The Effectiveness of Teaching Aids for Elementary Students' Renewable Energy Learning and an Analysis of Their Energy Attitude Formation

Ying-Chyi Chou & Hsin-Yi Yen & Hong-Wei Yen
Tunghai University

Yu-Long Chao & Ying-Hsiu Huang
National Kaohsiung Normal University

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As an examination of the influences of a renewable energy teaching activity employing teaching aids on elementary students' knowledge of, attitude toward, and behavior of energy saving and carbon reduction, this study designed a teaching experiment in which experimental group was subjected to the teaching with four teaching aids for students to practice whereas the control group was not. Results revealed that the teaching activity significantly improved the attitude and increased some knowledge items but did not affect the behavior. The behavior was more connected to attitude and knowledge for experimental group than for control group. The formation of the positive attitude could be related to the sensory stimulation generated by the teaching aids and associated affective responses when it was analyzed from a product-trial perspective. The analysis should inspire the understanding of the possible mechanisms of how learning experiences affect attitude.

Keywords: Energy education, teaching aids, experiential learning, product-trial, attitude formation.

INTRODUCTION

In a geographical region frequently impacted by climate events such as torrential rainfall, severe typhoons, and subsequent natural disasters of landslides and debris flows, the public in Taiwan is aware of the importance of saving energy and reducing carbon emissions, especially in the aftermath of typhoon Morak in 2009. Messages of energy saving and carbon reduction are widespread in media coverage and being stressed throughout the country's educational system. In shifting the energy use from fossil fuels to renewable sources, it is necessary for teachers to use effective pedagogies and materials in energy education that make the next generation knowledgeable, dedicated, skilled and active in renewable energy and its associated actions. Teaching aids consisting of tangible objects are helpful for students to learn abstract concepts in science as they enable students to visualize the concepts (Choi & Chang, 2004). To clarify, they are operationalized in this study as supplementary apparatus that can be used for both teacher demonstration and student practice about a topic for which the apparatus are specifically applicable, excluding materials or instruments that are used in teaching different topics. We thought the function of teaching aids in converting abstract concepts into visible phenomena is particularly true for elementary students aged between eight and ten to learn the topic of renewable energy. A learning activity based on the hands-on experiences with teaching aids should be influential for them to learn it. In light of this background, this study aims to examine the effects of the teaching aids used in elementary students' learning of renewable energy on their knowledge about, attitude toward, and behavior of energy saving and carbon reduction.

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LITERATURE REVIEW

As Orr (1992) stated that "real learning is participatory and experiential, not just didactic" (p. 91), it is commonly suggested that elementary school teachers offer pupils with opportunities to experiential learning that helps them develop new and in-depth understanding in environmental topics or science (e.g., Corney, 2000; Osborne & Freyberg, 1985; Tytler, 2002). The experiential learning model proposed by Kolb (1984) serves as an appropriate framework for comprehending the learning process of students from a viewpoint of experiences. "Learning is the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping experience and transforming it" (Kolb, 1984, p.41). The model regards learning as a cycle of four stages:

- Concrete experience: the involvement in an activity in which initial reactions and affective responses are aroused. It emphasizes how one feels about his or her direct exposure to the subject matter. For example, the students are surprised at the lighting of a bulb powered by flowing water.
- Reflective observation: the search for the meanings of things through observing it from different viewpoints. It focuses on how one sees the subject matter. For example, the students see teacher's demonstration of setting up a hydraulic power generator to know what it means.
- Abstract conceptualization: the construction of the logics, reasoning of the principles, and evaluation of perspectives. It refers to how one thinks over the subject matter. For example, the students might figure out the "work" that flowing water did to generate energy.
- Active experimentation: the undertaking of actions to solve the problems, test the concepts learned, or participate activities. It stresses how the learner practices what he or she learned about the subject matter. For example, the students set up on their own a hydraulic power generator and make it work.

Experienced-based teaching activities are shown to be effective in improving children's learning in a number of studies. Ballantyne and Packer (2009) investigated primary and secondary students' learning experiences in the natural environment in Queensland environmental education centers. Compared with teacher-directed strategies, experienced-based learning resulted in more engaging, effective, and sustained learning experiences. The students attributed more of what helped them learn to hands-on ('what I did') and visual ('what I saw') experiences than to teacher's instruction and there were more hands-on experiences remembered three months after the program. A similar study by Jarvis and Pell (2005) analyzed elementary students' attitudes about sciences before, during and after a visit to a space center, a science center where hands-on activities are emphasized (Falk, Koran, & Dierking, 1986; Ramey-Gassert, Walberg, & Walberg, 1994) and experiences which are necessary for the growth in children's cognition (Perry, 1993; Roschelle, 1995) are provided. Results showed a positive effect on the pupils' attitude toward science in a social context after the visit, consistent with the result of Finson and Enochs' (1987) study. With respect to the effects on environmental attitude, Carrier, Tugurian, and Thomson (2013) obtained a parallel result that the elementary students who learned with outdoor experiences held more positive environmental attitude than those who learned indoors. Narrowing the range of the objects which an individual experiences down to teaching aids, we found a few studies that tested the functions of teaching aids in teaching topics about science or sustainable development. Ibeh et al. (2013) indicated that the teaching aids employed in the teaching of physics for sustainable technology improved the attitude toward and performance in physics for secondary students. The improvement in elementary students' understanding of sustainable development was also observed in Crapper et al. (2008) study that used two models of a river valley and a hydropower gadget. By demonstrating how alternative locations of the hydropower plant, which generates electricity from renewable energy, affect nearby environment and downstream land use, teachers helped students learn there could be a solution that meets the needs for economy of a society while reduces the impacts of developing energy on the environment.

As far as the theme of renewable energy is concerned, results of empirical studies that probed into the influences of teaching aids varied. Lee et al. (2012) devised a hands-on learning activity with models of energy saving houses for elementary students but the effects of the learning activity on knowledge, attitude, and behavior all failed to be statistically significant. Likewise, in Liu, Chen, Chiu, and Lai's (2012) study in which elementary students worked on green building models, their cognition, attitudes, and behaviors did not change after this teaching activity, however pupils who participated in this activity had higher knowledge scores than those who did not on the post-test. Lin's (2012) teaching experiment in an elementary school indicated the success of green energy teaching aids in increasing knowledge of energy saving and carbon reduction. Ou et al. (2007) used five demonstration apparatuse in their energy education courses and found that the children were statistically more knowledgeable after the courses. In Japan, Takaki et al. (2007) devised an energy and environmental program for elementary schools and analyzed the effects of teaching aids employed in the program. They concluded that despite students knew the issues well, they were not motivated by the program to take actions.

We consider that experiential learning using teaching aids occurs through a process similar, in some way, to product-trial that puts much emphasis on experiences as well. Both teaching aids and products are tangible objects which stimulate sensory responses and are employed to affect people's attitude and to make them accept or obtain something. Experiential learning with teaching aids and experiential marketing (Schmitt, 1999) with product-trial have a common ground of psychological principles regarding experiences and attitude formation. Fazio and Zanna (1981) indicated that strong attitudes are tightly linked with direct experience. In trying a product, consumers directly experience it with their five senses of touching, smelling, listening, tasting, and seeing (Kim & Morris, 2007). Marketing research demonstrated that experiential events can cause long term attitudinal changes (Sneath, Finney, & Close, 2005) and analyzed the roles that affective responses play in transforming the product-trial experiences to the attitude toward the product (e.g., Bodur, Brinberg, & Coupey, 2000; Morris et al., 2002; Kim & Morris, 2007). Ashley, Oliver, and Zemanek (2011) focused on the trial-attitude formation in green product, suggesting that hands-on trials increased adoption. Considering the teaching aids of renewable energy as green products in a broad sense, it might be justified to provide additional explanations from a product-trial perspective for the results concerning how the experiential learning with these teaching aids affected students' attitude toward energy saving and carbon reduction.

METHOD

An elementary school affiliated to a university in central Taiwan participated in this study. The students of two fourth-graded classes served as experimental group (55 pupils) and control group (35 pupils) respectively and received courses on renewable energy in which teachers introduced electricity generated by different types of renewable energy. These two classes of 10-years-old students were similar in their gender proportions and third-graded natural science performances. This was a result of class placement, where students were randomly enrolled in different classes, in their transition from the third to fourth grade. The difference between experimental and control groups was the employment of teaching aids including four demonstration apparatuses of water-, wind-, solar-, and

Figure 1. Renewable energy teaching aids (apparatuses of water-, wind-, solar-, and manually powered generators)

manually powered generators in the experimental group (Figure 1). These teaching aids were absent in the teaching for the control group. Total time of the teaching activities in each group was six hours, composed of six periods of natural science course in three consecutive weeks. They proceeded through three stages: firstly an introduction of renewable energy, secondly, teacher demonstration and student practice with renewable energy apparatuses, which were replaced with pictures and videos in control group, and thirdly, student discussion and presentation of renewable energy generation ideas. At each of these stages, students of both groups were taught by the same teachers. During this series of teaching activities, students' contact with the teaching aids took three hours in total, including assembling and operating the apparatuses.

In consideration of possible enduring effects of the teaching activities, the survey on students of both groups was conducted three months after the course, when these students became fifth-graders. They were surveyed with a questionnaire designed to collect data on their knowledge of, attitude toward, and behavior of energy saving and carbon reduction. In order to fit the context of this study in Taiwan, we devised the questionnaire for the purpose of this study. An experienced elementary teacher and two professors in this field were consulted to collectively evaluate the content validity of the scales in the questionnaire. It consists of 20 items of knowledge scale, 19 items of attitude scale, and 20 items of behavior scale of which the consistency reliabilities of Cronbach's α obtained from a pilot test are 0.84, 0.82, and 0.94 respectively. All items use the Likert-type scale of five points. As Plato thought that a justified true belief is knowledge and epistemologists assume that knowledge implies belief (Steup, 2006), we dealt with knowledge of energy saving and carbon reduction as a psychological variable that reflects the degree to which a student believe the factual statements about the topic to be true rather than simply treated it as those that compel students to arbitrarily judge them as either true or false. The knowledge scale is hence in a five-pointed scale ranging from "not at all" (1) to "very much" (5) to measure how much they believe the statements to be true. For the attitude scale, the five-pointed scale ranges from "strongly disagree" (1) to "strongly agree" (5) and for behavior scale it ranges from "never" (1) to "always" (5). The differences between the two groups were tested for statistical significance using independent sample t-tests and Pearson's correlation coefficients were computed for the associations among knowledge, attitude, and behavior.

RESULTS AND DISCUSSION

The three domains of overall knowledge, attitude, and behavior of experimental and control groups are compared in Table 1. The two groups differ significantly in only one domain, attitude; the attitude score of experimental group is .28 higher than that of control group. Nevertheless, by breaking down each of the three domains into it's constituent items to examine the differences between the two groups on an item level, some item-specific differences emerged and these are presented as follows.

The differences in knowledge items

Table 2 presents the differences in each of the 20 knowledge items between experimental and control groups. The experimental group has significantly higher scores than control group in three items: "Energy can be divided into renewable and non-renewable energy", "The earth's high temperature is likely because of the massive use of fossil fuel", and "Renewable energy produces no pollution and can be used without limitations". The concepts of

Table 1. Overall knowledge, attitude, and behavior of experimental and control groups

Item		Mean	Std. Deviation	Mean Difference
Knowledge	Control	3.49	.66	-.23
	Exprm.	3.72	.56	
Attitude	Control	3.90	.75	-.28*
	Exprm.	4.18	.49	
Behavior	Control	3.87	.74	.04
	Exprm.	3.91	.89	

*$p <$ .05

Table 2 The differences in the knowledge items between experimental and control groups

Item (On a five-point Likert scale)		Mean	Std. Deviation	Mean Difference
knw1. Energy can be divided into renewable and non-renewable energy.	Control	4.26	1.04	-.45*
	Exprm.	4.71	.60	
knw2. The earth's high temperature is likely because of the massive use of fossil fuel.	Control	3.60	1.31	-.69*
	Exprm.	4.29	1.08	
knw3. Taiwan's electricity comes mostly from nuclear power plants.	Control	3.74	1.48	.00
	Exprm.	3.75	1.34	
knw4. The greenhouse effect causes sea level rise.	Control	4.26	1.07	.05
	Exprm.	4.20	1.12	
knw5. In theory, any movement can be transformed to electricity.	Control	3.31	1.28	.21
	Exprm.	3.11	1.45	
knw6. Unplugging appliances saves electricity.	Control	4.60	.91	.04
	Exprm.	4.56	.90	
knw7. Hydro-power generators has many benefits but the dam causes ecological effects.	Control	4.00	1.03	-.31
	Exprm.	4.31	.94	
knw8. Wind-power generators are constrained by area size and are region-limited.	Control	3.77	1.19	-.37
	Exprm.	4.15	.99	
knw9. If floating sea ice melts, it causes sea level rise.	Control	4.03	1.20	-.41
	Exprm.	4.44	.90	
knw10. Renewable energy produces no pollution and can be used without limitations.	Control	2.97	1.48	-.85*
	Exprm.	3.82	1.49	
knw11. Kyoto Protocol aims mainly to control the amount of international fossil fuel used.	Control	3.40	1.22	-.13
	Exprm.	3.53	1.18	
knw12. Biomass fuel is a renewable energy source.	Control	3.17	1.36	-.30
	Exprm.	3.47	1.39	
knw13. Carbon dioxide is one of major greenhouse gases, so is water vapor.	Control	3.51	1.31	-.47
	Exprm.	3.98	1.18	
knw14. Greenhouse effect causes only sea level rise, having little effects on the environment.	Control	2.00	1.26	-.07
	Exprm.	2.07	1.45	
knw15. Petroleum with biomass alcohol added reduces the carbon dioxide generated in burning.	Control	3.23	1.14	-.22
	Exprm.	3.44	1.34	
knw16. The engine of an idhling car runs slowly and consumes little energy. No need to shut it off.	Control	2.14	1.40	.09
	Exprm.	2.05	1.45	
knw17. Setting the temperature of air-conditioner at 26-28℃ and running it with an electrical fan saves energy.	Control	3.83	1.34	-.15
	Exprm.	3.98	1.39	
knw18. The limitations of electrical vehicles lie in the recharging efficiency and endurability of the battery.	Control	3.69	1.13	-.13
	Exprm.	3.82	1.12	
knw19. Hydrogen fuel is the cleanest energy as it generates no carbon dioxide.	Control	2.63	1.26	-.08
	Exprm.	2.71	1.41	
knw20. A higher carbon emission of a product means more carbon dioxide generated in the production processes.	Control	3.69	1.43	-.30
	Exprm.	3.98	1.16	

$*p < .05$

the three items converge in one topic: renewable energy, informing us about the attribution of the emergence of these three items to the experiential learning with renewable teaching aids. It is shown that students who had hands-on experiences with the teaching aids in the renewable energy courses knew the renewability of energy and the consequence of using non-renewables energy better than those who had no such experiences. Through the experience in operating these renewable teaching aids, students' favoring renewable energy could have been reinforced, which in turn strengthens their conceptual connection to the reason why we should use renewable energy: the global warming problems caused by massive use of fossil fuel. Also, the real experience with renewable energy apparatuses could have assisted them to see the features that distinguish renewable energy from non-renewable energy. However, their high agreement on the cleanness and inexhaustibility of renewable energy is problematic. This could be either a misconception or a preference formed as a result of the experiential learning with the teaching aids. In addition, it is noteworthy that there existed in both groups of students a misconception that the melting of floating sea ice causes sea level rise, consistent with Boylan's (2008) finding that there are misconceptions about energy and climate change among elementary students. Item knw5, "In theory, any movement can be transformed to electricity", is perplexing as its result contradicts our expectation that experimental group students should have a stronger belief in it than control group students. Notwithstanding its stastically insignificance of the difference betweeen experimental and control groups, we presume that it could be a counter effect of the experiential learning with teaching aids. The students' experiences in practicing the renewable energy apparatuses in stead increased their sensitivity about the feasibility of transformung any movement to electricity. In sum, only three of the 20 knowledge items present significant differences and no significant differences is obtained for the average of the overall 20 items indicate that the knowledge increased by experiential learning with teaching aids is limited. It is speculated that elementary students knew quite well about energy saving and carbon reduction in the first place, leaving little room for further improvement brought about by the hands-on learning (Lee et al., 2012).

The differences in attitude items

As Table 3 shows, of the 19 attitude items, there are six that make significant differences between experimental and control groups: "In order to mitigate climate change, I approve restrictions on carbon emission even though it might weaken economy", "The government should build convenient public transportation systems to reduce the growing number of vehicles", "Taiwan's high reliance on imported oil is a serious problem at present", "It is feasible to lower the ticket prices of public transportations to increase public's willingness to take them", "Energy crisis is a critical matter, I would reduce the consumption of energy as possible as I can", and "The safety and stability of energy use is the first priority of consideration". Students of both groups held equally high positive attitude toward the remaining items.

Students with experiences with the hands-on teaching aids in renewable energy courses held more positive attitude toward energy saving and carbon reduction, in particular they agreed to the seriousness of the problems and situations as well as the necessity of the solutions. To see how these attitudes are formed in the pupils' interaction with the teaching aids is theoretically and practically important. As explained in the literature review above, attitude formation in the context of this study can be analyzed from a perspective of product-trial. The situation of experiential learning with teaching aids is quite as same as that of product-trial, in which sensory experiences are the central component and they can bring about adverse changes in consumer attitudes (Gobe, 2001). The process might be that sensory experiences stimulate affective responses which play important roles in the formation of product-trial attitudes (Kim & Morris, 2007). Indeed, evidences show that experienced-based learning was more likely to pertain to positive emotions (e.g., feeling happy, calm) than teacher-directed learning. Students engaging in experiential learning mostly expressed positive feelings of high intensity such as excitement, interest and surprise (Ballantyne & Packer, 2009).

Attitudinal learning is more related to positive emotions rather than negative emotions (Ballantyne & Packer 2009). Most of the emotions triggered by the teaching aids used in this study are positive. Moreover, environmental values have positive relationships with hedonic attitudes toward environmentally friendly products (Ashley et al., 2011). All these help to explain why experiential learning with teaching aids resulted in more positive attitude toward energy saving and carbon reduction. For a number of other items showing more positive attittude of experimental group without statistically significant differences, such as att10, att15, att16, and att18, we envisaged that it could be a matter of the range of the students' concern at their age. Apparently low scores of both experimental and control groups for item att18 indicate that these pupils regarded themselves as just children. Experimental group pupils would held a significantly more positive general attitude toward renewable energy than control group pupils as presented in the previous results, but their positive attitude would be weakened when it comes to specific topics of renewable energy such as techniques, taxes, and governments.

Table 3 The differences in the attitude items between experimental and control groups

Item (On a five-point Likert scale)		Mean	Std. Deviation	Mean Difference
att1. If the functions of products are similar, I would first adopt solar energy products.	Control	4.94	5.03	.47
	Exprm.	4.47	.86	
att2. Despite heightened costs and prices of electricity, I approve electricity generated in more environmental friendly ways.	Control	3.97	1.18	-.34
	Exprm.	4.31	.86	
att3. In order to mitigate climate change, I approve restrictions on carbon emission even though it might weaken economy	Control	3.60	1.26	-.58*
	Exprm.	4.18	1.06	
att4. The government should build convenient public transportation systems to reduce the growing number of vehicles.	Control	3.76	1.23	-.56*
	Exprm.	4.33	.88	
att5. Taiwan's high reliance on imported oil is a serious problem at present.	Control	3.85	1.02	-.54*
	Exprm.	4.39	.86	
att6. Setting bicycle days or certain days of free buses changes the public's habits of using vehicles.	Control	4.09	1.09	-.26
	Exprm.	4.35	.91	
att7. It is feasible to lower the ticket prices of public transportations to increase public's willingness to take them.	Control	3.63	1.29	-.66*
	Exprm.	4.29	1.01	
att8. Energy crisis is a critical matter, I would reduce the consumption of energy as possible I can.	Control	4.06	1.10	-.44*
	Exprm.	4.50	.77	
att9. The safety and stability of energy use is the first priority of consideration.	Control	3.79	1.07	-.52*
	Exprm.	4.31	.91	
att10. We should use as many natural sources as possible for lighting in order to save energy.	Control	4.03	1.11	-.16
	Exprm.	4.19	.83	
att11. I approve the rewarding measures that governments take to encourage energy saving.	Control	4.18	1.03	-.23
	Exprm.	4.41	.86	
att12. Low oil consumption is the first consideration when buying vehicles.	Control	3.74	1.29	-.20
	Exprm.	3.94	1.16	
att13. Promoting education of energy saving and carbon reduction and providing relevant information can facilitate consensus reaching on a carbon reduction lifestyle.	Control	4.20	.96	-.30
	Exprm.	4.50	.82	
att14. Well-ventilated buildings can reduce the use of air-condition.	Control	4.29	1.06	.02
	Exprm.	4.28	.98	
att15. The development and prevalence of electrical vehicles should be promoted and tax should be imposed on oil-consuming vehicles.	Control	3.49	1.22	-.48
	Exprm.	3.96	1.21	
att16. Governments should put a lot of money, materials, and manpower in the development of green energy.	Control	4.03	1.15	-.08
	Exprm.	4.11	.95	
att17. Governments should be the models of working on energy saving and carbon reduction in public sectors.	Control	4.17	1.04	-.09
	Exprm.	4.26	.99	
att18. Searching for new or alternative energy is the adults' business, not children's.	Control	2.40	1.33	-.19
	Exprm.	2.59	1.61	
att19. Governments should put budget in finding techniques increasing energy efficiency.	Control	3.83	1.25	-.32
	Exprm.	4.15	1.02	

$*p < .05$

Conversely, it must be cautioned that positive attitude toward the purchase of renewable energy products is not necessarily formed. As the result of item att1 shows, experimental group students gave lower, though statistically insignificant, priority to solar energy product than control group students did. The experiences in operating these renewable energy apparatuses on one hand could increase their attitude favoring renewable energy but on the other hand limitations of renewable energy products could as well be exposed in such experiences, making them adopt a reserved attitude toward the purchase of renewable energy products. Finally, consumer psychology in product-trial also helps in explaining why students' overall knowledge was not affected by such experiential learning. It might be because that affect has a more direct and strong effect on attitude than on cognition (Bodur et al., 2000; Morris et al., 2002).

The differences in behavior items

None of the 20 behavior items presents significant difference between experimental and control groups (Table 4). Consistent with the results of Liu et al. (2012) and Lee et al. (2012) studies in which elementary students also participated in energy education activities with hands-on models, the experiential learning with teaching aids failed to affect elementary students' behavior concerning energy saving and carbon reduction. A possible explanation for the common results of no significant effect on behavior for these studies is the limitation of age on the behavioral abilities of these children. Evans et al. (2007) enumerated limitations of measuring children's environmental behavior among which is that children have no discretion over some behaviors. As Aguirre-Bielschowsky (2013) pointed out, their energy saving practices are largely instructed by parents. It might entail a meta-analysis to verify this explanation concerning the age-appropriateness of some energy saving behaviors.

Differences in the correlations among knowledge, attitude, and behavior

The differences between experimental and control groups also emerge in the strength of relationships among knowledge, attitude, and behavior. As Table 5 presents, the control group has only one significant correlation coefficient of .62 between knowledge and attitude while all the correlation coefficients of experimental group are statistically significant and of approximately the same value of .30. For students in the experimental group, their knowledge, attitude, and behavior are more inter-connected. This pattern of the relationships among the three

Table 4 The differences in the behavior items between experimental and control groups

Item (On a five-point Likert scale)		Mean	Std. Deviation	Mean Difference
beh1. I pay attention to whether my family and friends' vehicles emitted black smoke.	Control	3.68	1.20	-.43
	Exprm.	4.11	1.18	
beh2. I carry personal tableware and avoid using disposable tableware.	Control	4.34	.91	.16
	Exprm.	4.19	.97	
beh3. I refuse buying over-packaged products.	Control	4.21	.81	.33
	Exprm.	3.87	1.23	
beh4. I suggest my family choose low pollution vehicles.	Control	4.15	1.08	.18
	Exprm.	3.96	1.27	
beh5. I reuse plastic bags.	Control	4.17	1.27	-.09
	Exprm.	4.26	1.17	
beh6. I remind my family and friends of regular examination and maintenance of vehicles.	Control	3.83	1.34	-.28
	Exprm.	4.11	1.14	
beh7. I remind my family of regular examination and maintenance of appliances.	Control	4.03	1.25	.03
	Exprm.	4.00	1.15	
beh8. I remind my family of not pumping gas after the nozzle clicks off automatically.	Control	3.76	1.30	-.30
	Exprm.	4.06	1.24	
beh9. I avoid using large amount of electricity during peak times as much as I possibly can.	Control	3.65	1.10	-.37
	Exprm.	4.02	1.14	
beh10. I learn actively about energy safety.	Control	3.94	1.13	-.34
	Exprm.	4.28	1.05	

Table 4. Continued.

Item (On a five-point Likert scale)		Mean	Std. Deviation	Mean Difference
beh11. I take public transportation as much as I possibly can.	Control	3.97	1.24	.16
	Exprm.	3.81	1.24	
beh12. I suggest my family replace the bulbs at home with energy-saving bulbs.	Control	3.91	1.26	-.05
	Exprm.	3.96	1.27	
beh13. I tell my family and friends about my experiences in and methods of saving energy.	Control	3.62	1.26	-.46
	Exprm.	4.07	1.06	
beh14. I suggest my family buy fuel saving vehicles.	Control	3.66	1.35	-.10
	Exprm.	3.75	1.34	
beh15. I suggest my family buy products bearing energy saving labels.	Control	4.26	1.09	.05
	Exprm.	4.20	1.20	
beh16. I am concerned about information about the development of new or alternative energy.	Control	3.77	1.19	.02
	Exprm.	3.75	1.25	
beh17. I discuss trends in future energy with my classmates and friends.	Control	3.43	1.27	.10
	Exprm.	3.33	1.49	
beh18. I actively inquire about issues of energy development on internet and in books.	Control	3.58	1.32	.24
	Exprm.	3.34	1.47	
beh19. I stop to read news about energy development in the media.	Control	3.59	1.10	.16
	Exprm.	3.43	1.49	
beh20. I introduce the benefits of renewable energy to my family and friends.	Control	3.83	1.27	.16
	Exprm.	3.67	1.35	

Table 5 Correlations among knowledge, attitude, and behavior for experimental and control groups

	Knowledge	Attitude	Behavior
Knowledge			
Control:	1	.62**	-.16
Exprm.:	1	.30*	.33*
Attitude			
Control:	.62**	1	.02
Exprm.:	.30*	1	.34*
Behavior			
Control:	-.16	.02	1
Exprm.:	.33*	.34*	1

*$p < .05$, **$p < .01$

domains of experimental group suggests a stronger and more completed structure of the relationships than that of control group. Accordingly, the experiential learning with the teaching aids is found to facilitate the pupils' connecting their knowledge and/or attitude with their behavior. It means that their better knowledge about and/or more positive attitude toward renewable energy could increase the likelihood of their undertaking behaviors of energy saving and carbon reduction. For students in the control group, however, though there is a high correlation between knowledge and attitude both their knowledge and attitude fail to be correlated with their behavior, implying that these students might not be as much willing to conduct those behaviors as much they know about renewable energy. Without the experiences with the teaching aids, students of control group seemed to be less sensitive in relating their knowledge and attitude to behavior.

CONCLUSION

Though ineffective in changing elementary students' behavior of energy saving and carbon reduction, the teaching aids this study employed in learning renewable energy benefited the formation of a positive attitude toward it and an increase in some knowledge in this regard. The positive attitude found to be significantly affected by the experiential learning with teaching aids concerns the recognitions of seriousness of the problems as well as the approval for the necessity of certain mitigation measures. Increased knowledge was reflected in the distinction between renewable and non-renewable energy and the use of fossil fuels as a cause of global warming. Also, students who had experience with the teaching aids possess stronger connections among knowledge, attitude, and behavior, implying that the teaching aids could have helped these children link the three domains with each other through the experiences.

The present study provided a product-trial perspective, from which we analyzed how learning experiences with the teaching aids are related to the formation of positive attitude toward energy saving and carbon reduction. Though applying that perspective here has some strength in that overt sensory stimulation do occur as those do in product-trial, it must be acknowledged that comparing the learning experiences to products-trial experiences is open to criticism about their different contexts and it hence could weaken associated arguments. We found in the analysis that the affective responses which arose from sensory stimulations in experience with the teaching aids might play an important role in forming an attitude favoring relevant issues. It is suggested that future studies use methods such as structural equation modeling to further test the interplay among affective responses, attitude, and sensory stimulations in experiential learning with teaching aids. Whether elementary students' behavior of energy saving and carbon reduction is limited due to their age needs study as well. Providing children with the opportunities to experience with teaching aids is still recommended for environmental educators, in particular those who attempt to shape young learners' pro-environmental attitude.

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REFERENCES

Aguirre-Bielschowsky, I. (2013). Electricity saving behaviours and energy literacy of New Zealand children. Doctoral dissertation, the University of Otago, New Zealand.

Ashley, C., Oliver, J. D., & Zemanek, J. E. (2011). Trial-attitude formation in green product evaluations. In R. Srinivasan & L. McAlister (Eds.), 2011 AMA Winter Educators' Conference: Marketing Theory and Applications (pp. 320–321). Chicago, IL: American Marketing Association.

Ballantyne, R., & Packer, J. (2009). Introducing a fifth pedagogy: Experience-based strategies for facilitating learning in natural environments. *Environmental Education Research, 15*(2), 243–262.

Bodur, H. O., Brinberg, D., & Coupey, E. (2000). Belief, affect, and attitude: Alternative models of the determinants of attitude. *Journal of Consumer Psychology, 9*(1), 17–28.

Boylan, C. (2008). Exploring elementary students' understanding of energy and climate change. *International Electronic Journal of Elementary Education, 1*(1), 1–15.

Carrier, S. J., Tugurian, L. P., & Thomson, M. M. (2013). Elementary science indoors and out: Teachers, time, and testing. *Research in Science Education*, DOI: 10.1007/s11165-012-9347-5

Choi, K., & Chang, H. (2004). The effects of using the electric circuit model in science education to facilitate learning electricity-related concepts. *Journal of the Korean Physical Society, 44*(6), 1341–1348.

Corney, G. (2000). Student geography teachers' pre-conceptions about teaching environmental topics. *Environmental Education Research, 6*(4), 313–329.

Crapper, M., Donald, R., Hill, D., Hall, A., & French, W. (2008). Models for teaching sustainable development to children. *Proceedings of the Institution of Civil Engineers: Engineering Sustainability, 161*(4), 229–236.

Evans, G. W., et al. (2007). Young children's environmental attitudes and behaviors. Environment and Behavior, 39, 635–659.

Falk, J. H., Koran, J. J. Jr., & Dierking, L. D. (1986). The things of science: Assessing the learning potential of science museums. *Science Education, 70*, 503–508.

Fazio, R. H., & Zanna, M. P. (1981). Direct experience and attitude-behavior consistency. In L. Berkowitz (Ed.), *Advances in experimental social psychology, Vol. 14* (pp. 161–202). New York: Academic Press.

Finson, K. D., & Enochs, L. G. (1987). Student attitudes toward science-technology-society resulting from visitation to a science-technology museum. *Journal of Research in Science Teaching, 24*, 593–609.

Gobe, M. (2001). *Emotional branding*. New York: Allworth.

Ibeh, G. F., Onah, D.U., Umahi, A. E., Ugwuonah, F. C., Nnachi, N. O., & Ekpe, J.E. (2013). Strategies to improve attitude of secondary school students towards physics for sustainable technological development in Abakaliki L.G.A, Ebonyi, Nigeria. *Journal of Sustainable Development Studies, 3*(2), 127-135.

Jarvis, T., & Pell, A. (2005). Factors influencing elementary school children's attitudes to science before, during and following a visit to the UK National Space Centre. *Journal of Research in Science Teaching, 42*(1), 53-83.

Kim, J., & Morris, J. D. (2007). The power of affective response and cognitive structure in product-trial attitude formation. *Journal of Advertizing, 36*(1), 95–106.

Kolb, D. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice Hall.

Lee, L. S., Lin, K. Y., Guu, Y. H., Chang, L. T., & Lai, C. C. (2012). The effect of hands-on 'energy saving house' learning activities on elementary school students' knowledge, attitudes, and behavior regarding energy saving and carbon-emissions reduction. *Environmental Education Research*, DOI: 10.1080/13504622.2012.727781

Lin, M. G. (2012). *Learning effectiveness of integrating the greenergy teaching aids into the elementary school curriculum*. Unpublished master's thesis, National University of Tainan, Taiwan.

Liu, S. Y., Chen, R. H, Chiu, Y. R, & Lai, C. M. (2012). Building energy and children: Theme-oriented and experience-based course development and educational effects. *Journal of Asian Architecture and Building Engineering, 11*(1), 185–192.

Morris, J. D., Woo, C., Geason, J. A., & Kim, J. (2002), The power of affect: Predicting intention. *Journal of Advertising Research, 42*(3), 7-17.

Orr, D.W. (1992). *Ecological literacy: Education and the transition to a postmodern world*. New York: State University of New York Press.

Osborne, R., & Freyberg, P. (1985). *Learning in science: The implications of children's science*. Melbourne: Heinemann.

Ou, C. H., Fang, P. L., Miao, R. I., Lai, C. H., & Pan, H. T. (2007). A study on the effects of implementing experiential energy education curriculum in an elementary school on the pupils' energy literacy. *2007 Annual report of research and development achievements made by authorities and schools of Kaohsiung City Government*.

Perry, D. L. (1993). Designing exhibits that motivate. In M. Borun, S. Grinell, P. McNamara, & B. Serrell (Eds.), *What research says about learning in science museums, Vol. 2* (pp. 25–29). Washington, DC: Association of Science.

Ramey-Gassert, L., Walberg, H. J., III, & Walberg, H. J. (1994). Reexamining connections: Museums as science learning environments. *Science Education, 78*, 345–363.

Roschelle, J. (1995). Learning in interactive environments: Prior knowledge and new experience. In J. H. Falk & L. D. Dierking (Eds.), *Public institutions for personal learning: Establishing a research agenda* (pp. 37-51). Washington, DC: American Association of Museums.

Schmitt, B. H. (1999). Experiential marketing. *Journal of Marketing Management, 15*, 53-67.

Sneath, J. Z., Finney, R. Z., & Close, A. G. (2005). An IMC approach to event marketing: The effects of sponsorship and experience on consumer attitudes. *Journal of Advertising Research, 45*(4), 373-381.

Steup, M. (2006). Analysis of knowledge. In E. N., Zalta (Ed.), Stanford encyclopedia of philosophy. Retrieved 04/04/2014 from http://plato.stanford.edu/entries/knowledge-analysis/

Takaki, K. Jinno, N., Kajiwara, S., Yamaguchi, A., Kikuchi, M., & Suzuki, M. (2007). Development of energy and environment education program and teaching aids for upper grade of elementary school by effective utilization of regional collaboration. *IEEJ Transactions on Fundamentals and Materials, 127*(4), 205-211.

Tytler, R. (2002). Teaching for understanding in science: Student conceptions research and changing views of learning. *Australian Science Teachers' Journal, 48*(3), 14-21.

Corresponding Author: Dr. Yu-Long Chao, Graduate Institute of Science Education and Environmental Education, National Kaohsiung Normal University. 62, Shenjung Rd. Yanchau District, Kaohsiung, Taiwan 82444 R.O.C. E-mail: chaoyulong@gmail.com

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