RIETI Discussion Paper Series 22-E-111

Nudges to Increase the Effectiveness of Environmental Education: New evidence from a field experiment

IGEI, Kengo
Keio University

KUROKAWA, Hirofumi
University of Hyogo

ISEKI, Masato
Zero Waste Japan

KITSUKI, Akinori
Kyushu University

KURITA, Kenichi
Kyushu University

MANAGI, Shunsuke
RIETI

NAKAMURO, Makiko
RIETI

SAKANO, Akira
Zero Waste Japan

RIETI
Research Institute of Economy, Trade & Industry, IAA

The Research Institute of Economy, Trade and Industry
https://www.rieti.go.jp/en/

RIETI Discussion Paper Series 22-E-111
December 2022

Nudges to increase the effectiveness of environmental education: New evidence from a field experiment*

Kengo IGEI[#], Hirofumi KUROKAWA[##]†, Masato ISEKI[###], Akinori KITSUKI[####], Kenichi KURITA[####], Shunsuke MANAGI[####], Makiko NAKAMURO[#], Akira SAKANO[###]
[#] Keio University, [##] University of Hyogo, [###]Zero Waste Japan, [####]Kyushu University

Abstract

We examined the effectiveness of nudge and boost in environmental education classes on students' attitudes toward environmental issues and energy-saving behaviors. We randomly assigned the target of this study, students in 8 primary schools and 6 junior high schools, with four types of interventions: receiving only environmental education (the control group), education with either nudges (goal-setting of energy-saving actions) or boosts (playing a game with "the tragedy of the commons" setting) only, and education with both nudges and boosts. We confirmed that students subject to boosts significantly became more environmentally conscious in the game and set more goals in the nudge task. The follow-up survey one month after the intervention revealed that students who set more targets in the nudge and boost group showed higher energy-saving awareness and environmental attitudes and took more energy-saving actions and reduced water consumption at home. We also found that even three months after the intervention, students who set more goals in the nudge and boost group were more energy conscious and implemented more energy-saving actions, and reduced water consumption at home.

Keywords: Green nudge, boost, environmental education, tragedy of the commons, energy saving
JEL classification: Q50, Q56, Q58

The RIETI Discussion Paper Series aims at widely disseminating research results in the form of professional papers, with the goal of stimulating lively discussion. The views expressed in the papers are solely those of the author(s), and neither represent those of the organization(s) to which the author(s) belong(s) nor the Research Institute of Economy, Trade and Industry.

*Acknowledgements: This study was conducted as part of the Project "FY2021 Project for Promotion of a Change in Low-Carbon-Type Behavior of Households through Information Provision (Nudges)" undertaken at the Ministry of the Environment and as a part of the Project "Human capital (Education·Health) investment and productivity" undertaken at the Research Institute of Economy, Trade and Industry (RIETI). We would like to thank Kenta Tanaka, Kazuyuki Iwata, Masayuki Morikawa, Kyoji Fukao, Tomohiko Inui, anonymous members of review committee in the Ministry of the Environment, and participants at a workshop held at RIETI for their valuable advice. The affiliation of Iseki is at the time of writing the paper.
† Corresponding author: Hirofumi Kurokawa, Associate Professor. School of Economics and Management, University of Hyogo, kurokawa@em.u-hyogo.ac.jp

1. Introduction

The tragedy of the commons (Hardin 1968) is adapted to environmental issues to be discussed. As with the management of the commons, environmental issues such as global warming and climate change can result in the pursuit of self-interest only, to the disadvantage of society as a whole. To prevent such disadvantages, it is important to promote cooperative behavior. Promoting cooperative behavior can be achieved not only through institutional design that encourages cooperation (Ostrom 1990, 1998; Mason and Philips 1997; Barclay 2004; Gächter et al. 2017), but also through educational approaches such as environmental education (Chawla et al. 2007; Jacobson et al. 2015; Monroe et al. 2019; Ardoin et al. 2020).

Cooperative behavior based on social preferences can also change with experience. For example, Voors et al. (2012) showed that the experience of civil war in Burundi in the 1990s increased social preferences measured in 2009. Karapetyan and d'Adda (2014) showed that people who subjectively experienced deforestation were more likely to engage in conservation activities. Their study also showed that the relationship between actual experience of deforestation and conservation activity was negative. It indicates that subjective perceptions, rather than objective experiences, influence subsequent conservation activities. These studies suggest that while large experiences such as civil wars are unlikely to cause a discrepancy between subjective and objective perceptions, environmental changes such as deforestation are small changes that may cause a discrepancy between objective and subjective perceptions. Experiences that are subjectively varied could influence preferences. Making people subjectively experience phenomena such as the tragedy of the commons may promote cooperative behavior.

This study examines whether the experience of setting the tragedy of the commons as part of environmental education can encourage energy saving behavior in the future. This study ran a multi-armed randomized controlled trial. The targets of this study were students in the later grades of primary schools and in junior high schools in Japan. In this study, all students received an environmental education class consisted of three parts: a lecture session on energy-saving lifestyle for global warming issue, a gaming session using an original board game ("CO2 Reduction Game") related to the four Rs action (renewable, restyle, reset, replace), and a reflection session to discuss the previous lecture and gaming sessions.

We incorporated boosts (Grüne-Yanoff and Hertwig 2016) in the gaming session and nudges (Thaler and Sunstein 2008) in the reflection session. The boosts in this study are playing the board game with "the tragedy of the commons" setting. More specifically, we added a new setting to the game so that each player's selfish actions undermine the profits

of the whole, and ultimately undermine the profits of each player. The purpose of the game is to help people better understand environmental issues such as global warming by experiencing them in a quasi-game-like environment. As a similar attempt in the past, Ohtani and Hayajiri (2013) developed a game for environmental education including "the tragedy of the commons" setting. In addition, the literature showed that cooperative behaviors in a group work increases altruism and reciprocity (Algan et al., 2013; Korbel and Paulus, 2018; Kubota et al. 2020; Ito et al., 2019). We intended that learning about the need to cooperate with others in "the tragedy of the commons" situation led to an increase in the impact of environmental education and nudges. The nudges in this study are goal-setting of energy-saving behaviors. We showed specific six behaviors to save the use of electricity, gas, or water in the worksheet of the reflection session and asked students to choose how many times per week they attempt to execute each behavior. We examine whether this goal-setting nudges become a reference point and motivate students to achieve each goal.

We randomly assigned students with four types of interventions; receiving the environmental education class without either nudges or boosts (the control group), a class with nudges only, with boosts only, and with both nudges and boosts. As a result of empirical analyses, we confirmed that students subject to boosts significantly became more environmentally conscious in the game and set goals more in the nudge task. The endline survey one month after the intervention revealed that students in the nudge and boost group who set more goals in the nudge task showed higher energy-saving awareness and took more energy-saving actions and reduced water consumption at home. We also found that even after three months of the intervention, students who set more goals in the nudge and boost group were more energy conscious and implemented more energy-saving actions, and reduced water consumption at home.

This study extends and overcomes our previous study, Kurokawa et al. (2023). Kurokawa et al. (2023) conducted a randomized controlled trial in which targets of high school students in Japan were randomly assigned with an environmental education class. Instead of the "CO2 Reduction Game," the "Zero Waste Game" was an environmental education game that aimed to conserve energy by reducing the use of plastic products. Using the primary survey data before and after the interventions, Kurokawa et al. (2023) found the statistically significant effects of the environmental education class on the knowledge of the environment and concern about plastic waste, and additional effects of the nudges (goal-settings regarding their reduction in the plastic products in the worksheet of the reflection session) on the concern about plastic waste. Kurokawa et al. (2023) also found that our interventions of nudges or boosts (evoking empathy for parties involved

in environmental issues in the worksheet of the reflection session) had significant effects on refusal of free wet tissues provided at convenience stores. However, Kurokawa et al. (2023)'s outcomes of environmental attitudes and behaviors used for the empirical analyses were measured by self-reporting of students. Thus, the effects shown in the study may be overestimated due to the social desirability bias. In addition, our previous study estimated the effects only in the short run, and so did not clarify the long-run effects of the interventions. The persist effects of nudges continues to be debated (Ferraro et al. 2011; Allcot and Rogers 2014; Bernedo et al. 2014; Hallsworth and Kirkman 2020; Brandon et al. 2022), so even if they are effective in the short term, their long-term effects may have disappeared.

This study overcomes the limitations of our previous studies by establishing not only self-reported attitudes and awareness, but also electricity and water usage in the home as outcomes, and following them up to 3 months after the end of environmental education. These objective outcomes are unlikely to be overestimated due to social desirability bias. Furthermore, we are able to examine spillover effects not only on the individuals who received environmental education but also on the families as a whole. By conducting a survey not only on the short-term effects immediately after the completion of environmental education, but also three months later, we are able to examine longer-term effects and observe persist effects. The environmental education of the board game we developed is successful and robust.

This study contributes to the literature on investigation of environmental education (Yang and Chen 2017; Fjællingsdal and Klöckner 2019; Mei and Yang 2019; Pan and Hsu 2020; Arachchi and Managi 2021; de Pontes et al, 2022). In the current era of increasing energy use, regulating by price, a traditional policy tool, can have a significant impact on households' consumption behavior. Environmental education that helps people understand not only energy-saving behaviors, such as not using energy, but also encouraging energy-saving behaviors, such as replacing appliances with energy-efficient ones, is significant in the long run. Non-price-based interventions are also justified because consumers can misbehave, such as not responding adequately to price (Allcot 2016; Andor and Fels 2018). Educational approaches such as environmental education and nudges and boosts are such interventions. We combined these approaches to increase the effectiveness of environmental education in promoting energy-saving behavior.

Our research also contributes to experimental studies on the tragedy of the commons or public goods game (Agimass and Mekonnen 2011; Kotani et al. 2014; Shahrier and Kotani 2019). In many of these studies, the management of the commons and the public goods provision itself are the focus of the experiment. For example, Drupp et al. (2019)

conduct the field experiment of fish-catch telling in the European Union. Compared to these studies, our study is novel in that it considers the tragedies of the commons as boosts.

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

The environmental education program in this study was developed by two of the authors' affiliations, the general incorporated association, Zero Waste Japan, specifically designed for the program. The organization of the program is the same as our previous study (Kurokawa et al. 2023); (i) a lecture session on environmental issues (20 minutes), (ii) a board game session (40 minutes), and (iii) a reflection session for discussion about the lecture and game (20 minutes), taking 80 minutes in total.

In the lecture session, teaching staffs employed for this study explained the current situation of global warming, the status of CO2 emissions from energy, and the measures for decarbonization in the energy sector so that students could make the promotion of global warming countermeasures in his/her own lifestyle such as energy conservation. The examples of the influences of global warming were based on what actually occurs in Japan and is widely known to the public, such an increase in disaster by typhoons and torrential rains, and an increase in heat stroke. In addition, by showing the percentage of energy emissions from households, we emphasized the necessity for each household to take action to reduce energy-induced CO2 emissions. The teaching materials were prepared by revising those of our previous study so that students could deepen their understanding, based on the experience in our previous study. We created two types of the materials, considering students in primary and junior high schools.

Next, students were divided into groups of five and played an original board game, called the "CO2 Reduction Game" (see Figure 1). The purpose of game is that through playing the game, students will understand how to think about the measures to be taken at home and the characteristics of each CO2 reduction action and be able to voluntarily practice these actions at their own homes. The basic rule of the game is that a player changes his/her CO2 emission mark (the initial value is 15 marks) to earth points as much as possible by carrying out action cards depicting CO2 reduction action. The action card contains two numbers: the value of earth points and the amount of money. When you perform the card, you pay the stated amount from your own wallet (the initial money in hand is 10,000 yen). Actions such as installing solar panels or replacing home appliances

have a large reduction effect (a large earth point), but there is a limit to the number of cards that can be carried out due to the budget constraint. After players have financially invested in the facilities to a certain extent, they have to depend on free energy-saving actions. Among free energy-saving actions, there is a difference in conditions between those that do not require many costs, e.g., simply changing the settings of the equipment to the energy-saving mode, and those that take some costs, e.g., turning off the lights frequently. Players compete against each other in the group, and to encourage earning of earth points, we explain that the winner is the player good at CO2 reduction with the most money left at the end of the game. In addition, in order to motive the practices of reduction actions after the game, we had players declare how they will implement at home when they choose action cards.

Aforementioned, we added "the tragedy of the commons" setting to the game as the intervention of boosts. In this setting, if players of the group fail to collect at least 8 earth points per person, i.e., the total earth points of the group are less than 40 in the case of the group of five players, they forfeit all money as a cost of environmental conservation. Thus, the winner is the player who accumulates a certain earth point while paying the least amount with action cards. We did not clearly inform of the threshold for forfeiture, 8 earth points per person, but implicitly stated in the explanation of the game that the goal was to collect 8 points. This setting aims to help students understand the dilemma in environmental issues, where the costs of environmental protection fall on the individual, but the disadvantages of environmental destruction are suffered equally by all, and realize the importance of a coordination strategy to solve the dilemma. The way to determine the winner is the same as the basic rule above.

In the reflection session after the game session, we summarized and discussed the contents of the class and provided worksheets. The worksheets have three questions. The first question asks the amount of earth points earned and money left at the end of game. The second question differs between the group subject to goal-setting nudges and the group not subject to. In the group subject to goal-setting nudges, the students are asked to set one-month goals for six energy-saving behaviors: (i) bathing within 10 minutes after filling the bathtub with hot water, (ii) not leaving the water running, (iii) turning off the lights in unoccupied rooms, (iv) setting hot water at lower temperatures, (v), turning off the main power of televisions, and (vi) unplugging a power of electric devices. These behaviors were selected from CO2 reduction actions in the board game, which are possible in any household and can be done by children. The students were asked to indicate on a 5-point scale how many times per week they engage in each of these behaviors. As explained above, this goal-setting question aims to become a reference

point for each student and promote students to attain each goal. In the group subject not to goal-setting nudges, we asked how the students considered the balance between earth points and money when playing the game. Specifically, we asked whether they placed more importance on acquiring earth points than on money, whether they placed more importance on not decreasing money than on earth points, or whether they acted in consideration of the balance between the two. The third question, common to both groups, asked the students to freely describe their impressions of the class. It is unlikely that this essay itself will cause students to set goals or become more altruistic.

3. Experiment design and data collection

3.1. Study sites

We called for the participation of primary and junior high schools with the following conditions: (1) classes in schools or groups within classes could be randomly divided for treatment assignment; and (2) cooperation with a total of three questionnaires, one before the class and two after the class. In recruiting schools, we prioritized public schools with diverse academic performance and family environments and those in urban areas to ensure consistency in standards of usage of electricity, water and gas.

As a result, 8 primary schools (7 public and 1 private) in Tokyo and Chiba Prefectures, and 6 junior high schools (4 public and 2 private) in Tokyo, Saitama, and Osaka Prefectures participated in this study. There are 2 through 5 classes within each school. The total number of participants were 1,261 (595 students of the fifth and sixth grades in the primary schools, and 666 students of the first through third grades in the junior high schools).

From September to December 2021, we implemented the environmental education classes described above. We sent teaching staffs trained before the class to the schools. Two primary schools were conducted online with the support of teachers in the classrooms as a preventive measure against the spread of COVID-19 infection.

3.2. Treatment assignment

As explained above, our environmental education program has two types of board game sessions with or without “the tragedy of the commons” setting (with or without boosts) and two types of reflection sessions using worksheets with or without a goal-setting question (with or without nudges). Firstly, we randomly determined in which class within each school “the tragedy of the commons” setting was added to the board game. Secondly, we randomly distributed two types of worksheets in the reflection session to each group of the board game, i.e., students in some groups within each class were asked

to answer a goal-setting question about six energy-saving behaviors, and those in other groups were not asked. Therefore, students were randomly divided into four groups: (1) a control group with neither nudges nor boosts, (2) a group with nudges only, (3) a group with boosts only, and (4) a group with nudges and boosts.

3.3. Data collection

3.3.1. Baseline survey

We conducted a baseline survey before implementing the environmental education program. Among 14 targeted schools, the survey was administered on paper at 6 schools, and on web at 8 schools. The questionnaire for primary school students was adjusted by using different expression to match their school age. The questions included the number of family members living together, knowledge about environmental issues, awareness and attitudes toward energy conservation and the environment, energy-saving actions usually taken at home, and the amount of electricity, gas, and water used in the home.

To measure the knowledge about environmental issues, students were shown six sentences related to the content of the lecture session of the environmental education program (e.g., global warming is caused by greenhouse gases such as CO2) and asked whether each statement was true or false. Primary school students were asked about only three sentences according to their school age. For each statement, one point was added for a correct answer, one point was subtracted for an incorrect answer, and no point was subtracted for no answer, and the final total score was calculated and used for analysis.

Regarding awareness toward energy conservation, students were directly asked on a four-point scale from “very aware” to “not aware at all” against energy conservation in their daily lives. Regarding attitudes toward energy conservation, we employed a modified version of the 2MEV scale developed by Johnson and Manoli (2010). Specifically, students were asked to rate on a five-point scale the extent to which they applied themselves to five statements related to environmental use, such as “I believe that people have the right to lead a rich life even at the expense of the future environment,” and five statements related to environmental conservation, such as “I try to conserve water and electricity every day even if it is only for a short time.” The higher the score, the more likely the student was to agree or disagree with the statement. Responses were quantified so that the higher the degree of applicability, the higher the score, and the average scores for each of the environmental utilization and conservation sentences were used for analysis. In addition, to assess whether the sense of responsibility for the environment changed, they were asked on a five-point scale whether they and each resident were responsible for improving the quality of the environment, similar to Hsu (2004). Finally,

to examine the change in the sense of control over the environment, they were asked on a five-point scale how much they think they can influence the solution of environmental problems by their own actions and by taking action with others, following Hsu (2004).

Regarding energy-saving actions, six actions were selected from the 29 energy-saving actions covered in the action cards of the board game, which every household can always do, and which even children can do. Three actions are related to the use of electricity (e.g., unplug a power of electric devices when not using more than 30 minutes), and two actions are related to the use of gas (e.g., entering the bathtub within 10 minutes after filling with hot water), and one action is related to the use of water (do not leave the water running for more than 1 minute except when washing hands or dishes or rinsing off). These actions are the target set for the goal-setting nudge in the reflection session as well. Students were asked on a five-point scale how many times per week they engage in each of six actions.

Regarding the use of water, gas, and electricity in the home, parents of students were informed of the purpose of the survey and asked to keep the meter readings during the period from the baseline and endline surveys, and were asked about their water, gas, and electricity consumption in the month of the survey and the previous month. For analysis, each energy usage was divided by the number of family members to compute per capita usage.

3.3.2. Endline survey

A paper or web-based questionnaire survey was administered in each of the schools approximately one month and three months after the environmental education program was conducted. Questions and adjustments of expression for schooling age are the same as in the baseline survey. After observing the response rate of the endline survey after one month, the method of the survey after three months was switched from on web to on paper at 5 schools to increase the response rate.

3.3.3. Analysis on survey responses

Table 1 shows the number of targeted students and responses at each survey. The total number of students targeted in this study is 1,153, and almost equally divided into the control and three treatment groups, i.e., 289, 281, 301, and 282 in the control, nudge, boost, and nudge and boost groups, respectively[2]. Of the targeted students, 671 (58%)

[2] The total number of targeted students differs slightly from the number of students who actually participated in the environmental education program. This is because the treatment status was unclear for a very small number of students, and such students were excluded from the data in the data cleaning

students answered the baseline survey in total, and the response ratio was similar by the treatment status.

In the process of data cleaning, we found that the missing rate in consumption of electricity, gas, and water was much higher than the rate in the other outcomes. Thus, this study separates the analysis by outcomes of energy consumption and others. Hereafter, we refer to the analysis on the observations with no missing values from the baseline and endline surveys in all environmental knowledge, awareness, attitudes, and actions other than energy consumption as "the first analysis," and to the analysis on the observations with no missing values in energy consumption as "the second analysis." As shown in Table 1, the number of the observations of the first analysis at the baseline survey is close to the number of respondents in each group, whereas that of the second analysis is much smaller. However, the rate in parentheses to the number of targeted students was similar by the treatment status in both observations of the first and second analysis.

The total number of respondents at the one-month endline survey was 407. The response rate to the targeted students was 35%, and there was no large difference in the rate by the treatment status. As in the baseline survey, the number of observations of the second analysis is much lower than the first analysis, but with no large difference in the response rate by the treatment status.

The total number of respondents at the three-month endline survey was 584, and the response rate to the targeted students was 51%. This improvement in the response rate from the one-month endline survey seems to be due to the change in the survey method in some schools as explained above. The results about the observations of the first and second analyses are similar to the one-month endline survey.

3.4. Descriptive statistics and balance check

Before the analyses based on the baseline and two endline surveys, we examine the effect of boosts on the results of the board game and the contents of goal-setting in the reflection session. Figure 2 compares the distribution of (a) the earth points obtained and (b) the amount of money remaining at the end of the game between the classes with and without boosts ("the tragedy of the commons" setting). As for the earth points, the distribution of the classes with boosts is slightly to the right of the distribution for the classes without. The distribution of the amount of money overlaps for both classes. The mean values of earth points are 8.530 and 8.149 for the classes with and without boosts, respectively, and the difference in the means is statistically significant[3]. As hypothesized,

process.

[3] The groups with less than 8 earth points (i.e. the threshold at which money is forfeited in the boost

the boost group has more earth points, suggesting that students understand the rules of the game. On the other hand, the mean values of the amount of money are about the same for both classes: 4.656 and 4.606 for the classes with and without boosts, respectively, and the difference in the means is not statistically significant[4]. These results imply that the boosts by adding "the tragedy of the commons" setting enhanced the environmental attitude in the game and encouraged players more to take CO2 reduction action without spending money much.

Table 2 compares the results of goal-setting work about six energy-saving behaviors between the nudge only and boost and nudge groups. As in Figure 2, the first to second columns show summary statistics of each result of goal-setting and the total number of goal-setting for the nudge only and boost and nudge groups and the third column reports differences between these two groups. Comparing the ratio of students who answered engaging in each energy-saving action at least four or five times per week, the boost and nudge group is statistically significantly higher for turning off the main power of televisions and setting hot water at lower temperatures. The number of actions that students answered engaging on at least four or five times per week is also statistically significantly higher in the boost and nudge group. These results suggest that the students in the boost and nudge group increased their environmental attitude and set higher goals by playing the game with "the tragedy of the commons" setting before conducting the goal-setting work, which is consistent with the results of the board game above. Thus, we could confirm the expected effects of boosts within the environmental education program.

Tables A.1 and A.2 show descriptive statistics and a balance check between the treatment and control groups for the samples of the one-month and three-month endline survey, respectively. The first to forth columns present summary statistics of outcomes as of the baseline survey for each group, and the fifth to seventh columns report differences between the control group and each treatment group. Although most of the outcomes are well-balanced in both tables, some variables, especially of the boost group, are largely unbalanced. We deal with potential biases arising from these imbalances in the regression as explained in the following section.

At the balance check in Tables A.1 and A.2, we found the imbalance of outcomes as of the baseline survey for the samples of the one-month and three-month endline surveys. In the following section, this study estimates the impacts of each treatment group, controlling the potential imbalance of students' attributions.

---

group) are 33.1 % of the classes with boost and 48.0% of the classes without boost.

[4] The amount of money before forfeiture is shown. The mean amount of money after forfeiture is 2.911 in the boost group.

3.5. Statistical approach

To identify the effects of each treatment, the following regressions are estimated by ordinary least squares for each sample of the one-month and three-month endline surveys:

$$Y_{ij} = \alpha_0 + \sum_{k=1}^{3} \alpha_k T_{ijk} + \beta_1 T_{ij1} \times G_{ij1} + \beta_3 T_{ij3} \times G_{ij3} + X'_{ij}\gamma + \theta_i^g + \theta_s + \epsilon_{ij}$$

where Y_{icj} is the outcome variable at each endline survey for student i in school j. Outcome variables other than those on energy-saving actions and energy consumption are used in the regression with the variables defined above. As for the dependent variables of energy-saving actions, we prepared a dummy variable for each action that is equal to 1 if students answered taking the action at least four or five times per week at the survey. As for the dependent variables of energy consumption, we used the natural logarithm of the amount of each energy consumption per capita.

T_{ijk} (k = 1,2,3) are dummy variables that are equal to 1 if the student is in the nudge, boost, and boost and nudge groups, respectively. To allow for the heterogeneous impacts of nudges by the results of goal-setting work, two interaction terms, $T_{ij1} \times G_{ij1}$ and $T_{ij3} \times G_{ij3}$, are added. G_{ij1} and G_{ij3} are the dummy variables related to the results of goal-setting work for the nudge and boost and nudge groups with different definition depending on the outcome variable. In the regression of environmental knowledge, awareness, attitudes (2MEV), responsibility, and locus of control, the variables take 1 if the number of actions that students answered engaging on at least four or five times per week was 5 or more out of 6 actions. In the regression of energy-saving actions, the variables take 1 if students answered engaging on the action of the depending variable at least four or five times per week. In the regression of energy-saving actions, the variables take 1 if students answered engaging on the action related to the depending variable at least four or five times per week. Thus, the coefficients β_1 and β_3 provide an estimate of the causal effect of nudges and combination of boosts and nudges in the case of setting higher goals in the reflection session of the program. The coefficients α_1 and α_3 provide an estimate of the causal effect of those interventions in the case of setting lower goals. Since the interaction term is not added for the boost group, the coefficient α_2 provides an estimate of the causal effect of boosts only.

To control the potential bias arising from the imbalance of attributions, X_i, a set of control variables, are controlled, which include the outcome variable at the baseline survey in all regression and the dummies in which month each energy usage was measured in the regression of electricity, gas, and water consumption (if missing, we

added a dummy variable indicating that it was missing). θ_i^g is grade fixed effects and θ_s is school fixed effects, and ϵ_{ij} is an error term that is correlated within groups. Particularly in the boost group, unobserved factors may be correlated within the group, just as there may be different effects on groups where money forfeiture occurred versus those where it did not. To take account these correlation, standard errors are clustered at the group level but corrected using wild bootstrap methods for the potential bias arising from the small number of groups in our sample (Roodman et al. 2019).

4. Empirical results

4.1. Estimates of the effects one month later

Table 3 reports the estimates of the effects on environmental knowledge, awareness, attitudes (2MEV), responsibility, and locus of control one month after the program. While most of the estimates are not significant, the estimates of two interaction terms, "Nudge×# of Goal-setting" and "Nudge+Boost×# of Goal-setting," on awareness toward energy conservation are significantly positive as reported in the second column. These results mean that students who set more goals in the reflection session had significantly higher awareness toward energy conservation one month later than those who did not, implying that setting higher goals seems to be important, but not just setting goals. However, the scope of the impacts of setting higher goals are limited because there are no highly significant estimates of the interaction terms on other outcomes.

Table 4 reports the estimates of the effects on energy-saving actions. Among others, the estimates of the interaction term, "Nudge+Boost×Goal-setting of Y," are significantly positive for four energy-saving actions such as taking a bath right away and never leaving the water running, and so on. These results mean that students who set a goal of engaging on an action at least four or five times per week in the program were significantly more likely to have actually taken the action one month later than those who did not. Since the interaction term of the nudge group, "Nudge×Goal-setting of Y," is not significant for any actions, the motivation by setting goals is considered to be enhanced more by the boosts, i.e., playing the game with "the tragedy of the commons" setting.

Table 5 reports the estimates of the effects on energy consumption at home. As in the results above, most of the estimates are not significant, whereas the estimates of the interaction term, "Nudge+Boost×Goal-setting_Action3," are significantly negative for water consumption. "Action3" refers to the third action in the list of energy-saving actions, "Never leave the water running." As in the previous estimates, this result means a significant difference in water consumption within the nudge and boost group between students who set the goal of never leaving the water running at least four or five times per

week and those who did not. To interpret this estimate, we add to the estimates of the nudge and boost group (0.521) and obtained -0.180. This figure means that those in the nudge and boost group who set the goal of "Never leave the water running" used 18.0% less water at home in compared to the control group. As for electricity and gas consumption, the estimates of the interaction term of the nudge and boost group are not significant, but negative and to a certain large. These results are consistent with the findings above in that the motivation of water conservation increased by setting a higher goal of specific water-saving action and the boosts led to actual action and water conservation at home even one month after the program.

In the regression analyses based on one-month endline survey, we found that the boosts increased the motivation effect of goal-setting nudges on awareness toward energy conservation, energy-saving action, and ultimately reduction in energy use. We investigate whether such effect of the boosts sustains in the longer run in the next subsection.

4.2. Estimates of the effects three months later

Table 6 reports the estimates of the effects on environmental knowledge, awareness, attitudes (2MEV), responsibility, and locus of control three months after the program. As in the results of the estimates one month later (Table 3), the estimates of two interaction terms, "Nudge×# of Goal-setting" and "Nudge+Boost×# of Goal-setting," on awareness toward energy conservation are still significantly positive as reported in the second column. These results indicate the persistent effect of setting more goals of energy-saving actions in the reflection session on environmental awareness. On the other hand, the effects of setting less goals on environmental awareness are significantly negative as shown in the coefficients on the nudge, and nudge and boost groups. Most of other estimates are not significant, and some are significantly negative.

Table 7 reports the estimates of the effects on energy-saving actions three month later. The estimates of the interaction term, "Nudge+Boost×Goal-setting of Y," are significantly positive for the actions of never leaving the water running and setting hot water at lower temperatures at the 10 percent level. In compared to the results one month later (Table 4), other estimates of the interaction term of the nudge and boost group became smaller, and not significant for some actions. These results imply that the effects of goal setting and boosts on energy-saving actions might not be strong in the long run.

Table 8 reports the estimates of the effects on energy consumption at home three month later. All the estimates of the interaction term of the nudge and boost group are negative, and significant for water consumption as reported in the third column. By

adding this to the estimates of the nudge and boost group (0.859), this result can be interpreted as a 43.9% reduction in water consumption at home for those in the nudge and boost group who set the goal of never leaving the water running in compared to the control group as of the three-month endline survey. Although this estimate of the effect is larger than the estimates one month later (18.0%), they cannot be simply compared because the observations used for the regression are different between these two analyses. Considering the persistently significant results for environmental awareness and the action of never leaving the water running above, it can be interpreted that those in the nudge and boost group who set the higher goal of energy-saving actions had actually reduced the water consumption at home by not only practicing the action of never leaving the water running, but also by implementing other actions not covered by the survey. In addition, the estimates of the effect of the boost group on electricity consumption is significantly negative, indicating 29.0% reduction in the consumption in comparison to the control group.

These results imply the effectiveness of the boosts, i.e., playing the game with "the tragedy of the commons" setting, on energy consumption in the long run as well. On the other hand, it should be noted that the observations used in the regression of energy consumption account for only about 10 percent of the students originally targeted by this study as shown in Table 1. Therefore, it is necessary to carefully assess whether the findings of this study can be generalized to the entire targeted students or to other populations of students.

5. Conclusions

This study aimed to examine whether the setting of the tragedies of the commons in environmental education boosts the effectiveness of the education on energy-saving actions as boosts. We conducted a multi-armed randomized controlled trial in which students were randomly divided into four groups: (1) a control group with neither nudges nor boosts, (2) a group with nudges only, (3) a group with boosts only, and (4) a group with nudges and boosts. First of all, we confirmed that the boosts enhanced the environmental attitude in the board game of the environmental education program and encouraged students to set higher goals in the nudge task. In the regression using the data from the one-month endline survey, we found the significant interaction effect of setting higher goals in the nudge task and boosts on awareness toward energy conservation, energy-saving actions, and water consumption at home. We also found the similar interaction effect of setting higher goals in the nudge task and boosts on awareness toward energy conservation, energy-saving actions, and water consumption at home, and the sole

effect of the boosts on electricity consumption as of the three-month endline survey. Therefore, these results indicate the effectiveness of the combination of nudges and boosts on energy consumption in the long run as well. In addition, the importance of setting higher goals in the nudges, but not just setting goals, is implied.

Our results of the household-level reductions in energy consumption, especially water use, are not necessarily attributed only to students themselves, but also to their other family members. It is possible that students tell what they learned at school to other family members and that other family members take energy-saving actions in their water use, such as turning off the main water valve a little. It is also possible that they pay financial cost of replacing appliances with energy-efficient ones. In this paper, it is unclear whether, to what extent, and how such spillover occurred within the household. For the future research, it would be interesting to survey parents as well to better clarify the mechanism of these spillover effects.

The low response rate, especially about the amount of energy consumption is also our limitation. It remains unclear whether the findings of this study can be generalized to the entire targeted students. In addition, the target schools in this study were recruited with priority to public schools in urban areas. It is necessary to carefully judge the generalizability of the findings of this study, i.e., whether the similar effects can be obtained when the same interventions are conducted in more general schools. Future work is needed to confirm the generalizability of the findings of this study in other situations.

References

Agimass, F., & Mekonnen, A. (2011). Low-income fishermen's willingness-to-pay for fisheries and watershed management: An application of choice experiment to Lake Tana, Ethiopia. *Ecological Economics*, 71, 162-170.

Agarwal, S., Rengarajan, S., Sing, T. F., & Yang, Y. (2017). Nudges from school children and electricity conservation: Evidence from the "Project Carbon Zero" campaign in Singapore. *Energy Economics*, 61, 29–41.

Allcott, H. (2016). Paternalism and energy efficiency: an overview. *Annual Review of Economics*, *8*, 145-176.

Allcott, H., & Rogers, T. (2014). The short-run and long-run effects of behavioral interventions: Experimental evidence from energy conservation. *American Economic Review*, *104*(10), 3003-37.

Andor, M. A., & Fels, K. M. (2018). Behavioral economics and energy conservation–a systematic review of non-price interventions and their causal effects. *Ecological economics*, *148*, 178-210.

Arachchi, J. I., & Managi, S. (2021). Preferences for energy sustainability: Different effects of gender on knowledge and importance. *Renewable and Sustainable Energy Reviews*, 141.

Ardoin, N. M., Bowers, A. W., & Gaillard, E. (2020). Environmental education outcomes for conservation: A systematic review. *Biological Conservation*, *241*, 108224.

Barclay, P. (2004). Trustworthiness and competitive altruism can also solve the "tragedy of the commons". *Evolution and Human Behavior*, *25*(4), 209-220.

Berenguer, J. (2007). The effect of empathy in proenvironmental attitudes and behaviors. *Environment and behavior*, *39*(2), 269-283.

Bernedo, M., Ferraro, P. J., & Price, M. (2014). The persistent impacts of norm-based messaging and their implications for water conservation. *Journal of Consumer Policy*, *37*(3), 437-452.

Bogner, F. X., & Wiseman, M. (2006). Adolescents' attitudes towards nature and environment: Quantifying the 2-MEV model. *Environmentalist*, 26(4), 247–254.

Brandon, A., Ferraro, P., List, J. A., Metcalfe, R., Price, M., & Rundhammer, F. (2022). Do the effects of social nudges persist? Theory and evidence from 38 natural field experiments. *NBER Working Paper*, (w23277).

Charry, K., & Parguel, B. (2019). Educating children to environmental behaviours with nudges: the effectiveness of social labelling and moderating role of age. *Environmental Education Research*, 25(10), 1495–1509.

Chawla, L., & Cushing, D. F. (2007). Education for strategic environmental

behavior. *Environmental education research*, *13*(4), 437-452.

Clark, D., Gill, D., Prowse, V., & Rush, M. (2020). Using goals to motivate college students: Theory and evidence from field experiments. *Review of Economics and Statistics*, *102*(4), 648-663.

Czap, N. V., Czap, H. J., Lynne, G. D., & Burbach, M. E. (2015). Walk in my shoes: Nudging for empathy conservation. *Ecological Economics*, *118*, 147-158.

Davis, M. H. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. Journal of Personality and Social Psychology, 44(1), 113.

Drupp, M. A., Khadjavi, M., & Quaas, M. F. (2019). Truth-telling and the regulator. Experimental evidence from commercial fishermen. *European Economic Review*, 120, 103310.

Ericson, T., Kjønstad, B. G., & Barstad, A. (2014). Mindfulness and sustainability. *Ecological Economics*, *104*, 73-79.

Falk, A., Becker, A., Dohmen, T., Enke, B., Huffman, D., & Sunde, U. (2018). Global evidence on economic preferences. *The Quarterly Journal of Economics*, 133(4), 1645–1692.

Ferraro, P. J., Miranda, J. J., & Price, M. K. (2011). The persistence of treatment effects with norm-based policy instruments: evidence from a randomized environmental policy experiment. *American Economic Review*, *101*(3), 318-22.

Fjællingsdal, K. S., & Klöckner, C. A. (2019). Gaming Green: The educational potential of Eco–A digital simulated ecosystem. *Frontiers in Psychology*, 10, 2846.

Gächter, S., Kölle, F., & Quercia, S. (2017). Reciprocity and the tragedies of maintaining and providing the commons. *Nature human behaviour*, *1*(9), 650-656.

Grüne-Yanoff, T., & Hertwig, R. (2016). Nudge versus boost: How coherent are policy and theory? Minds and Machines, 26, 149–183.

Hallsworth, M., & Kirkman, E. (2020). *Behavioral insights*. MIT Press.

Hardin, G. (1968). The tragedy of the commons: the population problem has no technical solution; it requires a fundamental extension in morality. S*cience*, *162*(3859), 1243-1248.

Heywood, J. S., Jirjahn, U., & Struewing, C. (2017). Locus of control and performance appraisal. *Journal of Economic Behavior & Organization*, 142, 205–225.

Hsu, S. J. (2004). The effects of an environmental education program on responsible environmental behavior and associated environmental literacy variables in Taiwanese college students. *The Journal of Environmental Education*, 35(2), 37–48.

Jacobson, S. K., McDuff, M. D., & Monroe, M. C. (2015). *Conservation education and outreach techniques*. Oxford University Press.

Johnson, B., & Manoli, C. C. (2010). The 2-MEV scale in the United States: a measure of children's environmental attitudes based on the theory of ecological attitude. *The Journal of Environmental Education*, 42(2), 84–97.

Karapetyan, D., & d'Adda, G. (2014). Determinants of conservation among the rural poor: A charitable contribution experiment. *Ecological Economics*, 99, 74-87.

Kotani, K., Tanaka, K., & Managi, S. (2014). Cooperative choice and its framing effect under threshold uncertainty in a provision point mechanism. *Economics of Governance*, 15(4), 329–353.

Kurokawa, H., Igei, K., Kitsuki, A., Kurita, K., Managi, S., Nakamuro, M., & Sakano, A. (2023). Improvement impact of nudges incorporated in environmental education on students' environmental knowledge, attitudes, and behaviors, *Journal of Environmental Management*, 325, 116612

Liefländer, A. K., & Bogner, F. X. (2014). The effects of children's age and sex on acquiring pro-environmental attitudes through environmental education. *The Journal of Environmental Education*, 45(2), 105–117.

Mason, C. F., & Phillips, O. R. (1997). Mitigating the tragedy of the commons through cooperation: an experimental evaluation. *Journal of environmental economics and management*, *34*(2), 148-172.

Mei, B., & Yang, S. (2019). Nurturing environmental education at the tertiary education level in China: can mobile augmented reality and gamification help?. *Sustainability*, *11*(16), 4292.

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge university press.

Ostrom, E. (1998). A behavioral approach to the rational choice theory of collective action: Presidential address, American Political Science Association, 1997. *American political science review*, *92*(1), 1-22.

de Pontes, S. R. S., Guimarães, C. C., Oliver Cornwell, T., & Krelling, A. P. (2022). Perceptions on the effectiveness of environmental education programs as environmental licensing tools for port-related enterprise in Brazil. *Environmental Management*, 70(4), 565-580.

Monroe, M. C., Plate, R. R., Oxarart, A., Bowers, A., & Chaves, W. A. (2019). Identifying effective climate change education strategies: A systematic review of the research. *Environmental Education Research*, *25*(6), 791-812.

Pan, C.-T., & Hsu, S.-J. (2020). Effects of a one-day environmental education program on sixth-graders' environmental literacy at a nature center in Eastern Taiwan. *Sustainability*, 12(12), 5043

Roodman, D., Nielsen, M. Ø., MacKinnon, J. G., & Webb, M. D. (2019). Fast and wild: Bootstrap inference in Stata using boottest. The Stata Journal, 19(1), 4-60. Roodman, D., Nielsen, M. Ø., MacKinnon, J. G., & Webb, M. D. (2019). Fast and wild: Bootstrap inference in Stata using boottest. *The Stata Journal*, 19(1), 4-60.

Shahrier, S., & Kotani, K. (2019). Natural disaster mitigation through voluntary donations in a developing country: the case of Bangladesh. *Environmental Economics and Policy Studies*, 21(1), 37-60.

Thaler, R. H. & Sunstein, C. R. (2008). *Nudge: Improving decisions about health, wealth, and happiness*. Yale University Press.

Yang, X., & Chen, J. (2017). Using discovery maps as a free-choice learning process can enhance the effectiveness of environmental education in a botanical garden. *Environmental Education Research*, *23*(5), 656-674.

Voors, M. J., Nillesen, E. E., Verwimp, P., Bulte, E. H., Lensink, R., & Van Soest, D. P. (2012). Violent conflict and behavior: a field experiment in Burundi. *American Economic Review*, *102*(2), 941-64.

Figure 1 CO2 Reduction Game

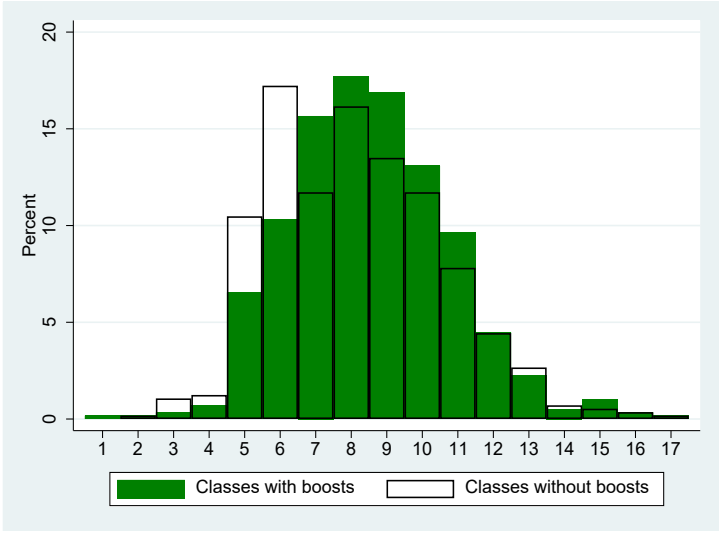
Overview:

Action Cards:

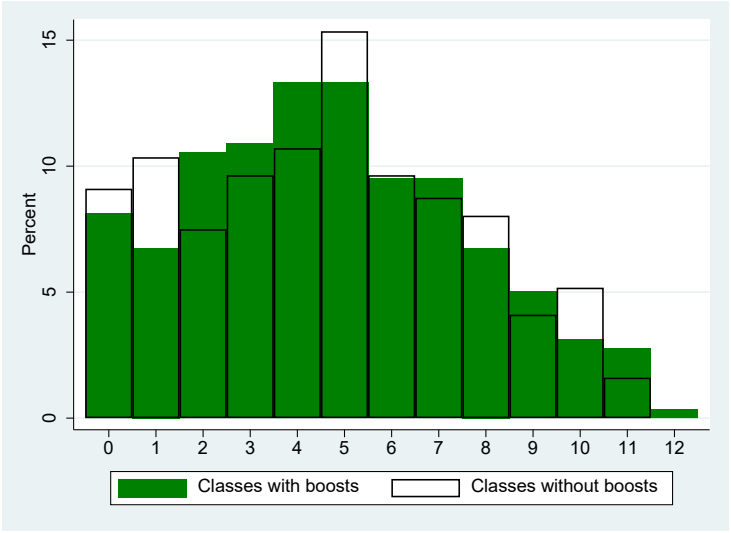
Source: Zero Waste Japan

Figure 2 Results of the Board Game

(a) Earth points



(b) Amount of money



Source: prepared by authors.

Table 1 Summary of Survey Responses

	Total	Control	Nudge	Boost	Nudge +Boost
Number of targeted students	1153	289	281	301	282
Number of respondents: baseline survey	671	170	154	179	168
	[58%]	[59%]	[55%]	[59%]	[60%]
Number of observations of the 1st analysis	635	160	143	173	159
	[55%]	[55%]	[51%]	[57%]	[56%]
Number of observations of the 2nd analysis	379	97	83	114	85
	[33%]	[34%]	[30%]	[38%]	[30%]
Number of respondents: one-month endline survey	407	103	95	113	96
	[35%]	[36%]	[34%]	[38%]	[34%]
Number of observations of the 1st analysis	282	70	60	82	70
	[24%]	[24%]	[21%]	[27%]	[25%]
Number of observations of the 2nd analysis	111	33	27	32	19
	[10%]	[11%]	[10%]	[11%]	[7%]
Number of respondents: three-month endline survey	584	163	138	145	138
	[51%]	[56%]	[49%]	[48%]	[49%]
Number of observations of the 1st analysis	358	90	76	101	91
	[31%]	[31%]	[27%]	[34%]	[32%]
Number of observations of the 2nd analysis	119	23	31	36	29
	[10%]	[8%]	[11%]	[12%]	[10%]

Figures in parentheses means the rate to the number of targeted students in each group. In the first analysis, we use the observations with no missing values from the baseline and endline surveys in all environmental knowledge, awareness, attitudes, and actions other than energy consumption. In the second analysis we use the observations with no missing values in energy consumption as "the second analysis."

Table 2 Comparison of Results of Goal-setting Work

	Nudge	Nudge +Boost	Difference
	(1)	(2)	(2)-(1)
Goal-setting (at least 4-5 times a week)			
1.Unplug a power of electric devices	0.516	0.555	0.038
	[0.031]	[0.035]	
2.Turn off the main power of televisions	0.491	0.584	0.093***
	[0.031]	[0.028]	
3.Turn off the lights in the room	0.927	0.905	0.022
	[0.019]	[0.016]	
4.Take a bath right away	0.633	0.602	-0.031
	[0.031]	[0.036]	
5.Setting hot water at lower temperatures	0.775	0.836	0.061***
	[0.028]	[0.021]	
6.Never leave the water running	0.822	0.828	0.007
	[0.023]	[0.026]	
Number of goal-setting actions	4.164	4.310	0.147**
	[0.086]	[0.082]	
N	275	274	

Means and standard errors (in parentheses) are shown in columns (1) and (2), and the differences in the means across the groups are shown in the difference column. Standard errors are clustered at the school level.
In the tests in the difference in the means, school and grade level fixed effects are controlled.
** and *** indicate significance at the 5 and 1 percent critical levels, respectively.

Table 3 Environmental Knowledge, Awareness, Attitudes (2MEV), Responsibility, and Locus of Control after One Month

	Environmental knowledge	Awareness toward energy conservation	2MEV:		Environmental responsibility:		Environmental locus of control:	
			Preserve	Utility	To self	To other residents	To self	To other residents
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Nudge	-0.220	-0.191	-0.026	0.285*	0.038	-0.154	0.062	-0.107
	[0.109]	[0.152]	[0.876]	[0.081]	[0.851]	[0.378]	[0.754]	[0.491]
Boost	-0.241	0.050	-0.056	-0.161*	0.217	0.086	-0.067	-0.142
	[0.109]	[0.697]	[0.610]	[0.079]	[0.221]	[0.476]	[0.740]	[0.254]
Nudge+Boost	-0.512**	-0.061	-0.092	0.158	-0.051	-0.004	-0.104	-0.114
	[0.031]	[0.598]	[0.460]	[0.484]	[0.793]	[0.977]	[0.586]	[0.424]
Nudge×# of Goal-setting	-0.024	0.358*	-0.002	-0.225	0.008	0.102	-0.305	-0.140
	[0.906]	[0.073]	[0.989]	[0.308]	[0.970]	[0.533]	[0.132]	[0.364]
Nudge+Boost×# of Goal-setting	0.342	0.348**	0.185	-0.161	0.213	0.252*	0.106	0.134
	[0.235]	[0.023]	[0.257]	[0.516]	[0.157]	[0.075]	[0.689]	[0.316]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Grade & school fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	282	282	282	282	282	282	282	282

**, and * indicate significance at the 5 and 10 percent critical levels, respectively. Control variables include the outcome variable at the baseline survey.

Table 4 Energy-saving Actions after One Month

	Electricity			Gas		Water
	1.Unplug a power of electric devices	2.Turn off the main power of televisions	3.Turn off the lights in the room	4.Take a bath right away	5.Setting hot water at lower temperatures	6.Never leave the water running
	(1)	(2)	(3)	(4)	(5)	(6)
Nudge	0.038	-0.213**	0.163	0.008	-0.144	-0.195
	[0.717]	[0.039]	[0.143]	[0.898]	[0.356]	[0.492]
Boost	0.044	-0.126	0.099**	0.107	0.050	0.046
	[0.498]	[0.165]	[0.049]	[0.375]	[0.278]	[0.487]
Nudge+Boost	-0.026	-0.262***	0.014	-0.082	-0.340*	-0.316*
	[0.679]	[0.007]	[0.926]	[0.394]	[0.078]	[0.073]
Nudge×Goal-setting of Y	0.027	0.101	-0.063	0.078	0.093	0.163
	[0.815]	[0.250]	[0.640]	[0.289]	[0.474]	[0.511]
Nudge+Boost×Goal-setting of Y	0.115	0.328***	0.074	0.242*	0.343*	0.312**
	[0.300]	[0.004]	[0.860]	[0.082]	[0.083]	[0.040]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Grade & school fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	282	282	282	282	282	282

***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively. Control variables include the outcome variable at the baseline survey.

Table 5 Energy Consumption after One Month

	Log of consumption per capita:		
	Electricity	Gas	Water
	(1)	(2)	(3)
Nudge	-0.132	-0.208	-0.163
	[0.427]	[0.496]	[0.610]
Boost	0.008	-0.522	-0.051
	[0.961]	[0.661]	[0.690]
Nudge+Boost	0.027	-0.057	0.521
	[0.756]	[0.862]	[0.165]
Nudge×Goal-setting_Action1	0.130		
	[0.463]		
Nudge+Boost×Goal-setting_Action1	-0.124		
	[0.308]		
Nudge×Goal-setting_Action5		-0.145	
		[0.552]	
Nudge+Boost×Goal-setting_Action5		-0.170	
		[0.360]	
Nudge×Goal-setting_Action6			0.138
			[0.552]
Nudge+Boost×Goal-setting_Action6			-0.701**
			[0.041]
Control variables	Yes	Yes	Yes
Grade & school fixed effects	Yes	Yes	Yes
N	111	111	111

** indicates significance at the 5 percent critical levels. Control variables include the outcome variable at the baseline survey and the dummies in which month each energy usage was measured in the regression of electricity, gas, and water consumption (if missing, we added a dummy variable indicating that it was missing).

Table 6 Environmental Knowledge, Awareness, Attitudes (2MEV), Responsibility, and Locus of Control after Three Months

	Environmental knowledge	Awareness toward energy conservation	2MEV:		Environmental responsibility:		Environmental locus of control:	
			Preserve	Utility	To self	To other residents	To self	To other residents
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Nudge	-0.105	-0.269***	-0.181**	0.180	0.128	0.047	-0.224	-0.280
	[0.537]	[0.007]	[0.042]	[0.422]	[0.411]	[0.787]	[0.368]	[0.202]
Boost	-0.196	-0.144*	-0.086	-0.052	-0.045	-0.042	-0.465**	-0.181
	[0.428]	[0.061]	[0.241]	[0.551]	[0.719]	[0.718]	[0.015]	[0.166]
Nudge+Boost	-0.564	-0.353**	-0.092	0.119	-0.116	-0.090	-0.159	-0.071
	[0.135]	[0.012]	[0.498]	[0.337]	[0.440]	[0.579]	[0.344]	[0.589]
Nudge×# of Goal-setting	-0.155	0.277**	-0.000	-0.115	-0.575***	-0.119	-0.045	0.315
	[0.508]	[0.027]	[0.997]	[0.517]	[0.001]	[0.342]	[0.866]	[0.119]
Nudge+Boost×# of Goal-setting	0.145	0.376**	-0.083	0.003	-0.110	-0.073	-0.025	0.013
	[0.681]	[0.039]	[0.635]	[0.994]	[0.496]	[0.634]	[0.844]	[0.925]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Grade & school fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	358	358	358	358	358	358	358	358

***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively. Control variables include the outcome variable at the baseline survey.

Table 7 Energy-saving Actions after Three Months

	Electricity			Gas		Water
	1.Unplug a power of electric devices	2.Turn off the main power of televisions	3.Turn off the lights in the room	4.Take a bath right away	5.Setting hot water at lower temperatures	6.Never leave the water running
	(1)	(2)	(3)	(4)	(5)	(6)
Nudge	0.122	-0.061	-0.454	-0.125	-0.144	-0.070
	[0.169]	[0.422]	[0.118]	[0.314]	[0.291]	[0.618]
Boost	0.076	0.070	0.030	0.066	-0.087*	0.150**
	[0.276]	[0.304]	[0.425]	[0.300]	[0.086]	[0.023]
Nudge+Boost	0.064	-0.063	-0.153	-0.016	-0.476***	-0.083
	[0.576]	[0.486]	[0.487]	[0.853]	[0.008]	[0.468]
Nudge×Goal-setting of Y	-0.073	0.150*	0.437	0.283**	0.102	0.186
	[0.547]	[0.099]	[0.237]	[0.016]	[0.483]	[0.192]
Nudge+Boost×Goal-setting of Y	-0.068	0.060	0.107	0.023	0.372*	0.232*
	[0.611]	[0.573]	[0.626]	[0.852]	[0.097]	[0.067]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Grade & school fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	355	358	358	358	352	357

***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively. Control variables include the outcome variable at the baseline survey.

Table 8 Energy Consumption after Three Months

	Log of consumption per capita:		
	Electricity	Gas	Water
	(1)	(2)	(3)
Nudge	-0.143	0.807	-0.155
	[0.366]	[0.434]	[0.494]
Boost	-0.290**	0.573	0.236
	[0.035]	[0.294]	[0.497]
Nudge+Boost	-0.014	0.721	0.859*
	[0.907]	[0.203]	[0.074]
Nudge×Goal-setting_Action1	0.141		
	[0.231]		
Nudge+Boost×Goal-setting_Action1	-0.257		
	[0.183]		
Nudge×Goal-setting_Action5		-0.321	
		[0.385]	
Nudge+Boost×Goal-setting_Action5		-0.429	
		[0.283]	
Nudge×Goal-setting_Action6			0.078
			[0.798]
Nudge+Boost×Goal-setting_Action6			-1.298**
			[0.029]
Control variables	Yes	Yes	Yes
Grade & school fixed effects	Yes	Yes	Yes
N	111	111	111

** indicates significance at the 5 percent critical levels. Control variables include the outcome variable at the baseline survey and the dummies in which month each energy usage was measured in the regression of electricity, gas, and water consumption (if missing, we added a dummy variable indicating that it was missing).

Appendix Table 1 Descriptive Statistics and Balance Check for Sample of One-month Endline Survey

	Control	Nudge	Boost	Nudge +Boost	Difference		
	(1)	(2)	(3)	(4)	(2)-(1)	(3)-(1)	(4)-(1)
Environmental knowledge score	1.243	1.283	1.049	0.929	0.040	-0.194	-0.314*
	[0.408]	[0.376]	[0.318]	[0.285]			
Awareness toward energy conservation (1-4)	2.900	2.933	2.793	2.786	0.033	-0.107**	-0.114
	[0.055]	[0.060]	[0.064]	[0.077]			
2MEV: Preserve (1–5)	3.914	3.863	3.802	3.651	-0.051	-0.112	-0.263**
	[0.076]	[0.069]	[0.081]	[0.091]			
2MEV: Utility (1–5)	1.995	2.027	1.888	2.004	0.032	-0.107	0.009
	[0.095]	[0.148]	[0.082]	[0.103]			
Environmental responsibility to self (1–5)	4.543	4.433	4.195	4.357	-0.110	-0.348***	-0.186
	[0.044]	[0.071]	[0.103]	[0.108]			
Environmental responsibility to other residents (1–5)	4.586	4.583	4.341	4.400	-0.003	-0.245	-0.186
	[0.057]	[0.077]	[0.108]	[0.123]			
Environmental locus of control to self (1–5)	3.471	3.533	3.268	3.214	0.062	-0.203	-0.257**
	[0.111]	[0.171]	[0.097]	[0.149]			
Environmental locus of control to other residents (1–5)	4.171	4.250	4.268	4.257	0.079*	0.097***	0.086
	[0.103]	[0.108]	[0.088]	[0.096]			
Energy-saving actions (1-6)	3.057	3.567	3.427	3.229	0.510*	0.370	0.172
	[0.199]	[0.128]	[0.169]	[0.208]			
N	70	60	82	70			
Amount of electricity consumption per capita (kWh)	97.807	96.644	101.952	100.054	-1.163	4.145***	2.247
	[11.358]	[8.314]	[11.171]	[10.403]			
Amount of gas consumption per capita (m^3)	7.268	5.689	6.689	7.378	-1.579	-0.579	0.110
	[0.442]	[0.737]	[0.963]	[0.614]			
Amount of water consumption per capita (m^3)	27.633	13.172	23.940	9.288	-14.461	-3.693	-18.345
	[7.614]	[2.067]	[7.117]	[0.792]			
N	33	27	32	19			

Means and standard errors (in parentheses) as of the baseline survey are shown in columns (1) through (4), and the differences in the means across the groups are shown in the difference column. Standard errors are clustered at the school level.

In the tests in the difference in the means, school and grade level fixed effects are controlled, and in addition, the dummies in which month each energy usage was measured for tests of electricity, gas, and water consumption (if missing, we added a dummy variable indicating that it was missing) are controlled.

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

Appendix Table 2 Descriptive Statistics and Balance Check for Sample of Three-month Endline Survey

	Control	Nudge	Boost	Nudge +Boost	Difference		
	(1)	(2)	(3)	(4)	(2)-(1)	(3)-(1)	(4)-(1)
Environmental knowledge score	1.544	1.566	1.594	1.813	0.022*	0.050	0.269
	[0.416]	[0.345]	[0.322]	[0.367]			
Awareness toward energy conservation (1-4)	2.789	2.895	2.792	2.769	0.106	0.003	-0.020
	[0.112]	[0.090]	[0.092]	[0.066]			
2MEV: Preserve (1–5)	3.782	3.834	3.782	3.657	0.052	0.000	-0.125
	[0.078]	[0.104]	[0.071]	[0.066]			
2MEV: Utility (1–5)	2.096	2.134	2.123	2.132	0.038	0.027	0.036
	[0.102]	[0.116]	[0.110]	[0.089]			
Environmental responsibility to self (1–5)	4.444	4.368	4.248	4.308	-0.076	-0.196*	-0.136
	[0.096]	[0.105]	[0.084]	[0.081]			
Environmental responsibility to other residents (1–5)	4.467	4.447	4.455	4.374	-0.020	-0.012	-0.093
	[0.102]	[0.120]	[0.067]	[0.090]			
Environmental locus of control to self (1–5)	3.300	3.566	3.485	3.505	0.266	0.185	0.205
	[0.128]	[0.117]	[0.094]	[0.114]			
Environmental locus of control to other residents (1–5)	4.156	4.145	4.406	4.297	-0.011	0.250**	0.141
	[0.102]	[0.095]	[0.077]	[0.074]			
Energy-saving actions (1-6)	3.067	3.592	3.436	2.978	0.525	0.369	-0.089
	[0.184]	[0.187]	[0.166]	[0.143]			
N	90	76	101	91			
Amount of electricity consumption per capita (kWh)	108.005	99.043	99.640	98.882	-8.962	-8.365	-9.123
	[20.676]	[11.704]	[7.596]	[13.860]			
Amount of gas consumption per capita (m^3)	7.657	6.416	9.595	7.401	-1.241	1.938	-0.256
	[0.816]	[0.556]	[2.604]	[0.355]			
Amount of water consumption per capita (m^3)	42.796	10.439	13.199	15.253	-32.357	-29.597	-27.543
	[14.961]	[0.631]	[1.664]	[5.189]			
N	23	31	36	29			

Means and standard errors (in parentheses) as of the baseline survey are shown in columns (1) through (4), and the differences in the means across the groups are shown in the difference column. Standard errors are clustered at the school level.
In the tests in the difference in the means, school and grade level fixed effects are controlled, and in addition, the dummies in which month each energy usage was measured for tests of electricity, gas, and water consumption (if missing, we added a dummy variable indicating that it was missing) are controlled.
***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.