Practice of Environmental Education in Early Childhood Using SMART CLOCK

Application of Eco-visualization

Preface

The content of this booklet is based on findings with the financial support of JSPS Bilateral Programs, Joint Research (2019–2022) “Cross-Cultural Study on Development and Evaluation of Environmental Education Tools in Preschools to Promote Pro-Environmental Behaviors in Japan and Sweden.”

The purpose of this project is to verify the effectiveness of educational programs that promote pro-environmental behaviors that are implemented in Japan and Sweden, by using Japanese and Swedish infants as subjects and conducting a cross-cultural comparison, as well as to develop environmental education materials that promote pro-environmental behaviors.

As one part of the latter, this booklet focuses on eco-visualization (EV) and introduces the practice of environmental education from early childhood to encourage pro-environmental behaviors mediated by the IoT. Specifically, this booklet introduces the topic of environmental education practice based on interview research results on young children's facilities that have introduced the SMART CLOCK, a wall clock developed by NIHON TECHNO CO., LTD that visualizes electricity use and other conditions with light and sound. The interview asked how these facilities incorporated the clock into environmental education activity and about the kinds of usage methods.

On the basis of the above, this booklet includes “Environmental Education in Early Childhood” (Chapter 1), “Eco-visualization” (Chapter 2), “SMART CLOCK” (Chapter 3), “Case Studies of Environmental Education Using SMART CLOCK in Preschools” (Chapter 4), and “Clues as to How to Practice Environmental Education Using SMART CLOCK in Preschools” (Chapter 5). This booklet was produced with the cooperation of NIHON TECHNO CO., LTD and Ms. Mayuko Suizu, a fourth-year undergraduate student at the Department of Environmental Science, International College of Arts and Sciences, Fukuoka Women's University. I would also like to thank my Swedish collaborator, Dr. Pimkamol Mattson of Lund University, for many useful suggestions in the production of this booklet. I would like to take this opportunity to express my sincere gratitude to all of the early-childhood facilities that agreed to be interviewed during the research.

In this booklet, I have introduced the practice of early-childhood environmental education using a SMART CLOCK, one of the EVs, but various EVs are being developed one after another. Furthermore, we can also customize EVs with our own hands by using existing products (e.g., Sony's MESH). I would be grateful if you could give us your frank opinions on the content of this booklet, including pointing my errors and suggestions for improvement.

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Photos of SMART CLOCK/SMARTMETER ERIA/Case Studies by NIHON TECHNO CO., LTD
Photo of Power-Aware Cord by Magnus Gyllenswärd
Photo of Salmisaari Power Plant by HeHe (Helen Evans & Heiko Hansen) 2008

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Chapter 1

Environmental Education in Early Childhood

Environmental Education from Early Childhood

Early childhood is an extremely important time when the foundation of human development is cultivated. Through various experiences, young children develop a variety of foundations while growing intellectually, emotionally, and in terms of human relationships. Environmental education in early childhood is considered to play an important role in fostering awareness and attitudes toward the environment and is attracting attention as an initiative with the potential to encourage pro-environmental behaviors over the long term.

Three Types of Environmental Education Programs

Environmental education programs have three aspects: ① “Education in the Environment (‘in’ type)”, ② “Education about the Environment (‘about’ type)”, and ③ “Education for the Environment (‘for’ type)”. The “about” type is the most common approach in environmental education. With regard to early childhood environmental education, the “in” type aims to cultivate a sensitivity to nature, and is the most popular approach. By contrast, very few practices and studies have examined the ‘for’ type in early childhood that are more compatible with sustainability.

In type: Learning that emphasizes the development of sensitivity to the environment through direct experience
About type: Learning that promotes the acquisition of knowledge and problem-solving skills related to the environment.
For type: Learning that reconstructs one's own values and encourages problem solving, action, and participation.

Comparison of Environmental Education in Early Childhood between Europe and Japan

Environmental education for young children in Europe is characterized by inducing children's self-development through their contact with nature in the open air and their perception of the richness of the natural environment, such as the Skogsmulle (Forest Mulle) program (Sweden) and the Forest Kindergarten (Germany), which aim for coexistence with nature.

In Japan, however, the focus is on learning about nature experiences and resource conservation. Experiencing nature is an important factor for children's development, and saving resources is in line with the Japanese concept of “mottainai” [having respect for the resources to not waste them]. The latter concept emphasizes not wasting visible resources, such as through “waste reduction” and “food education”, but energy conservation, such as electricity, which is difficult to notice without visualization, is not actively incorporated into environmental education in early childhood due to safety and health concerns (such as heat stroke and fear of the dark).

Eco-visualization is one of the external supports to foster environmental education.

Need for External Support to Foster Environmental Education in Early Childhood

The presence or absence of environmental education activities in early-childhood facilities and their content are influenced by the natural and social environment surrounding the schoolyard and facilities (e.g., forest, river, ocean, learning facilities, etc.) and the educational policy of each school. In addition, since early-childhood teachers are busy with various tasks, external support is important in considering the promotion of early childhood environmental education. For example, Eco-Schools Green Flag is a global support program to encourage environmental learning. In addition, various external approaches are needed to promote early childhood environmental education, such as visiting lectures by external instructors, provision of educational tools, and environmental maintenance.

Box 1 Content of Environmental Education in Preschools of Fukuoka

Fukuoka Prefecture has the Eco Delivery Lecture, an initiative to support environmental education in early childhood. The external lectures from Fukuoka Center for Climate Change Actions visit an early-childhood facility and holds lectures on eco-friendly activities such as global warming countermeasures. According to the results of the survey of 77 preschools in Fukuoka Prefecture that took the Eco Delivery Lecture, 45 (58.4%) early-childhood facilities practiced environmental education activities other than the lectures. There were many reports on activities around the themes of the 3Rs of garbage, the environment in general, and dietary education.

Photo Eco Delivery Lecture (Fukuoka, Japan)

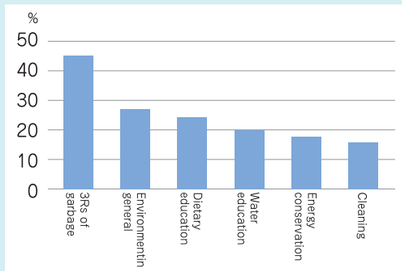


Figure Content of Early Childhood Environmental Education in Fukuoka (n=45)

The “environment in general” refers to nature experiences, lectures, courses, and community activities conducted with instructors who are knowledgeable about environmental issues.

Box 2 Eco-Schools Green Flag

Eco-Schools is an international environmental education program that supports environmental learning in schools, including early-childhood facilities. Schools certified as Eco-Schools are awarded the Green Flag, an international certification, and can display the flag or certificate in their schools. As of February 2022, the program is being implemented by more than 59,000 schools in more than 72 countries and regions around the world. Schools must meet seven criteria: ① establishing an eco-committee, ② identifying issues, ③ action plan, ④ linking to the curriculum, ⑤ diverse participation, ⑥ review, and ⑦ Eco code.
The Swedish Eco-Schools Office provides online educational resources and assistance with program management.

Photo Display of Green Flag Certificates in the facility (Sweden)

Photo Eco code by Aikawa Preschool (Japan)

Chapter 2

Eco-visualization

What is Eco-visualization?

Eco-visualization (EV) is a method of eco-feedback based on Human–Computer Interaction (HCI), which conducts interactive communication between humans and computers. The objective of EV is to promote pro-environmental behaviors of the users by visualizing the consumption of environmental resources. The use of EVs is expected not only to visualize the consequences of environmental behavior, but also to encourage users to engage in the initiative with playfulness, to become aware of their own behavior, to raise environmental awareness, and to provide social incentives (e.g., competition and goal setting) among users.

Targets of Eco-visualization

In recent years, a variety of EVs have been developed due to advances in information technology, and the target audience for promoting pro-environmental behaviors using EVs spans different scales, including ① single or a small specified users (Photo A), ② multiple specific users such as schools and offices (Photo B), and ③ an unspecified number of users (Photo C). In particular, EVs falling under ② are expected to not only promote users' pro-environmental behaviors but also create environmental communication among users and provide opportunities for "for"-type environmental education practices. The SMART CLOCK introduced in this booklet falls under ②.

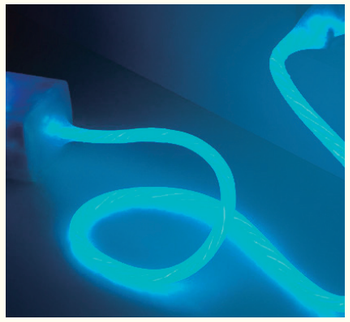


Photo A Cable

(Example of ①: Power-Aware Cord designed by Magnus Gyllensward and Anton Gustafsson)
Visualizing the current use of electricity of the appliances connected with in through glowing pulses, flow, and intensity of light

Photo B Clock

(Example of ②: SMART CLOCK designed by NIHON TECHNO CO., LTD)
Warnings with color change and sound are given when the set power usage target value is exceeded

Photo C Steam cloud

(example in ③: Salmisaari Power Plant designed by HeHe)
Visualizing changes in power plant output by the size of the projected green light

Chapter 3

SMART CLOCK

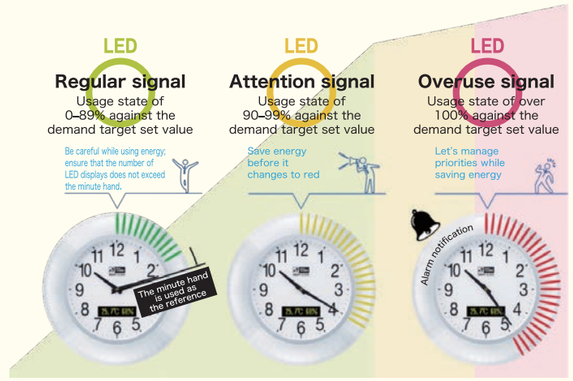
Profile of SMART CLOCK

A SMART CLOCK is an eco-visualization (EV) in the form of a wall clock that visualizes the status of electricity use and the like, developed by NIHON TECHNO CO., LTD. SMART CLOCK was sold in 2011 as an option for SMARTMETER ERIA, another EV that visualizes the status of electricity use and the like. Everyone has the opportunity to see a clock in their daily life. Through users checking the clock, this SMART CLOCK is expected to induce energy-saving behaviors. The introduction of the SMART CLOCK is limited to facilities equipped with high-voltage power-receiving and transforming equipment (cubicles). SMART CLOCK can be used in combination with "SMARTMETER ERIA" by concluding a contract for electric safety management with NIHON TECHNO CO., LTD.

Figure SMARTMETER ERIA

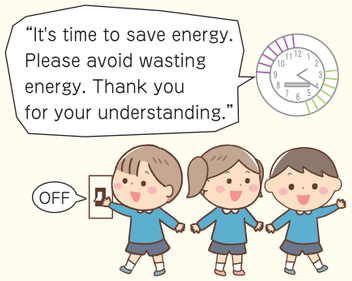
LED Display and Sound

LED is applied around the SMART CLOCK clock version, and the color changes according to the current electricity use situation against the demand target set value. Color changes according to the same principle as a traffic light. With a usage state of 0–89% against the demand target set value, the color green (regular color) will be displayed. The number of LED displays does not exceed the minute hand. For 90–99%, LED increases to the same place as the minute hand, changing to yellow (attention signal), and the number of LED displays exceeds the minute hand when it becomes 100% or more, changing to red (overuse). When it turns red, an audio clip is played: "Demand is about to exceed the target set value." Using the same principle as this traffic light makes it easy to understand the status of electricity use without anyone needing to read, write, or have detailed knowledge of electricity conservation. In addition, it is also possible to switch the display of predicted demand (purple for up to 99%, red for over 100%), instantaneous demand (increase or decrease of the number of LEDs), and to display current power use and predicted demand at the same time.



Other Functions

On SMART CLOCK with OLED panel, voice messages, date, temperature, humidity, current demand value, predicted demand value, instantaneous demand value, peak demand value for the day and the month, electricity consumption for the day and the month, electricity charge (estimate) for the month, electricity spot unit price for the current time, and CO_2 conversion amount for the day and the month are displayed. Timer A message can also be delivered by voice and OLED panel at the time set by the timer.



Chapter 4

Case Studies of Environmental Education Using SMART CLOCK in Preschools

This booklet is based on a literature survey conducted in cooperation with NIHON TECHNO CO., LTD, using the quarterly magazine “Kankyo Shijo Shinbun” (Environmental Market News) published by the company four times a year, and the installation case-study website (https://www.n-techno.org/) is introduced on the company's website. Among the early-childhood facilities discussed in the article, we will introduce three schools that are working on environmental education practices using SMART CLOCKs based on the results of the interview survey.

Case 1

Konomi Kindergarten

Address: 1690-1, Nishihabumachi, Matsuyama-city, Ehime, 791-8044
Capacity: 340 children (3 to 5 years)

Purpose of introducing SMART CLOCK

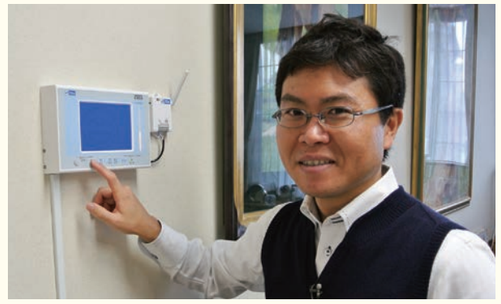
We were looking for environmental education materials that could be understood even by young children who cannot read or write well, as the facility is an early-childhood facility under the jurisdiction of the Ministry of Education, Culture, Sports, Science and Technology (MEXT). We introduced SMART CLOCK in 2012 because it was superior to other electricity meters, not only in terms of saving electricity but also in terms of education.

Operation method of SMART CLOCK arrangement and demand target set value

The SMART CLOCK is placed in front of the staff room at the main entrance, where children can easily see it not only on their way to and from school but also in their daily life in the school. Children of all grades pass this place during the pool time held once a week. In the past, we adjusted the demand target-settings so that they were not too strict, and the LED colors changed frequently as we approached the 9:00 to 12:00 timeslot. It is difficult to adjust the demand target-setting value during the season of high demand for heating and cooling. The COVID-19 pandemic required thorough ventilation of the room, and after the implementation of the MEXT's heat stroke guidelines set for 2021, we used a less strict demand target-setting value than before, so the color changes occurred less frequently.

Children's response to SMART CLOCK and energy-saving behavior

Since the introduction of SMART CLOCK, the children have become more aware of changes in the clocks and have become more proactive in talking to each other about this and taking energy-saving actions. However, since the demand target-setting value was loosened during the COVID-19 pandemic, the number of color changes decreased, and there were fewer opportunities for the preschoolers to communicate.



President, Kenichiro Nakaya

Environmental education practice using SMART CLOCK

We are conducting environmental education activities that focus on the color change of SMART CLOCK. We have prepared lines for when the color turns yellow or red. When the children actually notice the color change, they call for cooperation in energy-saving behavior through the in-house broadcast. I think that the children's awareness has changed in a positive direction through the environmental education activities. At home, we have received many comments that the children have started to take energy-saving actions, such as telling their parents when they leave the lights on or telling them when their parents forget to turn them off.

Lines for when the color turns yellow

Can I start a story?
The lamp at the front door has turned yellow.
If there is electricity that is not being used.
please turn it off.
Thank you for cooperation.

Lines for when the color turns red

Can I start a story?
The lamp at the front door has turned red.
Please turn on the power for a short while.
When the lamp turns green and things become OK.
I’ ll start the broadcast again.

Case 2

Certified Children's Garden Minori

Address: 1-9-15, Kamigasa, Kusatsu-city, Shiga, 525-0028
Capacity: 285 children (0 to 5 years)

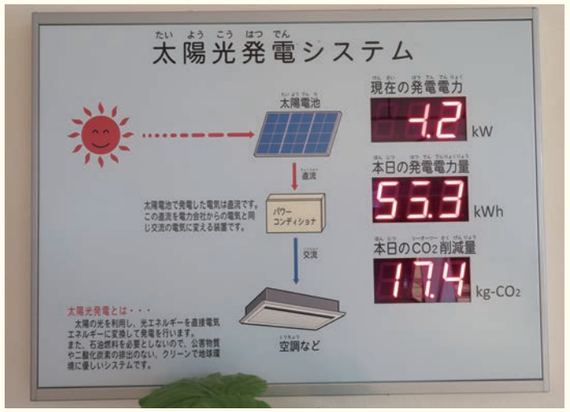
Purpose of introducing SMART CLOCK

When we switched to a high-voltage power-receiving contract at the time of the renovation, we found that the basic electricity usage charge increased. In order to reduce the maximum power demand, we introduced SMART CLOCK in 2014. Although installation of SMART CLOCK as an option for SMARTMETER ERIA incurred additional cost, the device enabled us to visualize the use of electricity. The deciding factor was that even the children at the school, mainly five-year-olds, could understand how much electricity was being used.

Director, Hisa Kishimoto-Radke

Operation method of SMART CLOCK arrangement and demand target set value

SMART CLOCK has one unit installed in the entrance area that can be seen when coming down the stairs from the senior class. The children can also easily see the solar panel electronic bulletin board near the SMART CLOCK. Before COVID-19, the demand target installation value was set strictly. Ventilation was demanded during COVID-19, and with outside air entering, it became difficult to adjust the body temperature of a preschooler, and the electricity consumption of an air conditioner increased, making it impossible to achieve the target as before. However, if the demand target-setting value is loosened, there is a concern that children will become careless, and energy-saving behavior cannot be practiced as in the past, so we use it with a strict setting value as before, though the situation has changed.



Children's response to SMART CLOCK and energy-saving behavior

The older children who came down from their classrooms on the second floor responded very well to the color change, and the children are more sensitive to SMART CLOCK's eco-feedback than the teachers and staff. When they realized that the color had changed, they checked while pointing at things. They had started to turn off the lights in the bathroom and classroom by themselves and call out to their friends and teachers. Use of SMART CLOCK enabled to consider the significance of putting our best effort into what we can do. As a consequence of initiating actions that could be implemented instantaneously—such as taking care to turn off lights in rooms—the amount of contracted electricity usage and total electricity usage were decreased in our school.

Environmental education practice using SMART CLOCK

When we introduced SMART CLOCK, we talked to the children about what SMART CLOCK is and the importance of electricity. Since then, we have been talking about the importance of electricity once a year in each class, but there is a difference in the understanding of the children. In particular, it is difficult for the youngest children and children in the middle grades to understand energy-saving and SMART CLOCK principles. However, the older children are taking action, understanding that SMART CLOCK refers to the excessive use of electricity. The teachers and staff do not educate the children to consciously look at the SMART CLOCK. This is because an educational approach such as this is adult-centered, where the children are viewed as passive learners who do not play an active role in their own learning. It undermines the imagination of the children looking at the SMART CLOCK and deciding what to do next. Hence, the teachers and staff bear in mind that the children use the SMART CLOCK as part of their lifestyle. With these efforts, the children are encouraged to promote voluntary energy-saving behavior through the color changes, which is not mandatory.

Case 3

Imamura Children's Garden

Address: 3-16, Takatsukimachi, Takatsuki-city, Osaka, 569-0803
Capacity: 195 children (0 to 5 years)

Purpose of introducing SMART CLOCK

Saving electricity was the deciding factor in the introduction of the SMART CLOCK, but the catalyst for introducing the SMART CLOCK was an exchange with a partner school in Fukushima Prefecture, which was affected by the nuclear power plant accident that occurred in 2011. After hearing about the experience of the nuclear power plant accident, we introduced SMART CLOCK in 2017 based on the strong desire of the director to avoid as much as possible using unnecessary electricity without relying on nuclear power plants.

Director, Miho Okada

Operation method of SMART CLOCK arrangement and demand target value setting

We installed SMART CLOCKs in two locations: between the classrooms where the children gather and the picture book corner, and next to the staff room on the third floor where the children often use the corridor for lunch. The demand targets are strictly set so that we cannot achieve them by taking it easy. In particular, the demand peaks around 2:00 p.m. to 3:00 p.m. during naptime in the summer, when the use of air conditioning often turns the color to red, and the color changes can be seen, and the sound warnings heard, frequently.

Children's response to SMART CLOCK and energy-saving behavior

Before the SMART CLOCK was installed, the children, teachers and staff had been less conscious of electricity usage. The SMART CLOCK provided us with more opportunities to think about energy conservation and environmental issues. Children frequently go back and forth between the yard and the room, and the children are more sensitive to color changes (yellow, red, etc.) in SMART CLOCK than are the teachers and staff. Regardless of the grade, the children who notice the color change will shout, “The color changed! Oh my God!” They also turn off the lights in rooms that are not in use and promote natural light. The whole school is taking the energy-saving actions of turning the display back to green after seeing the SMART CLOCK.

Environmental education practice using SMART CLOCK

SMART CLOCK was introduced for the purpose of saving electricity. Therefore, SMART CLOCK is not directly used for environmental education. However, the children recognize that the LED turning red indicates excessive use of electricity (despite differences in their understanding), and they take action to avoid excessive use of electricity and to conserve electricity. The younger children react to the red color by imitating their older students, but as they get older, they become more aware that it is caused by excessive use of electricity. In daily activities during the three-year period, they learn about the excessive usage of electricity and importance of electricity through children and teachers calling each other, or children calling each other. Since we do not explain the actual nature of SMART CLOCK, we would like to have an opportunity to explain and talk about energy conservation once a year.

Chapter 5

Clues as to How to Practice Environmental Education Using Smart Clocks in Preschools

Energy-saving effect of SMART CLOCK

SMART CLOCK is an eco-visualization tool developed with the intention of inducing energy-saving behaviors in a large number of specific users through clock checking. From the literature review, the study found that the amount of contracted electricity usage significantly decreased by 21 kW in early-childhood facilities (n=6) where SMART CLOCK was introduced, by comparing each year before and after the introduction. By reducing the maximum power demand, the basic charge can be reduced, and, thus, the introduction of SMART CLOCK in early-childhood facilities can be said to be practical.

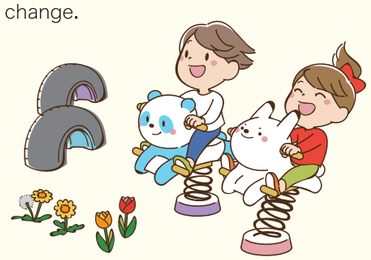
How to use the SMART CLOCK

As a result of the survey, we can classify the early-childhood facilities that introduced SMART CLOCK into three categories: those that introduced it for educational purposes (proactive type), those that introduced it for the purpose of saving electricity but did not use it for environmental education (non-use type), and those that introduced it for the purpose of saving electricity, which led to environmental education (result type).

The characteristic of the “proactive type” is that SMART CLOCK was introduced for educational purposes from the beginning, and children who noticed the yellow and red LED signals broadcast the information in the building (see Chapter 4, Case Study 1). It is reported that the children became aware of energy saving and started to watch the clock because of the fun they had with the in-school broadcasting, and, furthermore, they practiced energy-saving behavior at home, which promoted intergenerational learning.

The characteristics of the “non-use type” include the fact that SMART CLOCK is not introduced for educational purposes and that the staff in charge of facility management centrally manage the facility, resulting in a lack of opportunities for children to participate in energy conservation activities, and a decrease in children's interest because the demand target-setting is too loose, and the frequency of color changes is low.

Unlike the non-use type, the “result type” is characterized by securing opportunities for children to participate in energy-saving behavior, placing SMART CLOCKs in places where children can easily see them and where there is a lot of traffic, and adjusting the demand target-setting value so that the color changes at a moderate frequency. Even without having a class on SMART CLOCK and the importance of saving electricity, students can learn about the overuse of electricity and the effectiveness of energy-saving behavior in their daily lives by watching the color of the SMART CLOCK change.



Key points of environmental education practice using SMART CLOCK

Location	A place where children can easily see and where there is a lot of traffic.
Devising demand target-setting values	It shall be set at a level that is not too severe. Have it to allow preschoolers to see yellow or red signals at specific times of the day, considering the season and preschool events.
Ensuring opportunities for participation	Ensure that preschoolers have opportunities to take energy-saving actions and include “fun” elements (such as in-school broadcasts and efforts to make preschoolers realize the connection between the results of their actions and color changes (from red or yellow to green)).
Safety and health care	Teachers and staff should monitor the energy-saving behavior of preschoolers. Consideration should be given to preschoolers who are uncomfortable in dark places or who have difficulty regulating their body temperature.