective norms have a positive and significant effect on e-waste recycling behavior.*
H_2: *Attitude has a positive and significant effect on e-waste recycling behavior.*
H_3: *Intention mediates the relationship between subjective norms and e-waste recycling behavior.*
H_4: *Intention mediates the relationship between attitude and e-waste recycling behavior.*
H_5: *Intention mediates the relationship between perceived behavioral control and e-waste recycling behavior.*

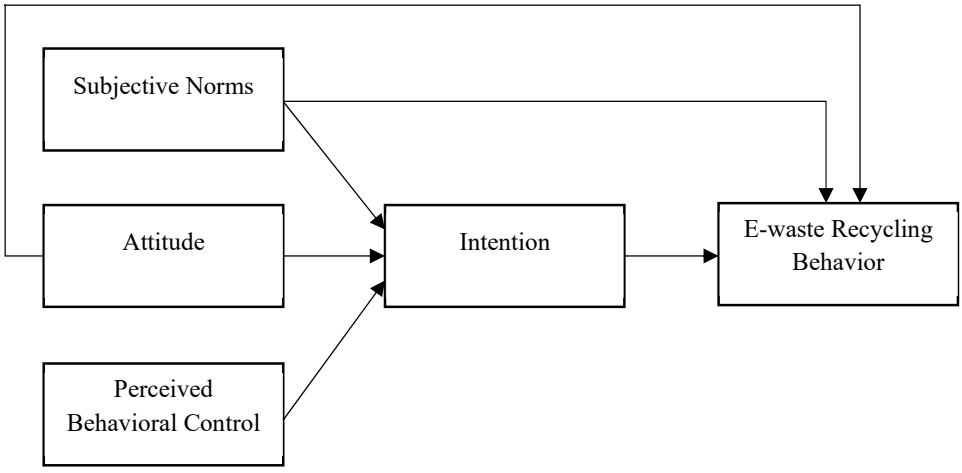

Fig. 1. Conceptual Framework

3. Research Method

The study employed a quantitative methodology for both data collection and analysis due to its ability to offer reliable and precise presentation of the variables. Since the goal was to examine the elements that influence the intention and conduct of e-waste disposal by examining established hypotheses employing the extended TPB, this approach was considered appropriate. During the month of October 2022, data was collected through a Google Forms online survey, which was sent to participants using purposive sampling. A total of 250 questionnaires were initially distributed, with 224 returned. Of the returned questionnaires, 219 were complete and suitable for further analysis, as 5 were incomplete. Sekaran & Bougie (2016) suggested that studies can typically use sample sizes between 30 and 500 participants.

Subjective norms refer to individuals' views of the norms that apply in society or the surrounding environment. Individuals who feel that good and diligent study behavior is needed to gain recognition from the community or those closest to them tend to be more diligent in studying than individuals who do not feel pressure from their environment (Abd Mutalib et al., 2017). This study used 5 items of subjective norms adopted from Mohamad et al. (2022) including expectation to recycle e-waste from friends, classmates or colleagues, family, institutions, and the media. Moreover, attitude refers to an individual's subjective evaluation of an object or action. In this study, individuals' attitudes towards e-waste were operationally defined as students' subjective evaluation towards e-waste recycling process and behavior. This means that individuals who have a positive attitude towards e-waste and the e-waste recycling process tend to be more motivated and active in the e-waste recycling process (Bagozzi, 1992). The items used for measuring attitude in this study were 3 items adopted from Mohamad et al. (2022), including E-waste recycling is pleasant, responsible, and beneficial. Perceived behavioral control refers to an individual's perception of his ability to perform a behavior. Perceived behavioral control in this study was operationally defined as students' perceptions of their ability to recycle e-waste greatly influence their e-waste recycling behavior. This means that if individuals feel that they have strong control over their e-waste recycling behavior, then they tend to be more motivated and active in the e-waste recycling process (Zolait, 2014). The items used to measure perceived behavioral control in this study were 6 items adopted from Mohamad et al. (2022), including knowledge about items of e-waste that can be recycled, opportunities to recycle e-waste, satisfactory resources for recycling e-waste, knowledge of where to take e-waste for recycling and knowledge to recycle e-waste.

This study evaluated model structures through a two-step process. The initial step involved evaluating the outer model (measurement model), while the subsequent step involved evaluating the inner model (structural model). Partial least squares structural equation modeling (PLS-SEM) was utilized to analyze the data. The analysis test in this study used SmartPLS which tested the effect of subjective norms, attitudes, and perceived behavioral control on e-waste recycling behavior. SmartPLS can be used to test hypotheses related to these variables. SmartPLS can produce output in the form of outer loading, R-squared and F Square values for each variable, so that it can help researchers to test the validity and reliability of the model being tested. Thus, the results of the SmartPLS analysis can be used to test the relationship between variables and provide valuable information for improving and improving the tested model.

4. Results

Outer loading is the correlation coefficient between each manifest variable and latent variables in the model. The outer loading value emphasized how much the measured manifest variable can explain the latent variable it represents. A good outer loading value is a value greater than 0.6, so it can be considered a valid and reliable indicator in measuring latent variables (Ghozali, 2014). The results of the outer loading values in this study are presented in Table 1.

Table 1
Outer Loading

Variable	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
NORM1 ← Subjective Norms	0.78	0.776	0.066	11.788	0
NORM2 ← Subjective Norms	0.908	0.908	0.016	55.727	0
NORM3 ← Subjective Norms	0.909	0.907	0.015	58.792	0
NORM4 ← Subjective Norms	0.908	0.909	0.014	67.222	0
NORM5 ← Subjective Norms	0.827	0.829	0.033	25.339	0
ATT1 ← Attitude	0.675	0.663	0.077	8.733	0
ATT2 ← Attitude	0.894	0.895	0.02	44.627	0
ATT3 ← Attitude	0.879	0.881	0.022	40.39	0
PBC1 ← Perceived Behavioral Control	0.751	0.746	0.042	18.069	0
PBC2 ← Perceived Behavioral Control	0.856	0.856	0.033	25.96	0
PBC3 ← Perceived Behavioral Control	0.794	0.791	0.037	21.671	0
PBC4 ← Perceived Behavioral Control	0.851	0.846	0.028	30.031	0
PBC5 ← Perceived Behavioral Control	0.82	0.817	0.028	28.771	0
PBC6 ← Perceived Behavioral Control	0.743	0.742	0.039	18.918	0
INT1 ← Intention	0.848	0.847	0.026	32.064	0
INT2 ← Intention	0.713	0.716	0.099	7.199	0
INT3 ← Intention	0.882	0.881	0.029	30.099	0
INT4 ← Intention	0.856	0.855	0.029	29.057	0
INT5 ← Intention	0.905	0.903	0.017	52.549	0
INT6 ← Intention	0.876	0.875	0.024	35.983	0
LB1 ← e-waste recycling behavior	0.713	0.708	0.046	15.491	0
LB2 ← e-waste recycling behavior	0.852	0.853	0.035	24.321	0
LB3 ← e-waste recycling behavior	0.854	0.852	0.025	33.906	0
LB4 ← e-waste recycling behavior	0.885	0.884	0.027	32.783	0

Table 1 shows that indicators of latent subjective norms variables have outer loading values ranging from 0.780 to 0.909. Therefore, these indicators can be said to be valid and reliable in measuring subjective norms variables. Then the indicators of the latent attitude variable obtain values ranging from 0.675 - 0.894, the value of the outer loading indicator used can also be said to be valid in measuring the attitude variable. Indicators of perceived behavioral control latent variables obtain values ranging from 0.743 - 0.856, so it can be concluded that the indicators used on perceived behavioral control latent variables can be relied upon in measuring these variables. Furthermore, the indicator of the intention variable gets an outer loading value that ranges from 0.713 - 0.905, meaning that the indicator used is valid. In the indicator of the latent e-waste recycling behavior variable, the outer loading value obtained is in the range of 0.713 - 0.885. Thus, the indicators used in the e-waste recycling behavior variable are also valid and reliable in measuring these latent variables.

The next analysis test is the R square analysis test. Where the value of R square is a value that shows how much the independent variables (subjective norms, attitude & perceived behavioral control) influence the dependent variable (e-waste recycling behavior). According to Chin (1998), the R-Square value is categorized as strong if it is more than 0.67, moderate if it is more than 0.33 but lower than 0.67, and weak if it is lower than 0.33. As for this study, the R-Square value obtained was 0.567 with an adjusted R Square value of 0.561. Thus, the magnitude of the independent variable influencing the dependent variable in this study is moderate (Table 2).

Table 2
R Square

Variable	R Square	R Square Adjusted
E-waste recycling behavior	0.567	0.561

The next analysis test is the reliability test and validity test. Reliability test is the extent to which measurement results using the same object will produce the same data. A good score in the reliability test is a value greater than 0.7. If the alpha value > 0.7 means sufficient reliability, while if alpha > 0.80 means that all items are reliable, and all tests consistently have strong reliability. If the reliability value is still low, the researcher may consider removing indicators that are less reliable or making improvements to the measurement instruments used. Then the validity test is used to show the extent to which the measuring instrument is used in a measure of what is being measured. The validity test is used to measure the legitimacy or validity of a questionnaire. A good value for validity is a value greater than 0.5. The results of the reliability test and validity test in this study can be seen in Table 3. From the results of the reliability test in the table above, it showed that the subjective norms variable has a Cronbach's alpha value of 0.917, attitude is 0.754, perceived behavioral control is 0.889, intention is 0.921, and e-waste recycling behavior obtains a Cronbach's alpha value of 0.845. This value is already above the value of 0.7, and even four of these have a Cronbach's alpha value > 0.8. This means that all items are reliable, and all tests consistently have strong reliability. Then in the validity test, the AVE value obtained from the subjective norm's variable is 0.754, attitude is 0.676, perceived behavioral control is 0.646, intention is 0.721 and e-waste recycling behavior is 0.686. All variables in this study have an AVE > 0.5, which means that all variables in this study can be said to be valid.

Table 3
Construct Reliability and Validity

Variables	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Subjective Norms	0.917	0.923	0.938	0.754
Attitude	0.754	0.784	0.861	0.676
Perceived Behavioral Control	0.889	0.892	0.916	0.646
Intention	0.921	0.928	0.939	0.721
E-waste recycling behavior	0.845	0.848	0.897	0.686

The hypothesis testing in this study was divided into 2 parts, namely direct hypothesis testing and indirect hypothesis testing or through mediation. Direct hypothesis testing is carried out to determine the effect of the independent variables directly on the dependent variable. In this study, direct hypothesis testing was carried out to examine the effect of subjective norms, attitudes, and perceived behavioral control on e-waste recycling behavior. Meanwhile, indirect hypothesis testing or through mediation is carried out to find out whether the relationship between the independent and dependent variables is influenced by the intermediary variable. In this study, indirect hypothesis testing was carried out to test whether intention can mediate the relationship between subjective norms, attitude, and perceived behavioral control on e-waste recycling behavior. Through this hypothesis test, it can be seen whether there is a direct or indirect relationship between the independent and dependent variables, and whether intention can be a mediator between this relationship. The hypothesis can be accepted or can be said to be significant if the T-statistics value is greater than 1.96 or it can be seen with a P value <0.05. The results of the hypothesis test directly can be seen in Table 4.

Table 4
The results of Path Analysis

Hypothesis		Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
H1	Subjective Norms → e-waste recycling behavior	0.384	0.383	0.083	4.641	0
H2	Attitude → e-waste recycling behavior	0.27	0.274	0.074	3.629	0
H3	Subjective Norms → Intention → e-waste recycling behavior	0.032	0.033	0.019	1.737	0.084
H4	Attitude → Intention → e-waste recycling behavior	0.038	0.037	0.019	1.994	0.047
H5	Perceived Behavioral Control → Intention → e-waste recycling behavior	0.116	0.111	0.047	2.477	0.014

From Table 4, in the first hypothesis, namely the influence of subjective norms on e-waste recycling behavior, the T statistics value is 4,641. The P value obtained in the first hypothesis is 0.000 (<0.05), meaning that the first hypothesis in this study is acceptable. Then in the second hypothesis which states that attitude influences e-waste recycling behavior, it obtains a T statistics value of 3.629 with a P value of 0.000 (<0.05). With these results it can also be said that the second hypothesis in this study can be accepted. Then in the indirect hypothesis test, the hypothesis can also be accepted, or it can be said to be significant if the T-statistics value obtained is > 1.96 or by looking at the P value it must be <0.05. In the fourth hypothesis, where intention mediates the relationship between subjective norms and e-waste recycling behavior, it obtains a T statistics value of 1.737 with a P value of 0.084. The T statistics value obtained is still below 1.96 and the P value obtained is above 0.05. Therefore, the third hypothesis in this study cannot be accepted. Then in the fourth hypothesis, where intention mediates the relationship between attitude and e-waste recycling behavior, it obtains a T statistics value of 1.994 and a P value of 0.047. Thus, the fourth hypothesis can be said to be accepted. Furthermore, in the fifth hypothesis, where intention mediates the relationship between perceived behavioral control and e-waste recycling behavior, it obtains a T statistics value of 2.477 with a P value of 0.014. From these values it can be concluded that the fifth hypothesis in this study can be accepted (Fig. 2).

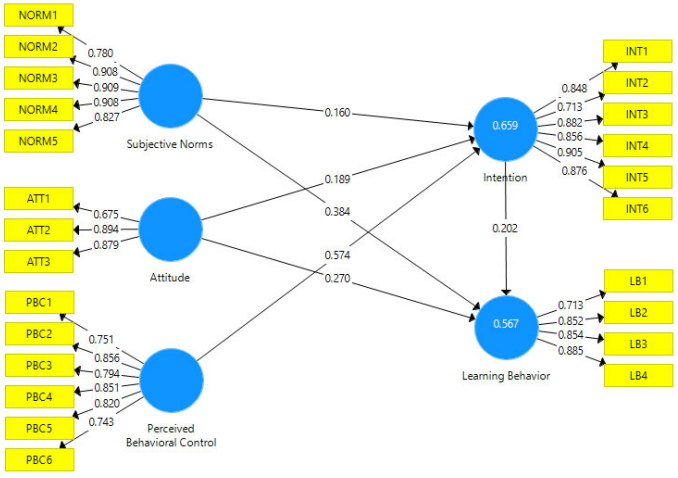

Fig. 2. SmartPLS Analysis

5. Discussion

The results of the study show that subjective norms, attitude, perceived behavioral control, and intentions have a significant influence on an individual's e-waste recycling behavior. These results can strengthen previous research conducted by Mahmud et al. (2020) and Kashif et al. (2018) which showed that attitude, subjective norms, and perceived behavioral control have a significant influence on intentions to behave ethically in the e-waste recycling context. This is in line with the results in this study which show that subjective factors such as subjective norms, attitude, and perceived behavioral control influence an individual's e-waste recycling behavior. In addition, intention also mediates the relationship between attitude and perceived behavioral control on e-waste recycling behavior. This is in line with previous research and can strengthen previous findings such as research by Wan and Shen (2015) and Dixit and Badgaiyan (2016). The results of research by Wan and Shen (2015) and Dixit and Badgaiyan (2016) stated that intention can be used as an appropriate mediating factor for subjective norms, attitudes and perceived behavioral control of e-waste recycling behavior. However, the results of hypothesis testing in this study state that intention has not been able to mediate the relationship between subjective norms and e-waste recycling behavior. In the context of E-waste, this showed that it is important for public awareness to provide positive support, motivation and inspiration to individuals, as well as apply innovative and interesting e-waste recycling methods. In addition, the use of effective e-waste recycling technology can also help improve individuals' perceived behavioral control over e-waste recycling. This research is expected to be able to contribute to developing an understanding of the factors that influence an individual's e-waste recycling behavior, especially in the context of e-waste in Indonesia. By increasing understanding of these factors, it is hoped that it can help improve e-waste recycling effectiveness and academic achievement of individuals in Indonesia.

6. Conclusion

The results concluded that in a supply chain perspective, subjective norms, attitude, perceived behavioral control, and intentions have significant influences on an individual's e-waste recycling behavior. In addition, intention also mediates the relationship between attitude and perceived behavioral control on e-waste recycling behavior. However, in this study, intention has not been able to become an appropriate mediating factor between subjective norms and e-waste recycling behavior. This showed that public awareness can help increase the awareness of e-waste recycling by providing positive support, motivation, and inspiration, as well as applying innovative and interesting e-waste recycling methods. The use of effective e-waste recycling technology can also help improve individuals' perceived behavioral control over e-waste recycling.

The implication of this research is the importance of the role of subjective norms, attitude, perceived behavioral control, and intention in influencing one's e-waste recycling behavior. Therefore, public awareness can pay attention to these factors in helping to increase the awareness of e-waste recycling. In addition, this research can also be the basis for developing more effective and innovative e-waste recycling programs, as well as developing more sophisticated measurement methods to understand the factors that influence e-waste recycling behavior. Thus, it is expected to increase the awareness of e-waste recycling and academic achievement of individuals in Indonesia. However, this study has limitations including in this study only using three subjective factors as independent variables. There are many other factors that can influence our e-waste recycling behavior such as motivation, and e-waste recycling environment. Then in this study only measured the influence of subjective factors on e-waste recycling behavior, without considering other factors such as psychological, social, and environmental factors.

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