Chapter 8
Plastic Waste Problem and Education for Plastic Waste Management

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Abstract Economic development and people's changing patterns of consumption and production have led to a drastic increase in plastic wastes all over the world. Plastic waste disposal harms the environment and poses threat to human health. Hence, there is great desire to reduce the plastic wastes. To reduce plastic wastes, education is of utmost importance as education can change people's knowledge, attitude, and behaviors toward plastic waste management. This study examines the effectiveness of three teaching strategies (direct teaching, hands-on teaching, and simulation game-based teaching) on change in knowledge, attitude, and behavior in students toward plastic waste management. The results are discussed in depth in this chapter.

Keywords Plastic waste education · Plastic waste management · Direct teaching · Hands-on teaching · Simulation game-based teaching

8.1 Plastic Waste Problem

The rapid urbanization and economic growth in different countries have led to a drastic increase in plastic production and consumption around the globe. Owing to the low recycling value of plastic and the lack of technological support, the recovery rate of plastic waste remains very low. Most of it is washed into the ocean,

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disposed of in landfills, or burned in incinerators. These enormous amounts of plastic waste bring disastrous consequences, such as pollution, food chain contamination, biodiversity breakdowns, energy waste, and economic loss. These plastic waste problems and adverse effects are especially serious and omnipresent in renowned countries/megacites such as Japan (PWMI, 2014), Taiwan (Walther, 2015), the UK (GHK, 2006; Howarth, 2013), and Hong Kong (Environmental Protection Department, 2013), where economic activities are flourishing and the plastic consumption level is high. Plastic waste not only causes air pollution (Li, Lee, Mi, & Su, 1995), land pollution (Barnes, Galgani, Thompson, & Barlaz, 2009; Steelys Drinkware, 2013), and harms human health (Crinnion, 2010; Elliott et al., 1996; Maffini, Rubin, Sonnenschein, & Soto, 2006; Yamamoto & Yasuhara, 1999), but it also causes water pollution (Howarth, 2013; Laist, 1987; Perkins, 2014; Schwartz, 2014; Zielinski, 2014) and contaminates the food chain (Rochman et al., 2014; Swan, 2008; Thompson, Moore, Saal, & Swan, 2009), endangers biodiversity (Derraik, 2002; Grant & Ryder, 2009; Gregory, 2009; McNamee, 2008), and causes enormous energy waste (Cho, 2012; European Commission, 2013; Hong Kong Cleanup, 2012; StudyMode, 2015; Themelis & Mussche, 2014), as summarized in Table 8.1.

Table 8.1 Current plastic waste problem in mega-cities

	Japan	Taiwan/Taipei	UK	Hong Kong
Status quo of plastic wastes	Around 9.3 million tons discharged per year	Near 7200 kg plastic waste collected on 18 beaches	5 million tons of plastic consumed per year	Around 730,000 tons of plastic waste discharged per year
Major source of plastic wastes	Domestic/packaging	Domestic/restaurants	Packaging	Municipal/shopping bags
Plastic waste management strategies	Incineration	/	/	Landfilling
Crisis of plastic wastes				
(a) Health	Respiratory infection	Food chain contamination	/	/
(b) Environment	Air pollution	Water pollution	/	Land pollution
(c) Biodiversity	/	/	Endanger biodiversity	/
(d) Energy	/	/	/	Energy waste and economic loss

8.2 Education for Plastic Waste Management

In order to reduce plastic waste, the popularity of plastic waste management among the public has to be enhanced by changing people's knowledge, attitudes, and behaviors toward plastic waste management. There are four areas of plastic waste management, which are (a) the 4Rs—reduce, reuse, recycle, and regeneration, (b) the two strategies—landfilling and incineration, (c) the four steps of recycling procedures—cleaning, separation, sorting, and compression, and (d) the knowledge of the life cycle of plastics.

8.2.1 Education for Plastic Waste Management in Japan, Taiwan, The UK, and Hong Kong

To cope with the serious plastic waste problem, education in plastic waste management is becoming increasingly prevalent all around the world, and in general there are four main different educational approaches, namely community-based education, government-based education, business-based education, and school-based education. Japan, Taiwan, the UK, and Hong Kong are, respectively, the representatives of these four approaches.

8.2.1.1 Japan

Characteristics

- Specific containers

The Japanese community is highly engaged in recycling and highly encourages Japanese citizens to do sorting at source before recycling by providing specific containers for PET bottles, PS foam containers, or PP bottle caps separately instead of mixing them with other plastics (Yoda, 1999).

- Publication and Broadcasting

The community promotes and provides guidance for recycling by the regular publication of various guidebooks and magazines, such as the door-to-door distributed Guidebook for Sorting Recyclables and Waste, regular articles relating to resource recycling posted in the newsletter, and "Minacle" 3R Information Magazine distributed in newspapers. In addition to publication, the Japanese community also broadcasts a special CATV program called "3R Forum" twice a year, which is sponsored by the 3R Promotion Committee (Hasegawa, 2014).

- Activities

The community and condominium residents together have formed some organizations, which voluntarily and periodically collect and gather resources mainly from household sources and then sell them to recyclers. In addition, the community also periodically launches some facility tours to incineration plants, recycling facilities, and other facilities (Hasegawa, 2014). Also, in the past 20 years, the Japan Environmental Action Network (JEAN) has been organizing beach cleanups and surveys every year (Lytle, 2015).

- Family education

In Japan, recycling also goes from the community into family. The municipal governments will set up rules and time schedules for the collection of recyclables, and most Japanese families follow those rules and schedules strictly by keeping the color-coded calendars with the rules and schedule on it in their kitchens to remind themselves (Hays, 2012). Those sorting rules include requiring households to separate plastic waste from other kitchen waste and to separate plastic wrappers, labels, and packages from polyethylene terephthalate (PET) bottles (McCurry, 2011).

Pros

The publication and the facility tours may enhance Japanese citizens' knowledge of recycling and plastic waste management. The specific containers, the voluntary activities, and the family education are likely to enhance Japanese citizens' behavior regarding plastic recycling.

8.2.1.2 Taiwan

Characteristics

- "Four-in-One" program

In 1997, the Taiwanese government established the "4-in-1 Recycling Program" in the hopes of stimulating the citizens to engage more in recycling. The program connected the collaboration of four different stakeholders, including community residents, recyclers and collectors, local governments, and the local recycling fund, to collect regulated recyclable waste, which includes 13 categories and 33 items, such as metal containers, glass containers, plastic containers, and waste electrical appliances. The waste plastic containers are further divided into 8 categories, which encourages sorting before recycling.

- Legislation

The Taiwanese government has enacted the Waste Disposal Act, which restricts the use and offering of plastic shopping bags and disposable plastic (including styrofoam) tableware to customers for free (Legislative Council Secretariat, 2005).

Pros

It is reported that the "Four-in-One" program enhanced Taiwanese residents' behavior regarding plastic recycling and plastic waste reduction (Huang, 2013). The Environmental Protection Agency Taiwan pointed out that the introduction of restrictive legislation has successfully enhanced Taipei residents' environmental protection awareness and changed their behaviors by using fewer plastic shopping bags and less disposable plastic tableware (Legislative Council Secretariat, 2005).

8.2.1.3 The UK

Characteristics

- WasteCare

WasteCare is a leading plastic waste management and recycling company that has provided plastic waste collection, recycling, and recovery solutions for over 20,000 organizations throughout the UK for over 30 years (WasteCare, 2015).

- LUXUS

Luxus is another plastic management and recycling company, which collects plastic waste from businesses in the UK and then recycles it or returns it to the moulding or extrusion company for remanufacture into new plastic products (Luxus Ltd., 2014).

- Plastic recycling schemes

There are different plastic recycling schemes in the UK to promote and facilitate plastic recycling, such as "Recovinyl," which provides financial incentives to support the collection of PVC waste; "Recofloor," which mainly collects and recycles vinyl flooring and diverts it from landfill; and the "Vinyl Plus programme," aimed at enhancing the recycling rates of PVC and developing innovative and advanced recycling technologies (British Plastics Federation, 2015).

Pros

The business-based education for plastic waste management in the UK aims at enhancing businesses' awareness and behavior regarding plastic recycling and plastic waste management by using those services.

8.2.1.4 Hong Kong

Characteristics

- Teacher's guidebook

The government has published a teacher's guidebook called "Reduce Your Waste and Recycle Your Plastics," which provides the four steps of recycling

procedures and the rationale behind the steps (Environmental Protection Department, 2011).

- The "Reduce Your Waste and Recycle Your Plastics Campaign"

The Environmental Campaign Committee 2012[1] organized a campaign called the "Reduce Your Waste and Recycle Your Plastics Campaign" in Hong Kong schools in 2012, in which the participating schools encouraged their students to bring their plastic bottles to school after cleaning and removing the caps and labels from the bottles and put them into the recycling bin at school (Environmental Protection Department, 2015).

Pros

The teacher's guidebook and the campaign aimed to "cultivate and sustain pupils' behavioral change on waste reduction and recycling" and to provide them with knowledge of waste management (Environmental Protection Department, 2015).

8.2.2 Importance of Plastic Waste Education

Research studies have revealed that it is possible for education to change knowledge, attitudes, and behaviors. The studies of Mobley, Vagias, and DeWard (2009) and Olofsson and Öhman (2006) (as cited in Manning, 2010) support that "the level of formal education people have received seems to correlate directly with the amount of environmental knowledge people have and the formation of positive attitudes." In addition, Scott and Willits (1994) (as cited in Manning, 2010) "also found that the more highly educated one is, the more likely one is to engage in environmentally responsible behaviors." The current environmental education for plastic waste management adopted by Japan, Taiwan, the UK, and Hong Kong is still not perfect. There is still much room for improvement in order to change all of the knowledge, attitudes, and behaviors regarding plastic waste management, which depends on the effectiveness of the educational strategies.

8.2.2.1 Change in Knowledge

Some academics have defined education as a "potent weapon to help develop new knowledge, skills, and values for achieving a healthier environment and a higher quality of life" (Nagra, 2010; UNCED, 1992). Indeed, education is a process of teaching and learning, in which the learners acquire and know new facts, information, and values.

[1]The Environmental Protection Department (EPD), the Environmental Campaign Committee (ECC), the Education Bureau (EDB) and the Yan Oi Tong EcoPark Plastic Resources Recycling Centre (YOT PRRC) formed the Environmental Campaign Committee 2012.

8.2.2.2 Change in Attitudes

Another environmental education's objective is to change people's attitudes by "helping social groups and individuals acquire a set of values and feelings of concern for the environment and motivation for actively participating in environmental improvement and protection," defined by the 1977 Tbilisi Intergovernmental Conference on Environmental Education (Hungerford & Volk, 1980).

8.2.2.3 Change in Behavior

The 1977 Tbilisi Intergovernmental Conference on Environmental Education also defined that education can change behavior by "providing social groups and individuals with an opportunity to be actively involved at all levels in working toward resolution of environmental problems and/or issues" (Hungerford & Volk, 1980).

8.2.2.4 Educational Strategies

To achieve the above changes, teaching strategies are critical for the learning outcomes. Traditional lectures have been reported to be less effective to affect behaviors in environmental-related topics due to the lack of interactive learning and thinking opportunities to students (Duerden & Witt, 2010). On the other hand, experiential learning is found to be more effective in empowering and engaging students to take part in environmental learning and actions (Sipos, Battisti, & Grimm 2008). There are no standard pedagogies developed specifically for teaching plastic waste management in schools. However, So and her colleagues (2014) suggested that inquiry learning approach (such as gaming activities or experimental investigation) could enhance students' knowledge, but the limited course time (70 min) was difficult to induce intended behavioral changes for plastic waste recycling education. More investigations should be studied for educational strategies in plastic waste recycling.

8.3 The Centre for Education in Environmental Sustainability's (CEES) Aim/Vision of Plastic Waste Education

CEES has been established since January 2013. The Centre's vision is to further develop effective environmental educational strategies and sustainability studies in Hong Kong through research and knowledge transfer networks with local, Chinese,

Table 8.2 Expected change in knowledge, attitude, and behavior toward plastic waste management induced by different education programs

		Education programs in Japan, Taiwan, the UK, and Hong Kong (not exhaustive)
Expected change in	Knowledge	• Publication and broadcasting (Japan) • Teacher's guidebook (Hong Kong) • The "Reduce Your Waste and Recycle Your Plastics Campaign" (Hong Kong)
	Attitude	• Legislation (Taiwan) • Plastic management and recycling companies (UK)
	Behavior	• Specific containers (Japan) • Voluntary activities (Japan) • Family education (Japan) • "Four-in-one" program (Taiwan) • Legislation (Taiwan) • Plastic management and recycling companies (UK) • Teacher's guidebook (Hong Kong) • The "Reduce Your Waste and Recycle Your Plastics Campaign" (Hong Kong)

and overseas universities. The mission of the centre is "to improve the understanding of environmentally related matters via education in environmental sustainability and to stimulate remedial actions through research and public education," as highlighted in the centre's slogan "Care for our Environment, and Educate our Students and Community" (CEES, EdUHK, 2015) (Table 8.2).

8.4 Plastic Waste Education Adopted by CEES

CEES has launched the 3Rs (reduce, reuse, recycle) education project with three different teaching strategies, i.e., direct teaching, hands-on teaching, and simulation game-based teaching strategies, attempting to enrich local primary school pupils' knowledge of environmental sustainability as well as pro-environmental attitudes and behaviors of plastic waste recycling.

Research question: How can educational strategies be used to enhance students' learning outcomes in terms of knowledge, attitude, and behavior?

8.4.1 Methodology

There were 61 pupils from seven local primary schools aged from 8 to 12, from grades 4 to 6, participating in this education project. They were divided into three

teaching groups to learn about plastic waste problems and plastic waste management in Hong Kong for 9 h (one-and-a-half-day course). Before and after the program, the pupils were given a pre- and post-test, respectively, to test their changes in knowledge, attitudes, and intended behaviors regarding recycling and plastic waste management. Quantitative data were collected with the prior consent received from pupils. All the statistical data were analyzed by the software SPSS ver.21 (IBM Corp., 2012).

8.4.1.1 Direct Teaching Strategy

The direct teaching strategy is about "teachers instructing students directly and assuming a highly structured, active, and dominant role in which teacher talk is relied upon to ensure that students interpret the work in the intended way and achieve the desired outcome" (Goodman, 1986). In the direct teaching sessions, the teacher presented plastic waste problems and management knowledge to pupils directly, mainly by using PowerPoint slides.

8.4.1.2 Hands-on Teaching Strategy

Hands-on teaching is a kind of inquiry teaching strategy, which "refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (National Research Council, 1996). In the hands-on teaching sessions, the teacher provided guidance for pupils to learn actively by observation, experiments, and interaction with the environment.

8.4.1.3 Simulation Game-Based Teaching Strategy

Simulation games "represent dynamic models of real situations (a reconstruction of a situation or reality that is itself a social construction)" (Kriz, 2003). Within a game-like context, pupils can experience in-person in the simulation of certain existing systems (i.e., instructive content). In the simulation game-based sessions, the teacher held a face-to-face simulation game called "plastic city," in which the pupils were involved in a role play and acted as citizens of the city. By "living in the plastic city," they can experience and understand more on the interconnections between their daily lives and environmental problems.

8.4.2 Results

8.4.2.1 Knowledge of the 3Rs and Plastic Waste Problems and Management

As shown in Table 8.3, all of the three groups' post-test scores for the knowledge of the 3Rs and plastic waste problems and management had a significant increase after the pupils went through either one of the teaching strategies. In other words, all of the three teaching strategies can enhance pupils' knowledge of the 3Rs and plastic waste problems and management. There was no significance found for the pre-test scores among the three groups for different teaching strategies on pupils' knowledge ($F = 1.938$; Sig. = 0.153), proving that the pupils from the three groups had a similar knowledge background before they underwent the teaching strategy.

As shown in Table 8.4, pupils who participated in the simulation game attained the most significant improvement in their knowledge of the 3Rs and plastic waste problems and management, when compared with those who were from the direct teaching group and the hands-on teaching group (Table 8.5).

In the test, the questions were divided into four different categories: plastic and waste, recycle, reuse, and reduce. For example, they included the knowledge of landfills in Hong Kong, plastic waste problems and management, and government policy. The post-test results revealed that the pupils from the simulation game-based teaching group achieved significantly higher scores than the other two groups in the category of plastic and waste, whereas there were no significant differences in the scores of the other categories among the three teaching groups.

8.4.2.2 Ecological Worldview Attitude

The results listed in Tables 8.6 and 8.7 indicate that there were no significant differences in the pupils' ecological worldview attitudes before and after the program for each teaching strategy. Nevertheless, the pupils from the hands-on

Table 8.3 Pre- and post-test scores for the knowledge of 3Rs and plastic waste problems and management

Teaching Strategies	N	Pre-mean	Post-mean	t-value	Significance p-value (2-tailed)
Direct	21	5.42 ± 1.56	7.90 ± 2.49	3.901	0.001**
Hands-on	19	5.36 ± 1.70	8.32 ± 2.71	5.321	0.000***
Simulation game-based	21	6.24 ± 1.04	10.48 ± 2.32	9.722	0.000***

**$p < 0.005$; ***$p < 0.001$
The full score is 15

Table 8.4 Comparison of the difference in the knowledge scores of the teaching groups

Teaching strategies	Mean dif. (post–pre)	SD	F	Sig.
Direct	2.28	0.67	3.493	0.038
Hands-on	2.87	2.29		
Simulation game-based	4.24*	2.00		

One-way ANOVA: *$p < 0.05$

Table 8.5 Pre- and Post-test mean score of the classified questions in different categories and teaching groups

Questions category	Full score	Post-test mean score ± SD		
		Direct	Hands-on	Simulation game-based
Plastic and waste	7	3.79 ± 1.27a	3.60 ± 1.30b	5.05 ± 0.97a, b*
Recycle	2	0.63 ± 0.60	1.13 ± 0.83	0.904 ± 0.77
Reuse	3	1.68 ± 1.00	1.60 ± 0.83	2.10 ± 0.94
Reduce	3	1.74 ± 0.73	1.53 ± 0.83	2.00 ± 0.77

One-way ANOVA
*Sig. = 0.004 for a and 0.002 for b

Table 8.6 Pre- and Post-test mean scores of the ecological worldview attitudes of the different teaching groups

Teaching strategies	N	Pre-mean	Post-mean	t-value	Significance p-value (2-tailed)
Direct	7	2.11 ± 0.34	1.91 ± 0.64	−0.85	0.429
Hands-on	9	2.211 ± 0.45	2.22 ± 0.41	0.098	0.924
Simulation game-based	19	2.04 ± 0.57	1.89 ± 0.74	−1.051	0.307

The full score is 5

Table 8.7 Comparison of the difference in the PEA scores of the teaching groups

Teaching strategies	Mean dif. (post–pre)	SD	F	Sig.
Direct	−2.00	6.24	0.34	0.72
Hands-on	0.11	3.41		
Simulation game-based	−1.53	6.33		

One-way ANOVA

teaching group had a slight improvement in their ecological worldview attitudes after the program and had slightly better performance in this part of the post-test than the other two groups (Table 8.8).

Table 8.8 Pre- and Post-test mean scores of the recycling attitudes of the different teaching groups

Teaching Strategies	N	Pre-mean	Post-mean	t-value	Significance p-value (2-tailed)
Direct	14	3.56 ± 0.36	3.50 ± 0.24	−0.715	0.487
Hands-on	10	3.52 ± 0.38	3.59 ± 0.50	0.633	0.543
Simulation game-based	21	3.54 ± 0.40	3.56 ± 0.37	0.279	0.783

The full score is 5

Table 8.9 Comparison of the difference in the recycling attitude scores of the teaching groups

Teaching strategies	Mean dif. (post–pre)	SD	F	Sig.
Direct	−0.64	3.37	0.44	0.65
Hands-on	0.70	3.50		
Simulation game-based	0.24	3.91		

One-way ANOVA

8.4.2.3 Recycling Attitude

In the tests, there were a series of questions asking about the recycling attitudes of the pupils. The results of the pre- and post-tests showed that there was no significant difference in the recycling attitudes of the pupils from each teaching group before and after the program. However, the post-test mean scores of the pupils from the hands-on group and simulation game-based group were slightly higher than the pre-test scores, indicating that there was a slight improvement, though insignificant, in recycling attitude for the pupils learning through hands-on teaching and simulation game-based teaching (Table 8.9).

8.4.2.4 Intended Behavior of Plastic Waste Recycling

The results in Tables 8.10 and 8.11 show that the pupils' intended behavior of plastic waste recycling and management did not change much after they had gone through the program, no matter which teaching group they had joined, with the hands-on group achieving a slight improvement in this aspect.

8.4.3 Discussion

In summary, all of the three teaching strategies can significantly enhance pupils' knowledge of the 3Rs and plastic waste problems and management, with the simulation game-based strategy being the most effective of the three strategies in

Table 8.10 Pre- and post-test mean scores of the intended behavior of the different teaching groups

Teaching strategies	N	Pre-mean	Post-mean	t-value	Significance p-value (2-tailed)
Direct	10	3.49 ± 0.68	3.20 ± 0.83	−1.891	0.091
Hands-on	10	3.15 ± 0.57	3.17 ± 0.57	0.069	0.946
Simulation game-based	16	3.15 ± 0.67	3.00 ± 0.75	−0.655	0.522

The full score is 5

Table 8.11 Comparison of the difference in the intended behavior scores of the teaching groups

Teaching strategies	Mean dif. (post–pre)	SD	F	Sig.
Direct	−3.80	6.36	0.41	0.67
Hands-on	0.20	9.14		
Simulation game-based	−1.94	11.83		

One-wayANOVA

this aspect, especially in the knowledge of the category of plastic and waste. Although the three teaching strategies did not make significant changes in pupils' ecological worldview attitudes, recycling attitudes, or behaviors in plastic waste recycling and management, the hands-on strategy achieved improvement in the pupils' ecological worldview attitudes and recycling attitudes and facilitated pupils' behavior in plastic waste recycling and management, although to an insignificant extent, while the simulation game-based strategy attained some enhancement in recycling attitudes as well.

The above results coincided with the literature review of different environmental education studies, which also suggested a number of elements which were associated with those teaching methods that led to those desired outcomes of environmental education (Stern, Powell, & Hill 2014). The benefit of direct teaching is that it involves school teacher engagement so that teachers with their own verbal and nonverbal communication styles act as role models in developing pupils' environmental literacy. The benefit of hands-on teaching is that it is experiential. That is, pupils can actively participate in a particular firsthand experience, which develops their skills and perceptions of self-efficacy. The benefit of simulation game-based teaching is that it allows pupils to have active and experiential engagement in real-world environmental problems (Stern et al., 2014).

One recommendation for the CEES study is to lengthen the time duration of the study for the sake of facilitating more significant changes in pupils' attitudes and behaviors (So 2014). Pupils could acquire new knowledge through either one of those teaching strategies easily in a short time, whereas it takes more time for their attitudes and behaviors to undergo significant change as they may already have inherent habits. Therefore, more time and human resources should be allocated to hands-on teaching and simulation game-based teaching, which are labor intensive and time-consuming, so as to change pupils' attitudes and intended behavior to a more significant extent. Also, some more education tools should be used.

For example, it was reported that the innovative 8-compartment plastic recycling bin (PRB) invented by CEES together with a poster and course intervention can facilitate pupils' change in knowledge and intended behavior (Chow, Cheng, Cheung, & So 2015).

8.5 Conclusion and Future Perspectives

To conclude, plastic waste problems are becoming increasingly serious all around the world. To cope with the situation, education is of the essence. Different countries have different education foci, but there is still room for improvement to change all people's knowledge, attitudes, and behaviors regarding plastic waste management. CEES has adopted three different teaching strategies, which are the direct teaching, hands-on, and simulation game-based strategies. It was found that all these three teaching strategies can significantly improve pupils' knowledge, while the hands-on and simulation game-based strategies can facilitate attitudes and behavior, though insignificantly. Therefore, it would be good if the PRB is to be employed as well as allocating more time and human resources to the hands-on and simulation game-based teaching strategies so as to facilitate more significant changes in pupils' attitudes and behaviors regarding plastic waste management.

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