A study to examine ways to increase the prevalence of courses in environmental studies using environmentally conscious technologies

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Abstract. Over the past few years, an increasing number of schools in Japan have been certified as eco-friendly. These schools incorporate environmentally conscious technologies in order to reduce energy use in school structures and to promote environmental education. The current study ascertained the use of environmentally conscious technologies in environmental education in elementary and middle schools, and it proposed an environmental studies program to increase the prevalence of environmental education. A course in environmental studies was conducted during Open House week, students and their parents were surveyed, group interviews were conducted with teachers, and the course was assessed using an environmental efforts worksheet. Survey results revealed that over 90% of parents considered the course in environmental studies necessary. Group interviews revealed that a positive aspect of conducting a course in environmental studies during Open House week was that it effectively increased the prevalence of such courses. Interviews also revealed several problems: the way in which to relay the course guide and course data need to be described in detail, and the course guide needs to be further simplified. The environmental efforts worksheet, schools that implemented the course reduced CO₂ emissions (kg/mo.) by an average of about 1.6 t.
1. Introduction

As part of school construction over the past few years, eco-friendly schools have been built with reduced energy use by buildings and the promotion of environmental education in mind. Moreover, environmentally conscious technologies such as solar power have increasingly been introduced at regular elementary schools as well. Environmentally conscious technologies should increase student awareness of environmental issues by being immediately evident, so those technologies need to be used in environmental education. However, a previous survey revealed a low level of use and awareness of environmentally conscious technologies. The survey also revealed that courses using environmentally conscious technologies are not being conducted often enough even though schools are being certified as eco-friendly.

Given these findings, a previous study created An Environmental Studies Course Guide featuring a detailed course map and simplified explanations of environmentally conscious technologies in order to reduce energy use in school buildings and to use environmentally conscious technologies in environmental education. In accordance with that Guide, a teacher conducted a course in environmental studies on a trial basis.

The current study ascertained the use of environmentally conscious technologies in environmental education in elementary and middle schools. This study also proposed a program using materials to learn about the environment to increase the prevalence of environmental education using environmentally conscious technologies. Moreover, this study examined and proposed ways for parents/guardians and local residents to assist the teacher of a course in environmental studies in order to increase the prevalence of courses in environmental studies, to make those courses self-sustaining, and to expand efforts to reduce energy use to the home.

2. Survey of management of solar power-generating equipment and environmental education at school facilities

2.1 Purposes of the survey and an overview

Solar power-generating equipment is the form of environmentally conscious technology that is used most often. This study surveyed the management and operation of that equipment and trends in its use in environmental education, and this study also ascertained examples of the use of that equipment and problems. In order to examine the future prevalence and use of solar power-generating equipment, a questionnaire was sent to 11 municipalities (including the City of Kodaira) in the Kanto region, which is where a large amount of solar power-generating equipment has been installed. Responses were received by fax or e-mail.

2.2 Installation of solar power-generating equipment

Figure 1 shows responses regarding plans to install solar power-generating equipment in the future. Over half of the communities had installed solar power-generating equipment in every school or planned to install that equipment in some elementary and middle schools. Responses revealed that most municipalities promoted the introduction of solar power-generating equipment.

![Figure 1. Plans to install solar power-generating equipment](image-url)
2.3 Management of solar power-generating equipment

Figure 2 shows responses regarding previous problems with stoppages in power production or reduced output. In terms of previous problems, about 80% of respondents cited stoppages in power production and about 30% cited reduced output; over half of the respondents were unaware of any problems. Respondents were often unaware if reduced output had occurred. This indicates that equipment is not adequately managed; respondents consider the equipment to be working if electricity is merely generated. Thus, the estimated amount of electricity generated needs to be periodically compared.

![Figure 2. Have there been stoppages in power production or has output been reduced?](chart)

2.4 Implementation of environmental education

Figure 3 shows responses regarding the implementation of environmental education. In about 40% of communities, city halls and ward offices monitored environmental education in elementary and middle schools. In the other communities, the school was entrusted with monitoring environmental education. This finding indicates that installation of solar power-generating equipment has been promoted, but environmental education using solar power has not.

![Figure 3. Is environmental education at elementary and middle schools monitored?](chart)

3. Identification and proposal of topics in a previous study to increase the prevalence of courses in environmental studies

Figure 4 shows a framework proposed in a previous study to increase the prevalence of courses in environmental studies. This framework envisions a reduction in energy use by schools via a course in environmental studies using environmentally conscious technologies in school facilities and an expansion of efforts to reduce energy use to the home and community. Previously identified problems were a lack of personnel for hands-on learning and experiments and lack of time for course preparations. Those problems could be addressed by coordination on campus and with neighboring residents and community organizations. Moreover, this approach could foster a local community with a high level of environmental awareness. In order to more effectively expand efforts to the community and home, the current study focused on “the community” and “the home” as shown in Fig. 4. This study conducted a course in environmental studies on a trial basis during Open House week.
4. Development of an environmental studies program

4.1 Course modules

Examples of course modules are shown in Fig. 5. Global warming is covered in a module describing an overview of global warming and its effects and a module explaining the relationship between power production as a form of development and global warming. Energy is covered in a module explaining the conversion of energy into power, a module involving the production of energy with a hand-cranked generator, and a module describing power consumption by electrical appliances at home. Environmentally conscious technologies are covered in a module that begins with solar power, which is the type of power-generating equipment that is most often installed in school facilities. In addition to an overview of how solar power is produced, course modules on monitoring solar panels and hooking up solar panels in accordance with transmitted video were created.
4.2 Sample curriculum
In order to help configure a course, a Sample course curriculum was created to provide an example of a combination of Course modules.

In group interviews, most teachers indicated that topics dealing with environmentally conscious technologies were appropriate for 4th and 5th graders, so a course consisting of 2 classes (90 min.) for 4th and 5th graders was devised. In order to effectively teach students, major steps in the course were proposed, i.e. ① An introduction to the problem (environmental issues), ② How the technology works, ③ Examples of its use, ④ Hands-on learning, and ⑤ Actions to take at home. ① An introduction to the problem (environmental issues) describes the effects of global warming, and it explains how solar power is used to combat global warming. ② How the technology works explains an overview of solar power using photographs and diagrams. ③ Examples of its use describes an overview of a megawatt solar power plant, and it describes the size of a megawatt solar power plant by overlaying its area on a map of an elementary school and is surroundings. In order to pique the students’ interest, ④ Hands-on learning explains how to hook up a solar panel, and it involves an experiment to change the amount of electricity a panel generates by covering it with a black cloth. ⑤ Actions to take at home describes immediate ways in which solar power is used and ways to conserve energy at home. Allotted times are indicated for each item to allow a teacher to envision the course as a whole. Among the course modules, Hands-on learning and Actions to take at home are crucial to improving student understanding and expanding efforts to reduce energy use to the home and community. The implementation and configuration of those modules have been examined here.

4.3 Creation of a worksheet on efforts to reduce home energy use

4.3.1 An overview of the worksheet
In order to expand efforts to reduce energy use to “the home” and to quantitatively assess the effectiveness of a course in environmental studies, a worksheet on efforts to reduce home energy use (denoted here as the environmental efforts worksheet) was created.

4.3.2 Use of the environmental efforts worksheet
Figure 6 shows a sample environmental efforts worksheet. After the course in environmental studies, students were asked to use the environmental efforts worksheet to implement Environmental efforts that can be done at home, i.e. items ①-⑧ listed in Table 2. Each day, students wrote the number of an implemented effort in a balloon and colored it in. Items ①-⑤ were specified by this Laboratory, and items ⑥-⑧ were left blank for students to write in their own environmental efforts. These efforts were assigned as homework after the course in environmental studies. Students filled out the worksheet over a period of 30 days (about 1 month).

![Figure 6. Sample environmental efforts worksheet](image)
5. Conducting a course in environmental studies using environmentally conscious technologies

5.1 Overview of schools where a course in environmental studies was conducted

Table 1 shows an overview of the course in environmental studies at each elementary school where it was conducted. The course was conducted at a total of 3 schools. At D Elementary School in Shinagawa Ward, the course is normally conducted in science class. The course was also conducted at J Elementary School and N Elementary School in the City of Kodaira, which intends to install solar power-generating equipment at all elementary and middle schools and public facilities in the City. The course was conducted at the 2 schools in the City of Kodaira in conjunction with the City of Kodaira’s Environmental Policy Section.

| Name of school | D Elementary School | J Elementary School | N Elementary School |
|----------------|---------------------|---------------------|---------------------|
| Course conducted on | 10/20 (Fri.) | 10/21 (Sat.) | 10/24 (Tues.) |
| Course intended for | 4th graders | 4th graders | 5th graders |
| Class size | 3 classes (107 students) | 2 classes (74 students) | 2 classes (77 students) |
| Class length | 45 min×2 | 45 min×2 | 45 min×2 |
| Solar power capacity | 10 kW | 20 kW | 20 kW |
| Rooftop access | × | × | ○ |
| Participants | 11 | 6 | 5 |

5.2 Course implementation

Teachers conducted a course in environmental studies featuring solar power, which is the form of environmentally conscious technology that is used most often. This Laboratory provided support for curriculum development, it helped prepare equipment on the date of installation, and it assisted with the course. Figure 7 shows a diagram of the layout of a relay system. At D Elementary School and J Elementary School, students are not allowed rooftop access, so this system facilitated an on-site class via video chat. Students at N Elementary School were allowed rooftop access, so they were able to view the solar panels firsthand during the course in environmental studies. Figure 8 shows scenes from the course in environmental studies.

![Figure 7. Layout of the relay system](image1)

![Figure 8. Scenes from the course](image2)
5.3 Group interviews with teachers after the course in environmental studies

Group interviews were conducted with elementary school teachers (7 teachers in total) after the course in environmental studies. Most of the teachers had a favorable view of conducting the course during Open House week, and they felt that conducting the course in environmental studies during Open House week was effective. When the course was conducted at N Elementary School with 5th graders, the students’ sense of independence was respected, i.e. students informed their parents/guardians of the curriculum. However, some parents/guardians felt that “the course need not be conducted during Open House week.” Problems with making the course self-sustaining were identified, e.g. “conducting with course without support from university personnel would be difficult, given their expertise.” When asked about the course guide, teachers from all 3 schools felt that “its content was too complex” and that “its content should be on par with a textbook for children. This findings revealed that the course guide needs to be improved. Asked about the environmental efforts worksheet, most of the teachers felt that “It was good to assign homework that capitalized on what students learned in the course.” Findings revealed that the environmental efforts worksheet was effective after the course in environmental studies. However, some teachers felt that “30 days was too long” and “the worksheet should be assigned as homework during winter break.” Findings revealed that the duration of worksheet use needs to be examined.

5.4 Survey of students and their parents/guardians after the course in environmental studies

Students at each school that conducted the course in environmental studies and their parents/guardians were surveyed regarding their understanding of the course material and the need for the course. Results are shown in Figs. 9 to 12. Figures 9 and 10 are student responses and Figs. 11 and 12 are parent/guardian responses.

When asked if they wanted to know more about solar power, close to 90% of students responded “① I really think so” or “② I think so to an extent,” as shown in Fig. 9. Thus, the course using environmentally conscious technologies was effective. The same results were obtained for schools using the relay system and the school where students were allowed to view the solar panels up close. This revealed that both course formats were effective.

![Figure 9](image)

**Figure 9.** Would you like to know more about solar power? (n=143)

When asked whether the frequency with which they monitored the solar power monitoring system changed after the course in environmental studies, over 50% of students responded “① It increased a lot” or “② It increased,” as shown in Fig. 10. Spurred by the course in environmental studies, students became interested in viewing the amount of electricity generated and graphs in the monitoring system, increasing their eagerness to learn about the environment.

![Figure 10](image)

**Figure 10.** Did the frequency with which you monitored the solar power monitoring system change after the course in environmental studies? (n=143)
When asked if a course in environmental studies is necessary, over 90% of parents/guardians responded “① I really think so” or “② I think so to an extent,” as shown in Fig. 11. Findings revealed that the course in environmental studies was effective for students as well as parents/guardians.

![Figure 11. Is a course in environmental studies necessary? (n=143)](image)

When asked if they would assist with the course in the future, over 60% of parents/guardians responded “① I really think so” or “② I think so to an extent,” as shown in Fig. 12. This revealed that the cooperation of parents/guardians could be obtained.

![Figure 12. Would you assist with a course in environmental studies in the future? (n=143)](image)

5.5 Expanding the course in environmental studies via the environmental efforts worksheet

5.5.1 Method of assessment

The environmental efforts worksheet was distributed to students after the course in environmental studies, and they implemented efforts to reduce energy use. Table 2 shows the reduction in annual CO₂ emissions for each item. Using the reduction in annual CO₂ emissions for each item and the number of days that a student implemented an environmental effort, the reduction in CO₂ emissions over 30 days was provisionally calculated to quantitatively assess the effectiveness of the course in environmental studies.

| Item no. | Reduced annual CO₂ emissions [kg/yr] |
|----------|--------------------------------------|
| ① Lowering the temperature of an air conditioner and making sure rooms are not too warm | 171 kg/yr |
| ② Decreasing TV viewing | 20 kg/yr |
| ③ Being sure to turn room and hallway lights off when not in use | 23 kg/yr |
| ④ Not leaving water running when washing dishes | 84 kg/yr |
| ⑤ Using a reusable bag when shopping instead of receiving a disposable bag during checkout | 14.4 kg/yr |
| ⑥-⑧ Other | Amt in line with the item in question |
5.5.2 Assessment results

Figure 13 shows the total number of days an item was implemented, and Fig. 14 shows the reduction in CO$_2$ emissions [kg/mo.] for each item. There was little bias in the total number of days an item was implemented, so the specified items were all easy to implement. Other items that were often implemented were “using hot water from the bathtub to wash clothes” and “unplugging appliances like the TV when not in use.” Item ① accounted for about 50% of the reduction in CO$_2$ emissions. This was because it resulted in a greater reduction in annual CO$_2$ emissions than other items.

Figure 15 is a graph comparing reduced CO$_2$ emissions [kg/mo.] as a result of the course in environmental studies and reduced CO$_2$ emissions [kg/yr] as a result of the use of solar power. Ten kW of solar power can reduce CO$_2$ emissions about by about 5 t annually, and 20 kW can reduce those emissions by about 10 t annually. Implementing the environmental efforts worksheet for 1 month reduced CO$_2$ emissions by about 1.6 t (average for the 3 schools). Students who participated in the course in environmental studies reduced their CO$_2$ emissions at home for 1 month, and that reduction was equivalent to about a 30% reduction in CO$_2$ emissions as a result of using 10 kW of solar power and about a 20% reduction as a result of using 20 kW of solar power.

Figure 13. Total number of days an item was implemented

Figure 14. Total reduction in CO$_2$ emissions [kg/mo.] for each item

Figure 15. Total reduction in CO$_2$ emissions [kg/mo.] for each item
6. Conclusion

This study examined the installation and management of solar power-generating equipment and the implementation of environmental education in 11 communities in the Kanto region. This study also proposed a program to increase the prevalence of courses in environmental studies, it conducted a course in environmental studies during Open House week, it surveyed students and their parents/guardians, it conducted group interviews with teachers, and it assessed the course via an environmental efforts worksheet. The following findings were obtained:

1) A survey regarding solar power-generating equipment indicated that solar power-generating equipment is being installed in elementary and middle schools, but city halls and ward offices are not adequately managing solar power or promoting environmental education.

2) An environmental studies program resulted in the same increased interest in solar power among students who viewed solar panels firsthand and students who viewed them via a relay system. Both course formats were effective.

3) Assessment of the course in environmental studies using the environmental efforts worksheet indicated that the course reduced CO\textsubscript{2} emissions (kg/mo.) by about 1.6 t (average for 3 schools). Implementation of environmental efforts reduced CO\textsubscript{2} emissions. In addition, the environmental efforts worksheet was effective at expanding efforts to reduce energy use to the home.

4) Survey responses from students and their parents/guardians revealed that over 90% of parents/guardians felt that a course in environmental studies was necessary. Moreover, over 60% of parents/guardians responded that they would assist with such a course in the future, so cooperation could likely be obtained from parents/guardians.

Links between school and community coordinators could facilitate the spread of courses in environmental studies to other schools in the future.

References

[1] Miyazaki G 2017 Research on Development of a Guide for Environmental Study Classes Using Environment-conscious Technologies of School Facilities (WSB Hong Kong)