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Nudges to Increase the Effectiveness of Environmental Education*

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Abstract

We ran randomized controlled trials to evaluate the effectiveness of our environmental education class and the impact of the nudge and boost on students' attitudes and behaviors toward environmental issues. We found that our environmental education class significantly improves the students' basic knowledge of the environment and concerns about plastic waste. Although there is no evidence that nudges and boosts amplify the effect of environmental education on basic knowledge of the environment, nudges are successful in making students who received environmental education more concerned about plastic waste. Our results also show that nudges and boosts can change students' pro-environmental behaviors. Students who were assigned to treatment groups with nudges or boosts are more likely to refuse free wet wipes provided at convenience stores. These results indicate that our interventions change students' pro-environmental behaviors only if the cost of changing their behaviors is low.

Keywords: Green nudge, boost, environmental education
JEL classification: Q50, Q56, Q58

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1. Introduction

In recent years, green nudges have become a promising new tool to encourage consumers to take environmentally friendly actions, such as choosing renewable energy sources and saving energy (Schubert 2017). Whereas traditional environmental economic theory adheres closely to the rational choice theory assumed by standard neoclassical models (Shogren and Taylor 2008), it is also becoming apparent that real-world consumers are motivated by more than incentives and information (Michalek et al. 2015). Not only environmental issues such as risk, uncertainty, and complexity but also the price mechanism forces the market to function much less effectively than markets for ordinary goods and services. These conditions prevent people from making rational decisions (Van den Bergh et al. 2000; Brown and Hagen 2010; Croson and Treich 2014).

Furthermore, traditional incentive-based policies often face methodological problems and political feasibility issues (Allcott 2011). In this context, there is growing interest in "behavioral-environmental policy" and the use of green nudges as a subset of such policy. A survey by Schubert (2017) identifies three practical green nudges that have been applied to policy. The first is nudges that promote pro-environmental behaviors by tapping into consumers' desire to maintain an attractive "self-image" by highlighting product features, such as eco-labels. The second is nudges that promote pro-environmental behaviors, such as energy conservation, by informing consumers of "social norms" through comparisons with neighboring residents and communities. The third is nudges that promote pro-environmental behaviors by using "defaults", which people are probably unwilling to change.

There has been a rapid increase in the use of nudges in education. Although education economics has traditionally relied on systematized human capital theory, which emphasizes education as a long-term investment, there are significant behavioral biases in decision-making at a young age. For this reason, nudges are likely to be effective (Jabbar 2011; Koch et al. 2015).

According to a survey by Damgaard and Nielsen (2018), there are two types of nudges that have been used in educational settings. The first is called "boosting" (Grüne-Yanoff and Hertwig 2016), which is an intervention to improve the active decision-making skills of children and students. Specifically, psychological interventions target students' mindsets, images of themselves, identities, and beliefs (Yeager and Walton 2011; Walton 2014). The second is the traditional nudge. When pupils/students cannot self-regulate their behavior, tools such as goal setting, reminders, deadlines, peer group manipulation, and framing are effective in altering their behaviors. In the past, the implementation of boosts and nudges in educational settings has revealed the following. First, many boosts have been found to have lasting effects on educational outcomes (Cohen et al. 2009; Sherman et al. 2013). Second, many studies show that nudges are highly effective when interventions that add information, support, and skills to decision-making are conducted when students themselves or their parents are trying to make better choices but are not able to do so (Bettinger et al. 2012; Kraft and Rogers 2015; Oreopoulos and Ford 2019). Third, boosts and nudges have heterogeneous effects, with some studies detecting adverse effects in some cases (Allcott 2011).

The purpose of this study is to clarify what types of green nudges (Thaler and Sunstein 2008) and boosts (Grüne-Yanoff and Hertwig 2016) can be effective to enhance environmental education. Specifically, we targeted high school students, provided them with opportunities to learn about environmental issues at school. In our environmental education, students learned about reduction in the use of plastic products for energy conservation in their daily lives. Our environmental education program provides not only a lecture on why environmental issues matter but also an original board game ("Zero Waste Game"). Our board game uses a gamification approach to adopting the six Rs action (reuse, repair, remake, recycle, rot, and refuse) to reduce plastic waste. We further carried out the nudges and boosts that lead to actual external pro-environmental behavior and internal pro-environmental behavior. After the board game, we used reflection sessions to discuss the lecture and game. In the reflection sessions, we randomly separated students into four groups and provided each group with one of four different worksheets: nudge, boost, nudge and boost, and control. In the nudge group, students were asked to set a goal regarding their level of effort in not throwing away plastic products. Goal setting is known to be effective in studies using nudges in education (Damgaard and Nielsen 2018; Clark et al. 2020). In the boost group, we provided psychological interventions intended to arouse sympathy for people involved in environmental issues. Empathy is linked to sustainable behavior and is associated with pro-environmental awareness and pro-environmental behavior (Berenguwer 2007; Ericson et al. 2014; Czap et al. 2015). Enhancing empathy is expected to move toward autonomous pro-environmental behavior. In the nudge and boost group, we asked students both to set the effort goal and provided psychological interventions. The combination of nudges and boosts is expected to be more effective in environmental education than either nudges or boosts alone. In the control group, we neither asked students to set the effort goal nor provided psychological interventions. Combining nudge and boost leads after the environmental education, we conducted endline surveys to understand the retention of knowledge, interest in environmental issues, and reduction in the use of plastic products.

In this multi-armed randomized controlled trial, we found that our environmental education class significantly improves students' basic knowledge of the environment and concern about plastic waste. Although there is no evidence that nudges and boosts amplify the effect of environmental education on knowledge, nudges are successful in making students who had received environmental education become more concerned about plastic waste. Our results also show that nudges and/or boosts can change students' pro-environmental behaviors. Students who were assigned to treatment groups with nudges and/or boosts are more likely to refuse free wet wipes provided at convenience stores. These results indicate that our interventions change pro-environmental behaviors only if the costs of changing behavior are low.

Our paper contributes to the literature on environmental education (Fjællingsdal and Klöckner 2019; Arachchi and Managi 2021). Environmental education is not guaranteed to be successful (Campbell-Arvai et al. 2014; Campbell-Arvai and Arvai 2015).Simply providing information (Yeomans and Herbersich 2014; Kurz et al. 2005) or telling students and teachers what to do for environment (Jiang et al. 2013) is not an effective approach in environmental education. Our study shows that a gamification approach and nudges are the key to successful environmental education. Gamification approaches are often used in environmental education (Yang and Chen 2017; Mei and Yang 2019; Pan and Hsu 2020). For example, Pan and Hsu (2020) experimented with sixth-grade elementary school students in Taiwan and showed that one-day environmental education using role-playing and games to learn about animal and forest conservation issues has an impact on their knowledge, sense of responsibility, preferences, and locus of control regarding environmental issues, as well as on their pro-environmental behaviors. This study suggests that role-playing and games on topics closely related to children's lives can help them focus and increase their educational effectiveness. Our study also found that game-based environmental education increases knowledge retention and raises awareness of environmental issues. We also identified additional benefits of nudges and boosts. Although the use of nudges in developing academic skills in education is growing, the use of nudges and boosts in environmental education is rare (Agarwal et al. 2017; Charry and Parguel 2019). For example, Agarwal et al. (2017) investigated whether children can effectively encourage their parents to change their energy consumption behavior. They conducted a quasi-experiment using Singapore's "Project Carbon Zero" energy-saving contest to test empirically the effectiveness of nudges to schoolchildren to take home energy-saving messages and influence the behavior of their families and neighbors. As with Agarwal et al. (2017), our nudges were able to enhance pro-environmental behavior. Nudges, which have low implementation costs, will ensure that environmental education is more effective.

The remainder of this paper proceeds as follows. Section 2 describes our environmental education program. Section 3 explains the experiment design and data. Section 4 shows the empirical results. Section 5 concludes and discusses policy implications.

2. Environmental education program

One of the goals of this study is to develop teaching materials for environmental education that are consistent with the national curriculum guidelines for Japanese public high schools. Based on these guidelines, which require students to learn about energy consumption, resource circulation, and ecosystems, our teaching materials specifically focus on a reduction in the use of plastic products for energy conservation in our daily lives.

One of the authors (Sakano) and the general incorporated association, Zero Waste Japan, originally designed teaching materials for the purpose of use in this study. We provided a single 45-minute class per school, which consisted of three parts: (i) a short lecture on how environmental issues matter (15 minutes), (ii) an originally designed board game (20 minutes), and (iii) a reflection session for discussion about the lecture and game, as well as a questionnaire (10 minutes).

The short lecture provided comprehensive knowledge of how plastic waste is produced, the harmful impact it has on the environment, and what efforts are being made to reduce it around the world. In particular, it emphasized how much plastic waste the students created themselves on a daily basis because the literature suggests that environmental education is more effective if the topic covered during the class is closely related to students' daily lives (Pan and Hsu 2020). The lecture also helped students understand that plastic waste leads to ocean pollution, resource depletion, and global warming. Most importantly, it introduced the plastic resource recycling strategy with the so-called six Rs actions (reuse, repair, remake, recycle, rot, and refuse), which students can adopt themselves to reduce plastic waste.

Next, each student was assigned to one of the groups with two to five members, and played an original board game, called the "Zero Waste Game" (see Figure 1). Pan and Hsu (2020) also suggest that the use of games that are closely related to students' lives can help them to concentrate, resulting in increased effectiveness of environmental education, especially for high school students (Fjællingsdal and Klöckne, 2019).

The game uses gamification and requires students to think about the circumstances under which they should adopt the six Rs actions to reduce plastic waste. During the game, a player draws a “plastic product card” from the deck, such as a plastic bag of stale bread and a pen with no ink, which are likely to be thrown away. The player must then develop ways to stop these particular plastic products from becoming garbage by using one of six Rs action cards. The player can earn points if s/he develops an idea to successfully reduce plastic waste in this way. The game also has a setting to make players draw an “event card” from the deck. The series of event cards change the incentives to adopt one of the six Rs actions. For example, one of the event cards indicates a change in government policy to offer a tax incentive for repair services so that adopting the “repair” action will earn extra points for the players.

Points vary among the six Rs action cards (e.g., “refuse” earns the highest number of points, five points, whereas “recycle” earns the lowest, one point) and the player with the highest number of points is the winner. The game was designed to promote active discussion among the players to develop ideas about what they can and cannot do in their daily lives to reduce waste.

After playing the board game, a reflection session was conducted to discuss the content of the class and provide worksheets. We prepared four different worksheets and randomly assigned one of them to students. The first question is common among the worksheets, but the second and subsequent questions are different. The content depends on the treatment groups: (1) none (neither nudge nor boost), (2) nudge, (3) boost, and (4) nudge and boost.

The first question, on all four sheets, asked students how often they typically buy or receive plastic bags, free wet wipes, and plastic bottles in a week. These plastic products appear in the “plastic product cards” in the board game. These three plastic products are familiar to high school students in Japan. It is very common for them to purchase drinks in plastic bottles from vending machines, which are ubiquitous. In addition, high school students frequently visit convenience stores to buy drinks in plastic bottles, food items such as rice balls, and snacks. Wet wipes are provided free of charge when buying food at convenience stores. Plastic bags are provided when buying items at convenience stores, but in Japan, plastic bags need to be purchased since July 1, 2020. Both wet wipes and plastic bags are provided by default, but it is possible to refuse them. These plastic products, familiar to high school students, vary according to the cost savings from reducing their use. Eliminating plastic bottle use can save 100–150 yen per bottle (equivalent to 1–2 US dollars). Although carrying water bottles requires planning, the monetary savings are significant. Not using a plastic bag saves about five yen per bag (equivalent to 5–10 cents), but not using wet wipes saves less than one yen. In other words, while the amount of money that can be made by not using wet wipes or plastic bags is small, the amount of money that can be saved by not using plastic bottles is large.

The subsequent questions are different for each of the four groups. For the nudge group, we asked them to set a goal regarding their reduction in the disposal of plastic bags, free wet wipes, and plastic bottles in the future. This nudge is intended to encourage them to set a specific goal for their environmentally friendly behavior so that the goal will become a reference point, loss aversion will be activated, and efforts toward achieving the goal will be exerted. Goal setting is known to be effective in studies using nudges in education (Damgaard and Nielsen 2018; Clark et al. 2020).

For the boost group, we focused on an "event card" used in the board game, which said "microplastics were found in fish sold in supermarkets," and asked them, "How would you feel if you found out that the fish you bought contained microplastics?" Then, we asked them to write an essay on "How would you feel if you were a fish living in a sea that accidentally ingested plastic waste?" These are psychological interventions intended to arouse empathy for the people involved in environmental issues and elicit actions that benefit such people even though they do not directly benefit the students themselves. Empathy is linked to sustainable behavior and is associated with pro-environmental awareness and pro-environmental behavior (Berenguwer 2007; Ericson et al. 2014; Czap et al. 2015). Enhancing empathy is expected to move toward autonomous pro-environmental behavior.

For the nudge and boost groups, both strategies described above were implemented. The none group and the nudge group were asked to write freely about their feelings and thoughts on environmental issues at the end of the session. The essays were only used to ensure that all groups finished the session at the same time. It is unlikely that the essays themselves will assist the students to set goals or increase their empathy.

As for differences in expected effects, compared with the neither nudging nor boosting group, the nudging group is expected to experience a larger reduction in the use of items that provide financial savings, such as plastic bottles, but not in the use of plastic bags or free wet wipes, which do not involve a financial saving. It is expected that the boosting group will reduce their use of plastic bags, free wet wipes, and plastic bottles by improving their social skills. The nudging and boosting groups are expected to be the most effective in reducing their use of plastic bags, free wet wipes, and plastic bottles because they are expected to promote prosocial behavior regardless of whether or not they receive a financial gain.

During February 2021, we offered a single 45-minute class per school and sent two teaching staff to run the environmental education classes described above. Prior to the class, teaching staff completed intensive online training designed to equalize the quality of instruction across classes/schools.

3. Experiment design and data collection

3.1. Study sites

In recruiting schools to participate in the study, we set the following conditions: (1) classes were divided (to some extent randomly) according to academic performance, (2) classes could be randomly divided into those in which environmental education was implemented and those in which it was not, (3) public schools with diverse academic performance and family environments, and (4) cooperation could be obtained not only from the school but also from the prefecture or the board of education. We called for participation from schools that met these conditions.

We negotiated with six municipalities (Miyagi, Nagano, Mie, Shimane, Kumamoto, and Miyazaki) and eight public high schools so that they could provide environmental education to first-year high school students as part of their mathematics ("data analysis" unit in the first year of high school) or general classes and we conducted baseline survey for all students. Finally, 915 first-year high school students from six municipalities and eight schools participated in this study.

3.2. Treatment assignment

We ran a clustered randomized controlled trial to estimate the effects of environmental education on pro-environmental behaviors and attitudes. Students were divided into two groups in each school: a treatment group that received the environmental education class described above and a control group that did not. In addition, to examine whether environmental education can be made more effective by incorporating nudging and boosting, the treatment group was randomly divided into four groups: (1) none (neither nudge nor boost), (2) nudge, (3) boost, and (4) nudge and boost. In this multiarmed randomized controlled trial, treatment assignment was done on an individual student basis rather than on a class basis.

3.3. Data collection

3.3.1. Baseline survey

Prior to the environmental education class, we conducted a baseline survey in October 2020. In each school, we administered a 20-minute questionnaire. In addition, a 30-minute paper-and-pencil standardized math test was conducted in five out of seven of our sample high schools. We administered the standardized math test to evaluate whether there exists a heterogeneous effect associated with students' level of cognitive skill. If environmental education is more effective for highly performing students and makes inequalities larger, it may be inappropriate to introduce it into public education.

The questionnaire included questions on the basic attributes of students, as well as those for estimating the degree of interest in environmental issues, prosociality scale, locus of control scale (i.e., whether one seeks the cause of actions or consequences from oneself or others or the environment), and multidimensional empathy scale. The objective was to confirm there was no difference in these indicators between the treatment and control groups before they receive our interventions.

Regarding interest in environmental issues, the participants were asked directly about their level of interest in the issue of marine plastic pollution (on a five-point scale) and their awareness of energy conservation (on a four-point scale).

The psychosocial scale was calculated using the method developed by Falk et al. (2018). In the questionnaire, students were asked to rate on a five-point scale their altruism ("I would be willing to donate to charity without expecting anything in return."), trust ("I believe that people have only good intentions." and "Generally speaking, people are generally trustworthy."), positive reciprocity ("If someone does me a favor, I would be willing to pay them back."), and negative reciprocity ("I want to retaliate against people who mistreat me, even if it is not worth it." and "I want to punish people who mistreat others, even if it is not worth it."). Another measure of altruism is constructed by asking students how much they would be willing to donate if they received unexpected money.

The locus of control scale was calculated using the method of Heywood et al. (2017). In the questionnaire, students were asked to respond to three statements based on thinking that they can control outcomes, or internal locus of control, (e.g., "It is up to me to decide what my life will be like."), and four statements based on the thinking that luck and other people control outcomes, or external locus of control, (e.g., "Natural ability is more important than effort."). The locus of control scale is a five-point scale that asks students to rate their level of agreement with seven statements. Higher scale points of statements on internal locus of control reflect a more internal locus of control, while higher scale points of statements on external locus of control reflect a more external locus of control. To construct an index of locus of control, we recorded inverse order for the scale points of the four statements on external locus of control, summed up the scale points of fourth statements and then divide by seven. Higher values of the index represent a more internal locus of control.

The multidimensional empathy scale is calculated using the method of Davis (1983). In the questionnaire, the respondent is asked to rate the degree to which he/she applies seven statements regarding empathy for others (e.g., "I want to be kind to those who are less fortunate than I am." and "I can be okay even if the people around me are unhappy.") on a five-point scale. The multidimensional empathy scale is calculated as an integrated index of these items.

3.3.2. Endline survey

The endline survey was conducted after the environmental education class in March 2021. In the endline survey, we first asked the same questions about interest in environmental issues as in the baseline survey (interest in the problem of marine plastic pollution and awareness of energy conservation). We evaluated whether subjective interest in the plastic waste issue had increased during our interventions. We also examined whether the effects of our interventions have increased awareness of energy-saving behaviors, as well as plastic waste problems. If education about one environmental problem, plastic waste, can raise awareness about other environmental problems, such as energy-saving behaviors, the potential for environmental education is very high.

We also added questions about knowledge of the content covered in the lecture part of the environmental education class to confirm the degree of knowledge acquisition. The number of correct answers to six correct/incorrect questions (e.g., the raw material of plastic is petroleum) on the content covered in the class was used as the outcome.

It is important to evaluate not only changes in awareness but also whether changes in awareness led to changes in behaviors. We examined the reduction in the use of three types of plastic products: plastic bottles, plastic bags, and wet wipes. These three plastic products appeared during the "Zero Waste game". Students in the nudge group and the nudge and boost group set goals for reductions in the use of these three items. We evaluate the use of plastic products on a four-point scale (1: never receive, 2: recycle or reuse all, 3: recycle or reuse occasionally, 4: throw away all). The smaller the value on the scale, the less students use the product and they can save larger money. In terms of cost savings, the greatest reduction in the use of plastic bottles is expected.

We also include questions about attitudes toward the environment to test whether it has changed. One of the essential evaluation methods is the two-factor model of environmental values (2MEV), a model developed by Bogner and Wiseman (2006) to measure adolescents' attitudes and the effectiveness of educational programs. Johnson and Manoli (2010) revised and administered the 2MEV to 9–12-year-olds in the United States over four years. Furthermore, confirmatory factor analysis showed that the results were consistent with the theory of ecological attitude. The revised 2MEV was able to measure statistically significant changes in the environmental attitudes of the Earth Education Program participants, but not the control group. Johnson and Manoli's (2010) revised 2MEV can be used for program evaluation to examine the relationship between environmental attitudes and other variables. Liefländera and Bogner (2014) evaluated a four-day program for pupils aged 9–10 and 11–13 years using the 2MEV on nature conservation and use. Their pre, post, and retention tests revealed that younger students were more likely to respond to positive attitudes than older students, but gender had no effect. They suggest that education has a more substantial influence on the environmental attitudes of young children. The revised 2MEV scale is a five-point scale that assesses the extent to which a participant's attitudes toward the environment apply to 16 statements, such as "I will try to appeal to the people around me about the importance of environmental issues."

To assess whether the students' sense of responsibility for the environment changed, they were asked, as in Hsu (2004), whether they and each other were responsible for improving the quality of the environment. Finally, as in Hsu (2004), to examine changes in the locus of control over the environment, students were asked to what extent they thought they could have an impact on solving environmental problems by acting on their own and by acting with others.

3.4. Summary statistics and balance check

Table 1 shows descriptive statistics and a balance check between the treatment and control groups for the baseline survey. A total of 641 students participated in both the baseline and follow-up surveys. Of the 641 students, 180 (28.1%) did not receive our environmental education class (the control group), and there were 105 (16.4%), 124 (19.3%), 120 (18.7%), and 112 (17.4%) in the none (neither nudge nor boost), boost, nudge, and nudge and boost treatment groups, respectively. The first to fifth columns present summary statistics for each group, and the sixth to eighth columns report differences between the control group and each treatment group. Although most of the attributions are well-balanced, some variables of prosocial measures and locus of control are unbalanced. Potential biases arising from these imbalances are discussed in the following subsection.

Table 2 shows descriptive statistics of outcomes of concern and balance checks between the treatment and control groups for the endline survey. The first to fifth columns present summary statistics for the control group, the none (neither nudge nor boost), boost, nudge, and nudge and boost groups, respectively. The sixth to eighth columns report the differences between the control group and each treatment group. Overall, there are significant increases in the variables of concern about plastic waste, basic knowledge of the environment, and pro-environmental behavior in the treatment groups, whereas no significant differences are detected in most of the environmental attitudes, responsibility, and locus of control variables. Controlling the potential imbalance of students' attributions, the impacts of treatment are identified.

3.5. Statistical approach

To identify the treatment effects of our environmental education class, the following regressions are estimated:

$$Y_{icj} = \alpha_0 + \alpha_1 Treatment^1_{cj} + X_i'\alpha_2 + \theta^1_j + \epsilon^1_{icj}, \qquad (1)$$

where Y_{icj} is the outcome variable in the follow-up survey for student i in class c of school j. $Treatment^1_{cj}$ is a dummy variable that is equal to 1 if the student received the environmental education program, X_i is a set of baseline control variables, θ_j is school fixed effects, and ϵ_{icj} is an error term that is correlated within schools. To control the potential bias arising from the imbalance of attributions, X_i includes all the variables in the baseline survey represented in Table 1. Standard errors are clustered at the school level but corrected using wild bootstrap methods for the potential bias arising from the small number of clusters in our sample (Roodman et al. 2019). The coefficient is an estimate of the causal effect of the environmental education class.

To allow for the heterogeneous impacts of the additional treatments of boost, nudge, and both boost and nudge, the following regression is also estimated:

$$Y_{icj} = \beta_0 + \sum_{k=1}^{4} \beta_k Treatment^2_{cjk} + X_i'\beta_2 + \theta^\beta_c + \epsilon^\beta_{icj}, \qquad (2)$$

where $Treatment_{cjk}^{2}$ ($k = 1,2,3,4$) are dummy variables that are equal to 1 if the student is in each environmental education treatment class without any additional treatment, with boost, with nudge, or with both boost and nudge treatments, respectively. The coefficients β_k provide an estimate of the causal effect of the environmental education program with or without additional treatments.

The outcome variables are (a) emotional concern and basic knowledge (concern about energy savings, concern about plastic waste, and basic knowledge of environment), (b) pro-environmental measures regarding plastic bags, wet wipes, and plastic bottles, or (c) environmental attitude (2MEV), responsibility, and locus of control measurement. In the analysis that follows, equations (1) and (2) are estimated by ordinary least squares for (a) and (c). For variable (b), because the dependent variables are ordinal, the corresponding ordered logit model is estimated.

4. Empirical results

Table 3 reports the estimated parameters of the treatment effects in equations (1) and (2). The first, third, and fifth columns report the estimated parameters in equation (1), and the second, fourth, and sixth columns in equation (2). The first column shows that our environmental education class significantly improves basic environmental knowledge. According to the results reported in the second column, these effects are significant regardless of the additional treatments, and their degree of impact is similar, ranging between 0.646 and 0.704.[2] Therefore, there is no evidence that nudges and boosts amplify the effect of environmental education on knowledge. Moving to environmental concerns about plastic waste, positive impacts are detected. According to the results reported in the fourth column, the impacts are significant only if the intervention of the lecture and board game is coupled with the additional treatment of a nudge. In other words, nudge and nudge with boost are successful in making students who had received environmental education become more concerned about plastic waste, but only boost is not successful. We also test the result of the effect of nudges and boosts on students' concern about energy savings as a placebo. Because our intervention focused specifically on plastic waste, the effect should only be seen in plastic waste and not in general energy savings. As expected, we find no significant impacts. This result indicates not an increase in general trend of environmental concerns about plastic waste and energy conservation,

[2] Five out of seven high schools.

but an increase in awareness of the plastic waste problem through environmental education. In addition, this result implies that the effect of our environmental education class about plastic waste does not spill over to concern about other areas of the environment.

Table 4 reports the estimated parameters of the latent equations of the ordered probit model regarding pro-environmental behavior. Among the three behaviors under consideration, pro-environmental behavior for wet wipes is most promoted by the program, whereas we cannot detect evidence that pro-environmental behavior for plastic bottles is promoted. The impact on pro-environmental behavior for plastic bags is positive with relatively small p-values of less than 0.2, but statistical significance is only detected for the program under the additional treatment of boost.

Why is the effect different between plastic bottles, plastic bags, and wet wipes? One of the most significant differences is that wet wipes are free, and students do not require any additional investment to refuse wet wipes at convenience stores, whereas they are required to make a small investment in non-plastic private shopping bags or a tumbler to refuse plastic bottles and plastic bags[3]. Moreover, compared with plastic bags and plastic bottles, it is much easier to do without wet wipes. These differences can explain the large impact on the pro-environmental behavior for wet wipes. This explanation is supported by the results of Table 5, which show the marginal effects of the estimation. Different from plastic bags or plastic bottles, the percentage of students who answered "never recycle, reuse, nor refuse" increased from 30.5% (boost) to 53.2% (nudge), whereas those who answered "always refuse" increased from 23.3% (boost) to 40.6% (nudge). These results indicate that our interventions change pro-environmental behaviors only if the costs of changing behavior are low.

Table 6 reports the estimated parameters of the treatment effects on environmental attitude (2MEV), responsibility, and locus of control. Overall, there is no strong evidence that our environmental education class influences the effect of these characteristics of students. However, some significant impacts are detected on environmental responsibility to self, and environmental locus of control to others. In particular, the p-values of the impact on environmental locus of control are less than 0.2 for all the additional treatments. A possible reason for this insignificance may be the small sample size in this paper,

[3] Another significant difference is in the learning content in the "Zero Waste Game". On the "plastic product cards" in the game, there are hints that plastic bags can be reused, remade, and recycled, wet wipes can only be refused, and plastic bottles can only be recycled. Through this game, students may have learned that wet wipes have a high environmental burden because they cannot be recycled, and that it is important to refuse them.

therefore, further studies with larger sample sizes are needed.

Finally, to address whether there exists a heterogeneous effect because of students' level of cognitive skills, we estimate the coefficients in equation (1) by adding an interaction term of the treatment dummy and the correct answer rate in the test conducted at the baseline survey (Table 7). Overall, there is no strong evidence that treatment effects are heterogeneous depending on students' level of cognitive skills. These results support environmental education in public schools because this education is equally beneficial both for high- and low-performing students.

5. Conclusions

This study aimed to provide opportunities for high school students to learn about environmental issues and to nudge and boost them so that they would take positive environmental actions and attitudes. We conducted clustered randomized controlled trials in which the classes were divided into two groups: a treatment group that received an environmental education class and a control group that did not. In addition, to examine whether environmental education can be made more effective by incorporating findings from the behavioral sciences such as nudges and boosts, we conducted a multiarmed randomized controlled trial in which the intervention group was divided into four groups: (1) none (neither nudge nor boost), (2) nudge, (3) boost, and (4) nudge and boost. We found that our environmental education class significantly improves basic knowledge of the environment and students' concern about plastic waste. Although there is no evidence that nudges and boosts amplify the effect of environmental education on knowledge, nudges are successful in making students who had received environmental education become more concerned about plastic waste. Results also show that nudges and boosts can change students' pro-environmental behaviors. Students who were assigned to treatment groups with nudges or boosts are more likely to refuse free wet wipes provided at convenience stores. These results indicate that our interventions change pro-environmental behaviors only if the costs of changing behavior are low.

Our environmental education increases knowledge of environmental issues and enhances pro-environmental attitudes. There is no heterogeneity in these effects by cognitive skills, which makes it worthwhile to implement environmental education in public education. If heterogeneity by cognitive skills exists, it is necessary to change the content of education according to cognitive skills, but this is not realistic in public education. The result of no heterogeneity by cognitive skills suggests that uniform course content in public education is sufficient. Furthermore, incorporating nudges and boosts, which have low marginal costs, ensured the effectiveness of environmental education. It is common practice to conduct a reflection worksheet after environmental education classes. We used a treatment on that worksheet to encourage goal-setting and empathy. There is little additional cost in providing worksheets with such questions. These nudges and boosts are widely applicable.

Our study has two limitations. First, because we asked for self-reported pro-environmental behaviors and attitudes, we might overestimate the effectiveness of the environmental education due to an upward bias. Students who received environmental education may have better evaluate pro-environmental behaviors and attitudes. We can verify the effectiveness of environmental education more accurately by examining objective variable rather than self-reporting. One objective variable, environmental knowledge, was improved by our environmental education. Thus, the effectiveness of environmental education is certainly there, although it may be overestimated. Second, we cannot see only the short-term impact. It is important to verify whether the effects of environmental education persist over the long term, such as one year after receiving environmental education. Future work is needed to verify the long-term effects of environmental education.

The game in this study did not include the tragedy of the commons even though it is critical to consider climate change or global warming. In future work, we will conduct an experiment using a game with a rule relating to the environment as a common good (Kotani et al. 2014).

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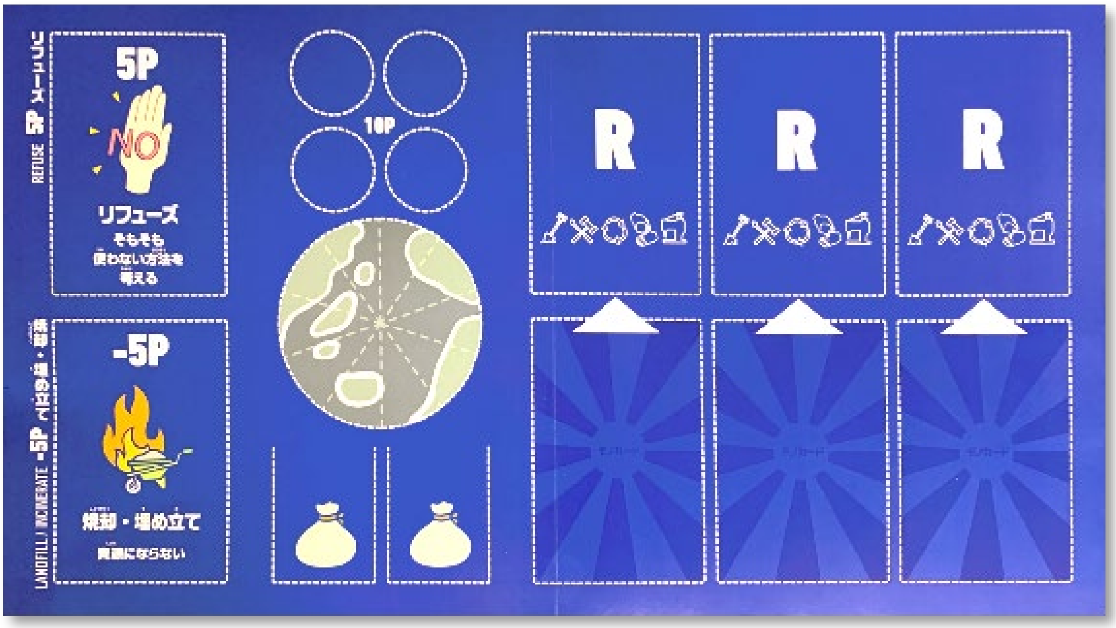
Figure 1: Zero Waste Game



Plastic Product Cards

Event Cards

Source: Zero Waste Japan

Table 1 Descriptive Statistics and Balance Check for Baseline Survey

	Control	Treatment				*t* test			
		None	Boost	Nudge	Boost + Nudge	Difference			
	n = 180	n = 105	n = 124	n = 120	n = 112				
	(1)	(2)	(3)	(4)	(5)	(2)–(1)	(3)–(1)	(4)–(1)	(5)–(1)
Male (0/1)	0.400	0.467	0.548	0.492	0.509	0.067	0.148	0.092	0.109
	[0.087]	[0.052]	[0.067]	[0.044]	[0.061]				
Study time (0/1)									
more than 2 hours	0.250	0.295	0.298	0.300	0.375	0.045	0.048	0.050	0.125
	[0.123]	[0.069]	[0.066]	[0.048]	[0.085]				
1–2 hours	0.256	0.314	0.298	0.333	0.205	0.059	0.043	0.078	–0.050
	[0.094]	[0.080]	[0.054]	[0.073]	[0.038]				
0.5–1 hours	0.217	0.219	0.202	0.200	0.205	0.002	–0.015	–0.017	–0.011
	[0.084]	[0.037]	[0.030]	[0.060]	[0.024]				
less than 0.5 hours	0.278	0.171	0.202	0.167	0.214	–0.106	–0.076	–0.111	–0.063
	[0.138]	[0.104]	[0.104]	[0.094]	[0.112]				
Career choices after graduation (0/1)									
Employed in industry	0.244	0.133	0.137	0.133	0.152	–0.111	–0.107	–0.111	–0.093
	[0.139]	[0.086]	[0.090]	[0.090]	[0.083]				
Go on to college	0.283	0.124	0.185	0.083	0.170	–0.160	–0.098	–0.200*	–0.114
	[0.096]	[0.061]	[0.086]	[0.055]	[0.096]				
Go on to university	0.461	0.705	0.710	0.708	0.696	0.244	0.249	0.247	0.235

	[0.283]	[0.172]	[0.148]	[0.167]	[0.140]				
Have not decided yet	0.161	0.105	0.073	0.092	0.089	–0.056	–0.089	–0.069	–0.072
	[0.075]	[0.066]	[0.018]	[0.052]	[0.026]				
Amount of a donation (yen)	431.111	364.762	356.452	342.500	395.536	–66.349	–74.659	–88.611	–35.575
	[46.137]	[51.382]	[25.949]	[68.884]	[26.699]				
Concern about energy savings (1–4)	3.122	2.962	3.000	3.125	2.991	–0.160*	–0.122	0.003	–0.131
	[0.051]	[0.067]	[0.075]	[0.044]	[0.053]				
Concern about plastic waste (1–5)	3.622	3.648	3.565	3.683	3.768	0.025	–0.058	0.061	0.146
	[0.086]	[0.063]	[0.092]	[0.083]	[0.092]				
Prosocial measures (1–5)									
Donation decision	3.694	3.410	3.500	3.450	3.634	–0.285**	–0.194	–0.244**	–0.061
	[0.047]	[0.101]	[0.122]	[0.079]	[0.080]				
People have only the best intentions	2.228	2.048	1.855	2.000	1.902	–0.180	–0.373**	–0.228	–0.326*
	[0.098]	[0.124]	[0.046]	[0.137]	[0.093]				
People are trustworthy in general	2.483	2.686	2.613	2.717	2.625	0.202	0.130	0.233	0.142
	[0.098]	[0.164]	[0.162]	[0.179]	[0.100]				
Positive reciprocity	4.461	4.362	4.298	4.442	4.446	–0.099	–0.163	–0.019	–0.015
	[0.113]	[0.097]	[0.089]	[0.128]	[0.135]				
Negative reciprocity toward self	3.017	3.152	3.194	3.250	3.259	0.136	0.177	0.233	0.242*
	[0.109]	[0.116]	[0.062]	[0.103]	[0.045]				
Negative reciprocity toward others	3.222	3.390	3.379	3.225	3.375	0.168**	0.157	0.003	0.153
	[0.087]	[0.054]	[0.060]	[0.054]	[0.066]				

Locus of control (1–5)	3.161	3.026	3.056	3.060	2.981	–0.135**	–0.105	–0.100	–0.180***
	[0.030]	[0.041]	[0.056]	[0.049]	[0.036]				

The values displayed for *t* tests are the differences in the means across the groups.

Means and standard deviations (in parentheses) are shown in each column. Standard errors are clustered at the school level.

***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Table 2 Summary Statistics (N = 641)

	Control		Treatment								*t* test			
			None		Boost		Nudge		Boost + Nudge					
											Difference			
	N	Mean /SE	N	Mean /SE	N	Mean /SE	N	Mean /SE	N	Mean /SE				
	(1)		(2)		(3)		(4)		(5)		(2)–(1)	(3)–(1)	(4)–(1)	(5)–(1)
Concern about energy savings (1–4)	180	3.450	105	3.505	124	3.484	120	3.550	112	3.473	0.055	0.034	0.100	0.023
		[0.040]		[0.053]		[0.054]		[0.055]		[0.055]				
Concern about plastic waste (1–5)	180	3.739	105	3.905	124	3.919	120	4.058	112	4.054	0.166 *	0.180 *	0.319 ***	0.315 ***
		[0.064]		[0.068]		[0.072]		[0.073]		[0.072]				
Basic knowledge of environment (0–6)	180	3.900	105	4.486	124	4.476	120	4.433	112	4.411	0.586 ***	0.576 ***	0.533 ***	0.511 ***
		[0.083]		[0.104]		[0.091]		[0.097]		[0.093]				
Pro-environmental Behavior: Plastic bags (1–4)	111	2.946	83	3.193	101	3.119	100	3.340	89	3.225	0.247 *	0.173	0.394 ***	0.279 **
		[0.096]		[0.096]		[0.105]		[0.086]		[0.090]				
Pro-environmental Behavior: Wet wipes (1–4)	111	1.432	83	2.072	101	1.980	100	2.550	89	2.169	0.640 ***	0.548 ***	1.118 ***	0.736 ***
		[0.088]		[0.143]		[0.134]		[0.136]		[0.143]				

Pro-environmental Behavior: Plastic bottles (1–4)	111	2.432	83	2.361	101	2.356	100	2.530	89	2.483	–0.071	–0.076	0.098	0.051
		[0.075]		[0.109]		[0.098]		[0.089]		[0.100]				
2MEV: Preserve (1–5)	180	3.533	83	3.495	96	3.421	92	3.506	86	3.543	–0.038	–0.112	–0.027	0.009
		[0.043]		[0.059]		[0.062]		[0.060]		[0.072]				
2MEV: Utility (1–5)	180	2.768	83	2.936	96	2.835	92	2.849	86	2.836	0.168**	0.067	0.081	0.067
		[0.041]		[0.055]		[0.061]		[0.050]		[0.072]				
Environmental responsibility to self (1–5)	180	4.000	83	3.952	96	3.990	92	4.043	86	4.047	–0.048	–0.010	0.043	0.047
		[0.065]		[0.094]		[0.083]		[0.090]		[0.099]				
Environmental responsibility to other residents (1–5)	180	4.211	83	4.133	96	4.073	92	4.261	86	4.256	–0.079	–0.138	0.050	0.045
		[0.062]		[0.094]		[0.088]		[0.082]		[0.086]				
Environmental locus of control to self (1–5)	180	3.317	83	3.205	96	3.198	92	3.391	86	3.302	–0.112	–0.119	0.075	–0.014
		[0.075]		[0.113]		[0.108]		[0.110]		[0.115]				
Environmental locus of control to other residents (1–5)	180	4.356	83	4.325	96	4.313	92	4.413	86	4.395	–0.030	–0.043	0.057	0.040

	[0.053]	[0.092]	[0.080]	[0.082]	[0.078]

The values displayed for *t* tests are the differences in the means across the groups.

Means and standard errors (in parentheses) are shown in each column. Standard errors are clustered at the school level.

***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Table 3 Basic Knowledge of the Environment and Environmental Concern

	Basic knowledge of the environment		Concern about plastic waste		Concern about energy savings	
	(1)	(2)	(3)	(4)	(5)	(6)
Baseline: Control						
Treatment (all)	0.674***		0.144**		0.015	
	[0.0100]		[0.0480]		[0.8929]	
Treatment: none		0.696***		0.093		0.046
		[0.0030]		[0.4615]		[0.7007]
Treatment: boost		0.704***		0.121		0.009
		[0.0030]		[0.2973]		[0.9219]
Treatment: nudge		0.651***		0.217**		0.038
		[0.0050]		[0.0220]		[0.7588]
Treatment: boost + nudge		0.646***		0.142*		–0.041
		[0.0010]		[0.0881]		[0.7818]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
School fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	641	641	641	641	641	641

Fixed effects for schools are included in all models.

Standard errors are clustered at the school level and bootstrapped via the wild bootstrap procedure. In all columns, bootstrapped *p*-values are shown in square brackets. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Table 4 Pro-environmental Behavior

	Plastic bags		Wet wipes		Plastic bottles	
	(1)	(2)	(3)	(4)	(5)	(6)
Baseline: Control						
Treatment (all)	0.478		1.676		0.053	
	[0.1051]		[0.1952]		[0.6897]	
Treatment: none		0.388		1.435		–0.193
		[0.1912]		[0.1732]		[0.6527]
Treatment: boost		0.308**		1.254*		–0.060
		[0.0410]		[0.0581]		[0.8098]
Treatment: nudge		0.723		2.189**		0.219
		[0.1882]		[0.0440]		[0.4254]
Treatment: boost + nudge		0.415		1.600*		0.190
		[0.1652]		[0.0611]		[0.4034]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
School fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	484	484	484	484	484	484

Fixed effects for schools are included in all models.

Standard errors are clustered at the school level and bootstrapped via the wild bootstrap procedure. In all columns, bootstrapped *p*-values are shown in square brackets. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Table 5 Pro-environmental Behavior: Marginal Effects

	Plastic bags				Wet wipes				Plastic bottles			
	Never recycle, reuse, nor refuse	Seldom recycle, reuse, or refuse	Always recycle or reuse	Always Refuse	Never recycle, reuse, nor refuse	Seldom recycle, reuse, or refuse	Always recycle or reuse	Always Refuse	Never recycle, reuse, nor refuse	Seldom recycle, reuse, or refuse	Always recycle or reuse	Always Refuse
	(1)	(2)	(3)	(4)	(6)	(7)	(8)	(9)	(11)	(12)	(13)	(14)
Treatment												
None	–0.018	–0.053	–0.025	0.096	–0.349	0.044	0.039	0.266	0.028	0.020	–0.034	–0.014
Boost	–0.015	–0.042	–0.020	0.077	–0.305	0.038	0.034	0.233	0.009	0.006	–0.011	–0.004
Nudge	–0.034	–0.099	–0.047	0.180	–0.532	0.067	0.059	0.406	–0.032	–0.023	0.039	0.016
Boost + nudge	–0.020	–0.057	–0.027	0.103	–0.389	0.049	0.043	0.297	–0.028	–0.020	0.034	0.014
N	484	484	484	484	484	484	484	484	484	484	484	484

Table 6 Environmental Attitudes (2MEV), Responsibilities, and Locus of Control

	2MEV: Preserve		2MEV: Utility		Environmental responsibility to self		Environmental responsibility to other residents		Environmental locus of control to self		Environmental locus of control to other residents	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Baseline: Control												
Treatment (all)	0.002		0.084		0.081*		0.039		0.131		0.119**	
	[0.9740]		[0.4224]		[0.0771]		[0.6797]		[0.2773]		[0.0440]	
None		0.037		0.159		0.052		0.021		0.066		0.107
		[0.5546]		[0.2092]		[0.7287]		[0.8999]		[0.6777]		[0.3844]
Boost		–0.023		0.061		0.134		–0.013		0.088		0.113*
		[0.7898]		[0.5526]		[0.1732]		[0.9269]		[0.3974]		[0.0881]
Nudge		–0.002		0.040		0.070		0.069		0.235*		0.155*
		[0.9800]		[0.7047]		[0.2963]		[0.4615]		[0.0911]		[0.0701]
Boost + nudge		–0.007		0.078		0.072		0.080		0.128		0.098
		[0.9109]		[0.5646]		[0.4625]		[0.4194]		[0.5065]		[0.1161]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	537	537	537	537	537	537	537	537	537	537	537	537

Fixed effects for schools are included in all models.

Standard errors are clustered at the school level and bootstrapped via the wild bootstrap procedure. In all columns, bootstrapped *p*-values are shown in square brackets. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Table 7 Heterogeneous Effect due to Students' Level of Cognitive Skills

	Environmental Concern and Basic Knowledge			Pro-environmental Behavior		
	Basic knowledge of the environment	Concern about plastic waste	Concern about energy savings	Plastic bags	Wet wipes	Plastic bottles
Baseline: Control						
Treatment (all)	0.600**	–0.120	0.195	–1.085	0.701	–1.024
	[0.0310]	[0.5305]	[0.2192]	[0.1642]	[0.2122]	[0.6767]
Treatment (all)* Test Score	0.313	0.534	–0.128	4.451	3.376	2.700
	[0.5896]	[0.3604]	[0.6256]	[0.2573]	[0.1622]	[0.7287]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
School fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	340	340	340	183	183	183

	2MEV		Environmental responsibility		Environmental locus of control	
	Preserve	Utility	to self	to other residents	to self	to other residents
Baseline: Control						
Treatment (all)	–0.005	0.115	0.210**	0.153	0.053	0.026
	[0.9670]	[0.4915]	[0.0380]	[0.1381]	[0.7578]	[0.7648]
Treatment (all)* Test Score	0.014	–0.009	–0.453*	–0.449	0.239	0.267
	[0.9289]	[0.9910]	[0.0961]	[0.2382]	[0.6517]	[0.2753]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
School fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	340	340	340	340	340	340

Fixed effects for schools are included in all models.

Standard errors are clustered at the school level and bootstrapped via the wild bootstrap procedure. In all columns, bootstrapped *p*-values are shown in square brackets. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.