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Waste Sorting Behavior Among Students: Testing the Effects of Visual Prompts

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Abstract

Garbage has various categories so it needs to be sorted to make it easier to sort according to its benefits. However, waste sorting is very difficult to implement for some people including in the school environment. Therefore, the objective of this study was to test the effects of visual prompt on waste sorting behavior among students in selected secondary schools in Lagos, Nigeria. Quasi-experimental design was adopted while visual prompt was manipulated at three levels of word, picture and word+ picture to obtain data on waste sorting behavior among 240participants. Data collected were analyzed using descriptive and inferential statistics to test one hypothesis which was accepted at p <.001 level of significance. The result demonstrated that picture was the most effective visual prompt that improved waste sorting behavior followed by word + picture prompt and then word prompt compared to the control group. The study concluded that visual prompt improved waste sorting behavior. The novelty of this study is that it is the first time effects of visual prompt on waste sorting behavior is studied using quasi-experimental design in Nigerian schools. The study recommended that school authority and other stakeholders' interested in solid waste management should design appropriate visual prompts to encourage waste sorting activities in their school environments.

Keywords: Visual prompts, waste-sorting behavior, secondary school students
SDGs: Goal 12 (Responsible Consumption and Production), Goal 11 (Sustainable Cities and Communities), and Goal 4 (Quality Education)

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INTRODUCTION

Waste sorting involves separating waste into different components (Rousta et al., 2020). It is the first step in an efficient waste recycling program. It can be done manually and mechanically. Manual waste sorting involves picking recyclable materials such as papers, plastic bottles, and pure water sachets from mixed waste generated in the environment (Adeniran et al., 2017; Odufuwa et al.,2024; Zhang et al., 2021). Waste sorting can be conducted at home, factories, industries, offices and in the school environment. Waste sorting has several benefits such as reduction in recyclable materials going into the landfills and dumpsites, reduction in environmental pollution, using in energy production in form of biogas, provision of employment opportunities, cleaner environment, and improvement in the quality of life of citizenry (Mutang & Haron, 2012).

Waste sorting behavior is affected by several factors. One factor considered in the current study is visual prompt which refers to written or visual messages that guide individuals to participate in waste sorting behavior (Deng & Zhang, 2019). Visual prompts are designed and used as stimuli to guide and trigger individuals to sort different recyclable materials. Some materials have been used as visual prompts to encourage or remind individuals to engage in waste sorting behavior such as written posters and electronic signage (Aikowe & Mazancová, 2021; Knickmeye, 2020; Leeabai et al., 2020; Varotto & Spagnolli, 2017). Some studies that tested the effects of visual prompts on waste sorting behavior have employed only words or pictures (Deng & Zhang, 2019; He & Wang, 2019; Yang, 2020). However, in the present study, word, picture and combined

word + picture prompts were used which made the study unique. Research has demonstrated that visual prompt, such as color-coded baskets and clearly labeled disposal stations, significantly enhance sorting accuracy (Yuan et al., 2024). Schools that have implemented visual prompts report higher compliance with waste sorting guidelines as students can easily identify the correct disposal method (Solekah & Jumriyah, 2023).

Other studies have found picture prompt to improve waste sorting behavior than word prompt (Kim et al., 2017; Shirleen & Kho, 2023; Yang, 2020). For example, Shirleen and Kho (2023) found visual prompt to improve waste sorting behavior among students in higher education institutions in Indonesia. Moreover, Shearer et al. (2016) found visual prompts of posters, signs, stickers, flyers to improve waste sorting behavior among UK households. Finally, Samaranakoye and Thennakoon (2021) found behavioral nudges to improve the accuracy of waste sorting behavior among students of the University of Peradeniya, Sri Lanka. Although some studies have been conducted on the effects of visual prompts on waste sorting behavior in developed and developing countries, the results tend to be inconsistent.

Also, studies linking visual prompts to waste sorting behavior in Nigeria are lacking therefore leaving gaps in knowledge to be filled. Therefore, the objective of this study was to test the effect of visual prompts on waste sorting behavior among students in selected public secondary schools in Lagos, Nigeria. Specifically, the study sought to provide answer to this question: Which types of visual prompts would improve waste sorting behavior? The study would test how visual prompts affect sorting of wastes into recyclable materials. In addition, the study would provide real-time data for the school management and other stakeholders on better ways of sorting wastes into useful recyclable materials.

METHOD

The study was a quasi-experimental design where visual prompts were manipulated at 3 levels of word, picture, and word & picture prompt to observe the effects on waste sorting behavior with a control group. The study was conducted at a School Complex with three public secondary schools where 240 Junior Secondary School (JSS) 3 students participated. The schools were selected because they provided diverse yet comparable environments to test the intervention where they sorted different categories of recyclable materials of papers, plastic bottles, water sachets, and a combination of recycled materials. JSS 3 students were selected because they fall within Piaget's theory of concrete operational thinking. The participants are referred to in this study as “Class of Participants”. The research procedure is shown in Figure 1.

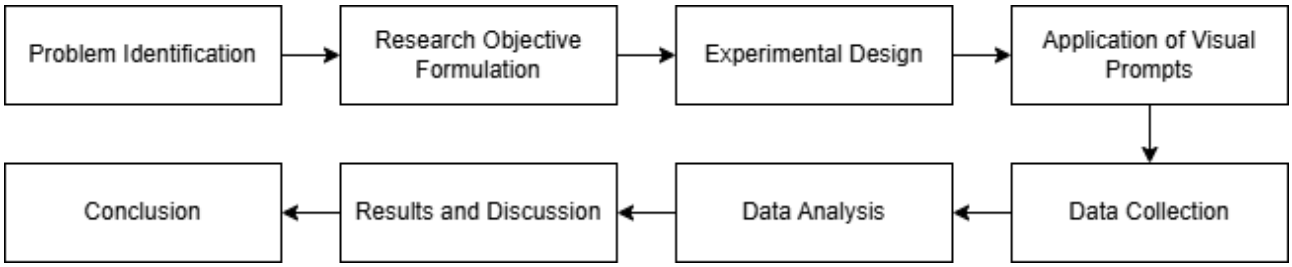

Figure 1. Research Flow Chart

According to Figure 1, experimental design begins through pre-test phase. Waste baskets were placed in both the classroom and corridor without any prompting materials. This was for 5days where research assistants collected and weighed the recyclable materials (categorized as papers, plastic bottles, and water sachets) to obtain an initial measurement of sorting behavior. The study utilized four color-coded baskets: Blue Bin was for papers, Green Bin was for plastic bottles, Yellow Bin was for water sachets while Grey Bin was for other wastes that did not fit into the recyclable categories. All of the bins have been labeled with the recyclable materials: blue for paper, green for plastic bottles, yellow for water sachets, and grey for other wastes according to Figure 2.

Figure 2. The Four Types of Waste Sorting Baskets

Figure 3. Word Prompt Poster

Figure 4. Picture Prompt Poster

Figure 5. Word & Picture Prompt

Figure 3 is word Prompt labelled as recyclable materials of "PAPERS, PLASTIC BOTTLES, and WATER SACHETS" and was printed on a red background. Picture prompt: The picture prompt posters used in this study were pictures of "PAPERS, PLASTIC BOTTLES, and WATER SACHETS" (see Figure 4). Word and picture prompt used in the study comprises both word for "PAPERS, PLASTIC BOTTLES, WATER SACHETS and PICTURE of PAPERS, PLASTIC BOTTLES, WATER SACHETS" according to Figure 5. All labels are printed measuring 30 cm × 60 cm.

Classroom Intervention: During the classroom phase of the data collection, waste sorting baskets equipped with the designated visual prompts were placed inside of the selected classrooms. The waste sorting baskets were secured to prevent movement, and the visual prompts were positioned at eye level to maximize visibility. In classrooms assigned to the control condition, no additional visual prompts were provided, and existing waste collection methods (e.g., standard waste baskets) were used. Data collection was for 10 days, Monday through Friday.

Corridor Intervention: After completing the classroom phase, the same waste sorting baskets (with their respective visual prompts) were relocated to corridors. In this phase, waste sorting baskets were attached to fixed structures such as railings to ensure they remained in place throughout data collection. The same procedures for collecting, sorting, and weighing recyclable materials were followed over another 10-day period. Control conditions in the corridor were obtained using conventional waste baskets, and data from these baskets were collected and processed identically. The corridor phase allowed the researchers to assess whether bin proximity-located inside the classroom or in the corridor had an effect on waste sorting behavior. Portable digital scales, each with a capacity of 50 kg, were used to measure the recyclables collected from each bin.

The collected data were analyzed using IBM SPSS version 26. Descriptive and inferential statistics were calculated. Descriptive statistics computed include means and standard deviation, while inferential statistics were used to test the hypothesis. The hypothesis was tested using multivariate analysis of variance (MANOVA), univariate analysis of variance (ANOVA), and Bonferroni post-hoc comparisons test. The hypothesis was accepted at a $p < .001$ level of significance. Ethical Approval: The study was reviewed and approved by the University of Ibadan Social Sciences and Humanities Research Ethics Committee (Approval Number: UI/SSHREC/2023/0146).

RESULTS AND DISCUSSION

First, the descriptive statistics of the results are presented in graphic formats of bar charts in Figures 6 until Figure 9.

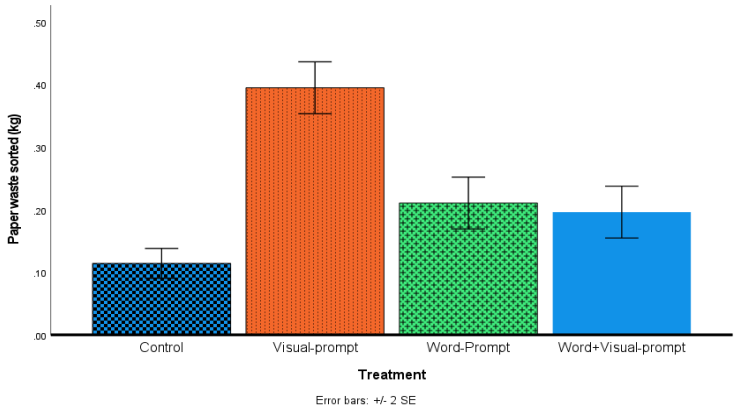

Figure 6. The Amount of Paper Waste Sorted Using Labeled Trash Bins

Figure 6 presents the results of the papers sorted with the visual prompts and the control groups. The results showed a value of 0.4 kg. The result reveals that picture prompt increased sorting of papers more than word prompt and word & picture prompts compared to the control group which was the lowest with a value between 0.1-0.2 kg.

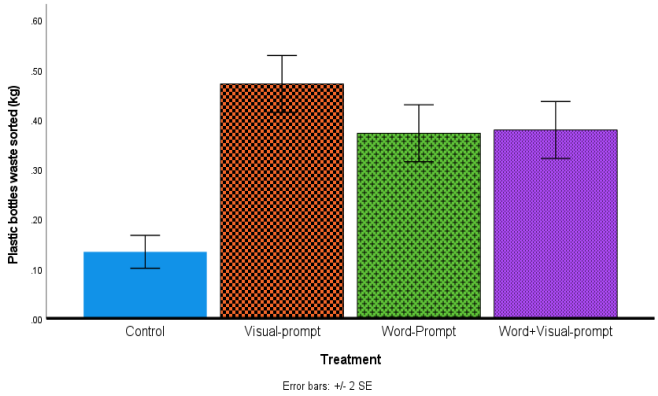

Figure 7. The Amount of Plastic Bottles Sorted Using Labeled Trash Bins

Figure 7 shows the results of sorting plastic bottles with visual prompts with values between 0.4 - 0.5 kg. The second sequence occurs word & visual prompt, then the third sequence for word prompt with a range of 0.3 - 0.4 kg. Finally, in the control group with a range of values 0.1 - 0.2 kg.

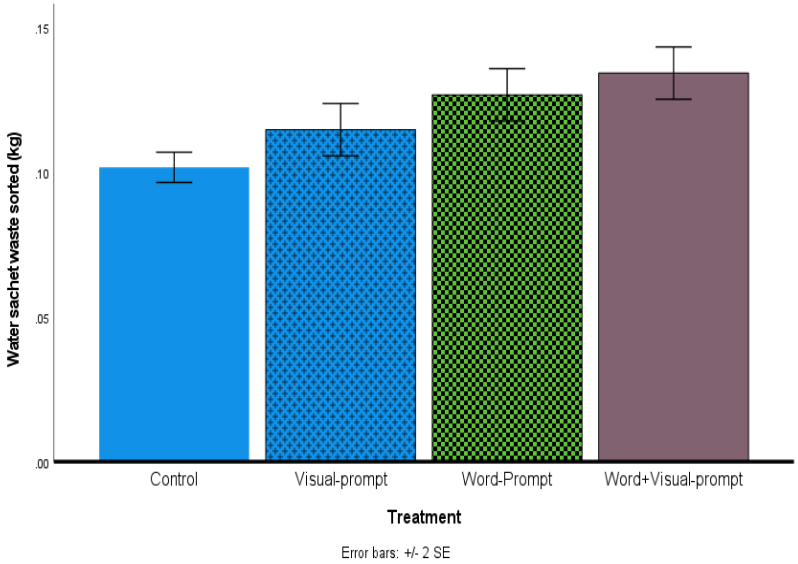

Figure 8. The Amount of Water Sachet Sorted Using Labeled Trash Bins

Figure 8 depicts the results of the water sachet sorted with the visual prompts and the control groups. In addition, the result presented in Table 5c demonstrates that word + picture prompt improved sorting of water sachets more than word or picture only prompt. However, the lowest water sachet sorted was from the control group.

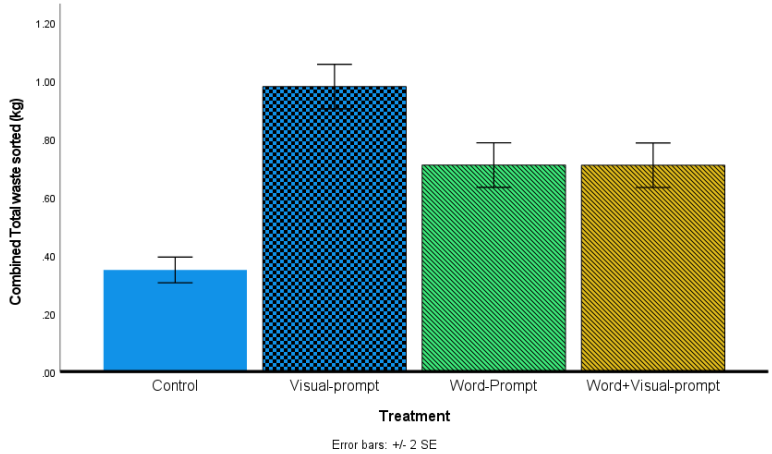

Figure 9. The Amount of Combined Recyclable Materials Sorted Using Labeled Trash Bins

Figure 9 shows that the picture prompt improves with a weight range approaching 1 kg. The results in the combined sorting of recycled materials are better than the word prompt and the word & picture prompt with a mass of 0.6 kg to 0.8 kg. The lowest results are always obtained from the control group, which is almost close to 0.4 kg.

Testing the hypothesis

There would be significant differences in the waste sorting behavior among participants exposed to word prompt, picture-prompt, and combination of word + picture prompt compared to control groups across all categories of recyclable materials sorted. This was tested using multivariate analysis of variance (MANOVA), univariate analysis of variance (ANOVA), and Bonferroni post-hoc comparisons test and the results are presented in Tables 1-3.

Table 1. Multivariate Analysis of Variance (MANOVA) of the Effects of Different Visual Prompts on Waste Sorting Behavior

	Value	**F**	**Hypothesis df**	**Error df**	**Sig.**	**Partial η²**
Pillai's Trace	1.041	15.268	12.000	345.000	.000	.347
Wilks' Lambda	.205	20.479	12.000	299.261	.000	.411
Hotelling's Trace	2.689	25.026	12.000	335.000	.000	.473
Roy's Largest Root	2.130	61.249[c]	4.000	115.000	.000	.681

Table 1 shows multivariate analysis of variance (MANOVA) of the effects of different visual prompts on waste sorting behavior among study participants. The MANOVA results indicate a statistically significant effect of the treatment group on waste sorting behavior (Wilks' Lambda = 0.205, $F(12,299) = 20.479$, $p < 0.001$, $\eta^2 = 0.411$). Also, the partial η^2 value of 0.411 showed a medium to large effect size, indicating that the prompts account for about 41.1% of the variance in waste sorting behavior, further emphasizing the influence of the intervention.

Furthermore, the univariate ANOVAs were conducted to explore the effect of the different visual prompts on waste sorting behavior across different recyclable materials and the results are presented in Table 2. Table 2 shows the univariate ANOVAs effects for visual prompts on waste sorting behavior across recyclable materials. The result revealed significant differences between the control, word prompt, picture prompt, and combination of word + picture prompt groups for papers ($F = 46.36$, $p < 0.001$), plastic bottles ($F = 48.24$, $p < 0.001$), water sachets ($F = 16.74$, $p < 0.001$) and combined recyclable materials ($F = 80.15$, $p = 0.001$). This suggests that there are significant differences among the control, word prompt, picture prompt, and

combination of word + picture prompt significantly improved sorting for plastic bottles and water sachets and combined total recyclable materials sorted.

Table 2. Univariate ANOVAs Effects for Visual Prompts on Waste Sorting Behavior Across Recyclable Materials

Source	Dependent Variable	SS	df	MS	F	Sig.	Partial η^2
Treatment	Papers	1.191	3	.397	46.362	.000	.545
	Plastic Bottles	2.367	3	.789	48.243	.000	.555
	Water Sachets	.020	3	.007	16.744	.000	.302
	Combined Recyclables	7.036	3	2.345	80.151	.000	.675
Error	Papers	.993	116	.009			
	Plastic Bottles	1.897	116	.016			
	Water Sachets	.047	116	.000			
	Combined Recyclables	3.394	116	.029			
Total	Papers	2.183	119				
	Plastic Bottles	4.264	119				
	Water Sachets	.068	119				
	Combined Recyclables	10.431	119				

Finally, the analysis compares waste sorting behavior based on the different visual prompts across recyclable materials by types and the results are presented in Table 3.

Table 3. Bonferroni Post-Hoc Comparisons of Effects of Visual Prompts Across Recyclable Materials

Dependent Variable	(I) Treatment \ (J) Treatment	Control	Visual-Prompt	Word-Prompt	Word + Picture Prompt
Papers	Control	0.000	-0.280*	-0.096*	-0.082*
	Picture Prompt	0.280*	0.000	0.184*	0.198*
	Word-Prompt	0.096*	-0.184*	0.000	0.014
	Word+ Picture Prompt	0.082*	-0.198*	-0.014	0.000
Plastic Bottles	Control	0.000	-0.337*	-0.238*	-0.245*
	Picture Prompt	0.337*	0.000	0.099	0.092
	Word-Prompt	0.238*	-0.099	0.000	-0.007
	Word + Picture Prompt	0.245*	-0.092	0.007	0.000
Water Sachets	Control	0.000	-0.013	-0.025*	-0.032*
	Picture Prompt	0.013	0.000	-0.012	-0.019*
	Word-Prompt	0.025*	0.012	0.000	-0.007
	Word+ Picture Prompt	0.032*	0.019*	0.007	0.000
Combined Recyclables	Control	0.000	-0.630*	-0.360*	-0.360*
	Picture Prompt	0.630*	0.000	0.270*	0.270*
	Word-Prompt	0.360*	-0.270*	0.000	0.000
	Word+ Picture Prompt	0.360*	-0.270*	0.000	0.000

Notes:

*. The mean difference is significant at the .05 level.

Table 3 shows the results of the post-hoc analysis comparing word prompt, picture prompt, combination of word + picture prompt and control groups for each recyclable material. The results of the Bonferroni post-hoc comparisons revealed the effectiveness of three treatments— Picture prompt, Word-prompt, and Word+ Picture prompt—across the four recyclable materials: Papers, Plastic Bottles, Water Sachets, and Combined Recyclable Materials.

First, the type of recyclable material discussed is paper. The Picture prompt treatment demonstrated the most substantial effect on paper sorting, significantly outperforming the Control group (M=0.280∗). Word-prompt (M=0.096∗M=0.096∗) and Word + Picture-prompt (M=0.082∗) also showed significant improvements compared to Control, though their effects were smaller. Additionally, Picture-prompt was significantly more effective than both Word-prompt (M=0.184∗) and Word + Picture-prompt (M=0.198∗). However, no significant difference was observed between Word-prompt and Word + Picture-prompt (M=0.014, p >.05).

Second, the type of recyclable material discussed is plastic bottle. Picture-prompt showed the greatest improvement over Control (M=0.337∗). Word-prompt (M=0.238∗) and Word+ Picture prompt (M=0.245∗) were also significantly better than Control. There were no significant differences between Word-prompt and Word + Picture -prompt (M =−0.007, p >.05) or between Picture-prompt and the combined Word + Picture treatment (M = 0.092, p >.05).

Third, for water sachet recyclables, all treatments showed limited differences compared to Control. Picture-prompt (M =−0.013, p >.05) and Word+ Picture-prompt (M=−0.032∗) were only slightly more effective than Control. Word-prompt demonstrated a small but significant improvement (M=−0.025∗). Among the treatments, there were few significant differences, except that Word Picture-prompt was slightly more effective than Picture -prompt (M=−0.019∗).

Fourth, for combined recyclable materials, Picture-prompt was the most effective treatment, significantly outperforming Control (M=0.630∗), Word-prompt (M=0.270), and Word+ Picture-prompt (M=0.270∗). Both Word-prompt and Word + Picture-prompt were significantly more effective than Control (M=0.360∗). There was no significant difference between Word-prompt and Word+ Picture-prompt (M=0.000, p >.05). The findings indicate that Picture-prompt was the most effective treatment for improving sorting behavior, particularly for papers, plastic bottles, and combined recyclable materials. Word-prompt and Word+ Picture-prompt were moderately effective but often produced comparable results. For water sachet recyclables, all treatments showed limited impact, suggesting the need for alternative interventions to address this specific sorting type. The hypothesis is thus supported.

The Effect of Visual Prompts on Students' Waste Sorting Behavior

The hypothesis that tested the effectiveness of each visual prompt on waste sorting behavior was supported. Picture prompts emerged as the most effective intervention, particularly for plastic bottles and combined recyclable materials, corroborating Gifford's (2011) findings on the salience of visual stimuli in promoting pro-environmental behaviors. While word prompts and combined interventions showed moderate effectiveness, the lack of substantial additional benefits from combining cues reflects Fogg's (2003) observations on diminishing returns from overlapping modalities. These findings are further supported by Ojedokun and Balogun (2011), who suggested that simplicity and clarity should be prioritized in designing interventions.

These findings indicate that the type of intervention—whether word-based, picture, or a combination of both—has a differential effect on waste sorting behaviors, with picture prompts emerging as the most effective across most waste categories. This is consistent with a broad body of literature that highlights the power of picture cues in shaping pro-environmental behavior, particularly in decision-making contexts that require rapid, intuitive processing. Visual prompts such as color-coded signage, icons, and stickers tend to outperform verbal prompts due to their simplicity and immediacy. Research by Shearer et al. (2017) demonstrated that using sticker prompts increased correct food waste sorting by more than 20% in a randomized control trial, and the effect was sustained even after the intervention was removed. This suggests that picture interventions can instill long-term behavioral changes through repeated exposure and ease of understanding. Similarly, Deng and Zhang (2019) found that visually engaging prompts improved battery recycling rates, reinforcing the importance of immediate picture recognition in shaping environmentally friendly habits.

Furthermore, the superior effectiveness of picture interventions over word-based prompts can be understood through the lens of Dual Coding Theory (Paivio, 2006), which posits that picture and verbal information are processed along distinct cognitive channels. Picture inputs are often easier to remember and apply, especially in high-distraction environments like hallways or cafeterias where people make quick decisions. In contrast, textual prompts demand higher cognitive load, particularly among individuals with limited literacy or when the message is poorly designed (Redford et al., 2009; Austin et al., 1993).

In addition, the results showed that while combined picture and word prompts did improve sorting performance compared to control groups, the marginal benefit over picture prompts alone was not statistically significant in all cases. This finding partially supports Mayer's (2009) multimedia learning theory, which

argues that learning is enhanced when complementary modalities are combined. However, it also suggests diminishing returns when one modality—such as picture prompts—is already highly effective. Fogg's (2003) behavior model similarly argues that when ability and motivation are already high, additional triggers (like adding text to pictures) may not yield substantial additional effects.

This is further corroborated by Shirleen and Kho (2023), who found that while combined prompts were beneficial in educational contexts, the gain was most pronounced when one type of prompt was weak or unfamiliar to the user. In their study, the combination of volunteer verbal instruction and picture posters was most effective for waste types that students found difficult to classify, but less so for common waste like plastic bottles.

Despite the strong performance of picture prompts, it is important to note that their effectiveness can vary depending on the context and waste type. For example, water sachets remained a problematic category across interventions. These results align with Baca-Motes et al. (2013), who highlighted the need for context-sensitive interventions tailored to specific waste types. The poor performance for water sachet sorting even in combined interventions underscores the need for further innovation—such as using more distinctive imagery, incorporating social norm cues, or deploying real-time feedback through digital means.

The implication of this finding is in the area of designing visual prompts to remind or stimulate individuals to sort their wastes into recyclable materials. By carefully designing the picture of the prompt, there would be a high probability of sorting waste. This study has impact on Sustainable Development Goal 12 which explains that individuals, society and the government should be involved in responsible consumption and production which include sorting waste into recyclable materials which are used as secondary resources to conserve and preserve the national resources for the better environment and the Earth in general.

One limitation of this study is that it was conducted within specific educational institutions which thus limit its generalizability to other settings or cultures. In addition, the study primarily focused on short-term behavioral changes following the implementation of the prompt interventions. Furthermore, the study concentrated on a few specific waste types, such as papers, plastic bottles, and water sachets. Finally, only one independent variable was tested which was not exhaustive.

CONCLUSION

The study tested the effects of visual prompt on waste sorting behavior among a class of participants in a learning environment using a quasi-experimental design. The results of this study have clearly demonstrated that visual prompt of picture significantly influenced waste sorting behavior among study participants. Visual prompt significantly improved sorting of waste into recyclable materials which was more in papers and plastic bottles than with water sachets. Further direction from the findings in this study would be to compare waste sorting behavior between public and private secondary schools.

AUTHOR CONTRIBUTIONS

Emmauel Etim Uye: Conceptualization, Methodology, Formal Analysis, Validation, Resources, Data Curation, Project Administration, and Writing - Original Draft; and **Peter Olamakinde Olapegba**: Project Supervision and Validation

DECLARATION OF COMPETING INTEREST

The authors declare no known financial conflicts of interest or personal relationships that could have influenced the work reported in this manuscript.

DECLARATION OF ETHICS

The authors declare that the research and writing of this manuscript adhere to ethical standards of research and publication, in accordance with scientific principles, and are free from plagiarism.

DECLARATION OF ASSISTIVE TECHNOLOGIES IN THE WRITING PROCCESS

The authors declare that Generative Artificial Intelligence and other assistive technologies were not excessively utilized in the research and writing processes of this manuscript. All AI-generated content has been thoroughly reviewed and edited by the authors to ensure accuracy, completeness, and adherence to ethical and scientific standards. The authors take full responsibility for the final version of the manuscript.

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