Assessing and promoting eco-policies in Toyota City, Japan

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\textbf{ABSTRACT}

This study analyzes the relationships between four factors related to the eco-policies of Toyota City, Japan, and its citizens’ environmental awareness: i.e. residence (Toyota City citizens or noncitizens), time of research (2012, 2015, and 2018), sex, and age. Understanding these factors is crucial for the municipal government to assess its success or failure in terms of promoting its eco-policies and to identify and address the population segments that are unaware of these eco-policies. In this study, 997 respondents completed a questionnaire to analyze the above-stated factors and environmental awareness. The findings suggest that all factors are likely to be associated with environmental awareness of Toyota City’s eco-policies. That is, citizens tend to be more aware of the city’s eco-policies than noncitizens; respondents in the 2015 and 2018 studies tend to be more aware of the eco-policies than those in the 2012 study; men tend to be more aware of the eco-policies than women; and respondents over 30 years old tend to be more aware of the eco-policies than respondents under 30 years old. Following these findings, this study suggests the need to target women and citizens under 30 to promote eco-policies. Finally, some suggestions for the promotion of eco-policies were discussed.

\textbf{Introduction}

Environmental issues in Toyota City are being experienced and addressed, largely because of the Toyota Motor Corporation (TMC) and its affiliated companies’ industrial activities. Through frequent collaboration with these companies and other stakeholders (e.g. civil society), the municipal government elaborated on and implemented action plans to improve its environment throughout the 1990s and 2000s. With these efforts, the Japanese government designated Toyota City as an environmental model.
city (EMC) in 2009. These EMCs aim to become low-carbon societies (Toyota City 2009) to reduce greenhouse gas emissions through the development of renewable energy (Gillard and Lock 2017).

This study analyzes the relationships between four factors related to Toyota City’s eco-policies and its citizens’ environmental awareness: (1) residence (Toyota City citizens or noncitizens), (2) time of research (i.e., 2012, 2015, and 2018), (3) sex, and (4) age. Environmental awareness has been suggested to be a necessary precondition for pro-environmental behavior (Kemp, Rotmans, and Loorbach 2007; Larson and Edsall 2010; Sennes et al. 2012; Williams 2010). Therefore, examining environmental awareness is “conducive to making environmental policy and implementing local environmental management practices” (Lin et al. 2010, p. 286).

A previous study examined changes in citizens’ environmental awareness related to Toyota City’s eco-policies between 2012 and 2015 by focusing on differences in residence and time of research. The findings showed that environmental awareness significantly improved during the study period (Ito and Kawazoe 2016). Another study that examined relationships between socio-demographic factors, such as age, sex, and environmental awareness of the city’s eco-policies, indicated that age and sex were not significantly associated with environmental awareness. However, the sample size of that study was relatively small ($n = 145$); therefore, the result may not be generalizable. The current study is a comprehensive follow-up of these previous studies that analyzes the relationships between the above-stated factors and environmental awareness. Understanding the relationships between residence, time of research, and environmental awareness is important for municipal governments to assess whether they have succeeded or failed in terms of promoting their eco-policies. Understanding the relationships between socio-demographic factors, such as age and sex, and environmental awareness is also crucial because this understanding may enable municipal governments to identify which segments of the population recognize the city’s eco-policies and focus on addressing the population that are unaware of the eco-policies (Mmojieje 2015).

Toyota City deserves substantial attention in the study of eco-policies and ecocities for the following reasons. The city is well-known internationally because it is the location of TMC’s headquarters. TMC has supported Toyota City’s eco-policies, especially considering transportation and industry, by producing vehicles with low CO2 emissions and developing a new mobility car-sharing service system to realize a low-carbon society. The city also aims to become an international exemplar of an eco-city (particularly in Asia where industrialization and consequential environmental degradation is accelerating). Indeed, to inform the international community of its eco-policies and practices, Toyota City has hosted various international environmental conferences and forums, including the Junior United Nations Eco-Forum and the High-Level Symposium on Sustainable Cities, which was cohosted by the United Nations Department of Economic and Social Affairs. During these and other eco-related events, eco-items comprising the eco-policies were presented, which will be explained later. Despite the potential demonstrated by Toyota City’s eco-policies, few studies have assessed or intended to promote the city’s eco-policies. This study contributes to closing this research gap.
In the following sections, we discuss the term “environmental awareness” and describe the eco-items included in Toyota City’s eco-policies. We then review the existing literature concerning residence, time of research, and socio-demographic factors in relation to environmental awareness. The research methodology used in the study is then explained, followed by the results of our analysis. The results of the study are discussed and the conclusion is followed by an acknowledgement of the limitations and agendas for future research.

Environmental awareness

Environmental awareness is defined as the attention, concern, and sensitivity of the social groups or individuals to environmental problems (Sudarmadi et al. 2001; UNESCO-UNEP 1977). Environmental awareness is an important component of environmental knowledge and attitudes (Kollmuss and Agyeman 2002). Awareness helps to enhance knowledge and attitudes and then influence pro-environmental behavior (Levy, Orion, and Leshem 2016), while the most significant factor that restrains the development of environmentally conscious behavior is lack of awareness (Genc 2015, p. 106).

This awareness–knowledge–attitude–behavior model has been criticized because awareness or knowledge does not necessarily directly influence behavior. For instance, Robelia and Murphy (2012) argued that the model “has conceptual limitations as it oversimplifies components, and neglects the interactions of factors that may govern behavior” (p. 300). However, as Jensen (2002) observed, environmental knowledge is one of the preconditions toward pro-environmental behavior. Gifford and Nilsson (2014) also note that individuals would not be concerned about the environment or act pro-environmentally if they knew nothing about the problem or potential positive actions.

In the context of Toyota City and this study, the term “environmental awareness” refers to the awareness of the eco-items comprising the eco-policies: i.e. eco-policy awareness. At least some awareness of these eco-items is assumed necessary for individuals to act on them and demonstrate environmental behaviors that work toward achieving the eco-policies’ goals. These eco-items are explained in the following section.

Toyota city’s eco-policies

This study focuses on the following five principal eco-items that comprise Toyota City’s eco-policies: i.e. next-generation cars (NGCs), the heat island effect, Ecoful Town (a pavilion showcasing eco-living), smart houses, and eco-family cards or eco-points.

Next-generation cars

The NGCs include electric vehicles (EVs), hybrid EVs (HEVs), and plug-in hybrid vehicles (PHVs), which TMC has a strategic focus on manufacturing for
An HEV has an electric motor and battery pack in addition to the standard internal combustion engine (ICE). The battery in an HEV is lighter and smaller than that in a pure EV because the ICE produces most of the power to drive the HEV (van Woo et al. 2012). A PHV is similar to an HEV except that it has a larger rechargeable battery that can be charged by both the vehicle’s ICE and by a plug-in electrical outlet. Thus, a PHV can greatly extend an original ICE’s driving range by two to four times with the same amount of gasoline (van Woo et al. 2012). The market of NGCs is expected to grow rapidly because they produce significantly less CO2 emissions and are increasingly subsidized by many governments pursuing low-carbon societies (Woodcock 2012) including Toyota City.

**Ecoful town**

Ecoful Town was established in 2012 to promote eco-policies and to improve citizens’ relevant environmental awareness and knowledge. Ecoful Town is a pavilion showcasing eco-living that demonstrates how Toyota City tackles challenges and elaborates on eco-strategies toward a low-carbon society. Eco-attractions like Ecoful Town provide an ideal setting for engaging people with ecological issues holistically (Dunkley 2016). Ecoful Town visitors can have hands-on experiences, such as riding in an NGC and visiting a smart house. Involvement and personal experience are important factors that positively affect behavioral changes (Griffin and O’Cass 2004); therefore, this kind of eco-learning is expected to enable individuals to actively participate in firsthand solutions directly related to real-world environmental problems (Blair 2009; Schelly et al. 2012; Stern et al. 2014; Wals 1996).

**Heat island effect**

The heat island effect is a phenomenon where temperatures in urban areas are higher than those of suburban areas, which is caused by high population densities, developed industries, car use, congestion, tall buildings, asphalt roads, and cement squares (Gao et al. 2015). Greening (e.g. creating urban green spaces) is a measure taken to mitigate the urban heat island effect (Karuppannan et al. 2013) because plants absorb CO2 and heat, which helps to stabilize temperatures. The municipal government has greened the urban center by 14.2% since 2009 and aims to reach 20% through implementing measures such as rooftop and wall greening and installing water-retentive pavements (Ito and Kawazoe 2016).

**Smart houses**

Smart houses are residential buildings that pursue energy saving and the reduction of CO2 gas emissions using renewable energy sources and monitoring energy consumption (Kim et al. 2015). Smart houses are “the integration of technology and services through home networking for a better quality of living” (Robles and Kim 2010, p. 37). As Al-Sumaiti et al. (2014) note, the primary objectives of a smart home are to increase home automation, facilitate energy management, and reduce environmental
emissions. The Toyota City smart houses are characterized by their home energy management systems (HEMS) that can monitor the building’s energy generation and consumption.

**Eco-family cards/eco-points**

To popularize its eco-policies among citizens, Toyota City promoted an eco-family card with eco-points. When registered citizens purchase an ecological product with their eco-family card at a green-affiliated store or recycle something at a designated place, they can receive eco-points that can be exchanged for certain goods, such as toilet paper, garbage bags, stationery, bus tickets, or gift certificates. Toyota City has been working on increasing the number of green-affiliated stores to further popularize the use of eco-points and promote its eco-policies (Ito 2014).

**Factors: differences in residence, time of research, age, and sex**

**Residential and time differences**

Eco-policies in general aim to increase the citizens’ awareness of environmental issues and encourage pro-environmental behaviors to address these issues; therefore, it is important to examine the citizens’ awareness of eco-policies compared with noncitizens. In addition, conducting comparative research studies over time or periodically is important for assessing environmental awareness because otherwise it remains unclear whether citizens improve, retain, or deteriorate awareness over time (Rioux and Pasquier 2013; Schneller 2008). In this context, previous studies examined environmental awareness of the eco-policies in different years as well as differences in awareness by residency: i.e. (1) how citizens’ and noncitizens’ awareness of eco-policies changed during the research period (2012–2015) and (2) how awareness differed between citizens and noncitizens. The findings suggest that Toyota City’s promotional activities may have been effective in increasing awareness of its eco-policies among its citizens. Awareness of the city’s eco-policies was significantly higher among citizens in 2015 than in 2012 and was significantly higher than among noncitizens in either period.

The most significant change among individual eco-items was related to Ecoful Town. Therefore, it may be the case that awareness had increased after visiting Ecoful Town. The establishment of Ecoful Town was arguably a driving force in communicating Toyota City’s eco-policies to its citizens (Ito and Kawazoe 2016). There were no significant differences in the citizens’ awareness of eco-items, such as smart houses and the heat island effect, during the study period.

One possible reason why awareness of smart houses or the heat island effect was not significantly higher among citizens than noncitizens may be that they were promoted nationwide, whereas Ecoful Town is unique to Toyota City. The study indicates that there may be an opportunity for Toyota City to take advantage of the large increase in awareness of Ecoful Town to promote other eco-items, i.e. eco-industries, by establishing substantial sections within Ecoful Town to showcase these alternative eco-items.
Age and sex

Previous studies have not produced evidence to indicate a consistent pattern of the influence of age on environmental awareness. Cheung et al.’s (2015) Hong Kong study suggests that environmental knowledge decreases as age increases: i.e. “younger people have generally had more opportunities to receive environmental-related information through informal and formal education in schools … through digital media, such as Facebook and Twitter, all of which have heavily been used as channels to promote environmental issues” (p. 517).

In contrast, Robelia and Murphy’s (2012) US research suggests that adults in the age group of 35 to 65 years are more knowledgeable than those under 35 years old. A study conducted by Aoyagi-Usui, Vinken, and Kuribayashi (2003) in Japan also suggests that age and eco-awareness and eco-behavior are correlated: i.e. as age increases, eco-awareness also increases. According to Shen and Saijo’s (2008) Shanghai study, the older generations are more concerned about the environment than are the younger generations.

Some other studies show no statistically significant difference between age and environmental knowledge or behavior (for an Indian example, see Hassan and Ratnakar 2012; for a German example, see Liefländer and Bogner 2014; for an American example, see Newman and Fernandes 2016).

As with age, previous studies have not indicated a consistent pattern for the influence of sex on environmental awareness. Some studies suggest that men are more likely to have more environmental knowledge than do women, while other studies have suggested the opposite. For instance, studies in the US (Robelia and Murphy 2012), Brazil (Bortoleto et al. 2012), Hong Kong (Cheung et al. 2015), and Israel (Levy, Orion, and Leshem 2016) found that men were more knowledgeable about environmental issues. However, studies in Turkey (Tayci and Uysal 2012), Pakistan (Awan and Abbasi 2013), and Japan (Aoyagi-Usui, Vinken, and Kuribayashi 2003) indicated that women have better knowledge about environmental issues than do men.

Based on their study on environmental concerns and behavior in the US, Newman and Fernandes (2016) argued that women were more likely “to be more concerned about the environment yet know less about the causes and solutions to environmental issues [than men do]” (p. 169). Kollmuss and Agyeman (2002) also note that women may be less knowledgeable than men, but they express greater concern about addressing environmental issues.

A previous study that examined the relationships between socio-demographic factors and environmental awareness related to Toyota City’s eco-policies showed no significant associations between them. However, the sample size of this previous study was relatively small (n = 145) and the results may not be generalizable.

The literature review shows inconsistent results in correlations between some socio-demographic factors, such as age and sex, on environmental awareness, knowledge, attitudes, and behavior. This inconsistency may derive from place of residence, cultural contexts, or research methods (Xiao and McCright 2007). Given the importance of looking into these correlations on a case-by-case basis because there appears to be differences based on place of residence, cultural contexts, or research methods,
it is important for Toyota City to understand the possible relationships among these factors at a local scale. As mentioned previously, it is important for municipal governments to understand these relationships to assess whether it has succeeded or failed in terms of promoting its eco-policies. Understanding the relationships between these socio-demographic factors is also crucial because it may enable municipal governments to identify which population segments recognize aspects of environmental awareness and focus on addressing the demands of the target population that are unaware of the eco-policies. The next section describes the research methodology.

### Methodology

#### Questionnaire

Three face-to-face street questionnaires were administered for this study in 2012, 2015, and 2018. Questionnaires are one of the available methods for obtaining reliable information on citizens’ current awareness and behaviors regarding eco-activities (McKenzie-Mohr 2012). The questionnaire was constructed based on relevant literature reviews and previous studies (Ito 2014; Ito and Kawazoe 2016, 2017). The questions included in the questionnaire are listed in Table 1.

#### Sample

Over 1000 individuals completed the questionnaires in this study, 997 of whom completed all necessary items. Only completed questionnaires were used in this analysis. The study took place in and around the Toyota City Station in November 2012, June 2015, and May 2018. This location was selected because approximately 90% of citizens reside in the city center where the station is located. Respondents were approached by one of the authors or one of the lead author’s students, who explained that they were researching knowledge of Toyota City’s eco-policies. Verbal consent was provided by all the respondents. One of the authors consolidated the data and transcribed them using Excel software (Microsoft, Redmond, WA, USA).

#### Data analysis

The collected data were analyzed with the use of Stata statistical software (version 14.0; Stata Corp, College Station, TX, USA) to test which variables were significantly associated with each eco-item. We used a logistic or Poisson regression adjusted by these variables. We also calculated the sum of “Yes” answers to each of the survey questions listed in Table 1, placed the general descriptive statistics of the research

| Survey questions |
|------------------|
| Q1. Do you know about next-generation cars? |
| Q2. Do you know about the heat island effect? |
| Q3. Do you know about Ecoful Town? |
| Q4. Do you know about smart houses? |
| Q5. Do you know about eco-points? |
participants’ residence, research year, age, and sex in Table 2, and regressed the sum to the explanatory variables listed in Table 3 based on Poisson regression. The sum of “Yes” answers reflects the citizens’ “overall” environmental knowledge of the eco-policies. The odds ratio (OR) of the logistic regression is a statistical measure that compares the likeliness of occurrence of an event between two cases. If the calculation results in an OR greater than 1.00, there is a higher likeliness of occurrence between the two factors, and if it is less than 1.00, there is a lesser likeliness of occurrence. For example, with the NGCs in the present study, the OR of participants aged 20 years old or older exceeded 1.00. This means that a respondent aged 20 years old or older was likely to give a positive answer for the question on item NGCs, compared with a respondent aged under 20 years. The incidence rate ratio of Poisson regression is the relative ratio of two incidence rates for an event between two cases.

Results

As opposed to being a noncitizen, being a Toyota City citizen is significantly associated with three eco-items: i.e. Ecoful Town, eco-points, and overall environmental awareness (i.e. all summed eco-items). This may be because Ecoful Town and eco-points are unique to Toyota City, whereas NGCs, smart houses, and the heat island effect are known at a national level with information about these items available in other locations throughout Japan.

As compared with the 2012 respondents, the 2015 respondents were significantly associated with Ecoful Town, eco-points, and overall environmental awareness, while the 2018 respondents were significantly associated with NGCs, Ecoful Town, smart houses, the heat island effect, and overall environmental awareness. The fact that the 2018 respondents were associated with eco-points coincides with the recent slowing rate of increase in the number of eco-point users. Eco-points started in 2009 and quickly gained users, arguably because subsidies for eco-products were partly acquired using eco-points. However, the rate of increase has been diminishing in the last few years, although the number of eco-points is still increasing.

Men were also significantly associated with NGCs and overall environmental awareness. Given that the other eco-items are not significantly associated according
Table 3. Factors and environmental awareness.

| Explanatory variable | NGCs OR (95% CI) | Ecoful Town OR (95% CI) | Heat island effect OR (95% CI) | Smart houses OR (95% CI) | Eco-points OR (95% CI) | Sum of “yes” IRR (95% CI) |
|----------------------|------------------|--------------------------|-------------------------------|--------------------------|------------------------|---------------------------|
| Residence (Ref. noncitizens) |                  |                          |                               |                          |                        |                           |
| Citizens             | 0.92 (0.69–1.23) | 2.58 (1.94–3.43)         | 0.98 (0.74–1.29)              | 1.15 (0.87–1.52)         | 1.51** (1.13–2.02)    | 1.15** (1.06–1.26)        |
| Year (Ref. 2012)     |                  |                          |                               |                          |                        |                           |
| 2015                 | 0.97 (0.68–1.39) | 3.66** (2.50–5.37)      | 1.05 (0.74–1.48)              | 0.96 (0.68–1.35)         | 3.34** (2.32–4.81)    | 1.28** (1.14–1.44)        |
| 2018                 | 8.37*** (5.11–13.71) | 2.99** (1.89–4.72)    | 3.02** (1.94–4.68)            | 0.45** (0.29–0.70)       | 0.87 (0.55–1.38)     | 1.38** (1.20–1.59)        |
| Sex (Ref. women)     |                  |                          |                               |                          |                        |                           |
| Men                  | 1.31* (1.00–1.71) | 1.03 (0.80–1.34)        | 1.25 (0.97–1.62)              | 1.19 (0.92–1.53)         | 1.23 (0.94–1.60)     | 1.08* (1.00–1.17)         |
| Age (Ref. 10s)       |                  |                          |                               |                          |                        |                           |
| 20s                  | 1.51* (1.01–2.25) | 0.89 (0.61–1.30)        | 1.01 (0.70–1.48)              | 1.00 (0.69–1.45)         | 1.69** (1.16–2.48)   | 1.09 (0.96–1.23)          |
| 30s                  | 2.45** (1.58–3.82) | 1.43 (0.93–2.19)        | 1.98** (1.29–3.03)            | 1.96** (1.29–2.96)       | 2.78** (1.80–4.29)   | 1.42** (1.25–1.62)        |
| 40s                  | 3.06** (1.92–4.86) | 1.24 (0.78–1.95)        | 1.52 (0.97–2.36)              | 1.64** (1.06–2.54)       | 2.86** (1.79–4.56)   | 1.38** (1.20–1.59)        |
| 50 or over           | 2.14** (1.47–3.13) | 1.77** (1.24–2.53)      | 1.92** (1.35–2.73)            | 1.48* (1.05–2.08)        | 3.56** (2.46–5.15)   | 1.42** (1.27–1.58)        |

CI: confidence interval; OR: odds ratio of logistic regression.
Sum of the number of “yes” odds ratio of logistic regression.
IRR: Incidence rate ratio of Poisson regression; "p < .05, **p < .01.
to the respondents’ sex, the NGCs likely play a crucial role in achieving men’s significant overall environmental awareness. Being in one’s 20s was significantly associated with NGCs and eco-points, but not significantly associated with overall eco-awareness. Being in one’s 30s was significantly associated with NGCs, smart houses, eco-points, the heat island effect, and overall eco-awareness. Being in one’s 40s was significantly associated with NGCs, smart houses, eco-points, and overall eco-awareness. Being in one’s 50s or older was significantly associated with NGCs, Ecoful Town, smart houses, eco-points, the heat island effect, and overall eco-awareness. These results suggest that age may matter in terms of eco-awareness: i.e. the older respondents become, the more they become aware of the different eco-items in the eco-policies.

Discussion, implications, and suggestions

The first part of the study results (residence and time of research) suggests that the municipal government’s intervention to promote eco-awareness was effective. Citizens are more likely to be aware of eco-policies than are noncitizens and recent respondents were more aware than past respondents. The second part of the study results (sex and age) indicates that male respondents were more likely to be aware of the eco-policies than were female respondents, and older respondents were more likely to be aware of the eco-policies than were younger respondents. While the first part of the study results is praiseworthy, the second part indicates that several issues remain to be addressed to further promote eco-policies. The second part of the study on socio-demographic factors suggests that female and younger respondents should be targeted to further promote the eco-policies because they are less likely to be aware of them.

Regarding the improvement of female citizens’ eco-awareness, NGCs appear to be a bottleneck. Approximately half of Japanese female drivers used a light vehicle called Kei (62% of Kei drivers are women). These drivers seem to prefer Kei to NGCs in part because a Kei is cheaper to purchase than NGCs or even ordinary gasoline vehicles (Ito 2017a, 2017b, 2017c). Given that NGCs are part of Toyota City’s eco-policies, however, the municipal government should encourage female citizens to be aware of and drive NGCs.

Although developing cheaper NGCs is what industry, especially TMC, should work on, the municipal government can inform its citizens of positive aspects of NGCs. According to a previous study, citizens tend to decide whether to take actions on eco-items (or not) based on economic (rather than environmental) incentives (Ito 2017a, 2017b, 2017c). Although NGCs are more expensive to produce than gasoline cars (Sperling 2018), they require substantially less maintenance costs (Kester 2018) and acquire long-term economic advantage over time (Ohta et al. 2013), with further probable saving in fuel costs, as “gasoline prices are still expected to increase” (Krause et al. 2016, p. 742). Indeed, according to a survey study conducted by Honda Access (2018), a branch of the Honda Motor Corporation, although female Japanese drivers regard the price as the most important factor in purchasing a car, approximately one-fourth of the total respondents regretted not considering fuel costs.
Therefore, “one way [for the municipal government] to foster changes in habits is to provide information indicating that … a shift from conventional car use to a new style of car use (i.e. purchase of NGCs) is more economical in the middle/long term, which saves money” (Ohta et al. 2013, p. 452). This strategy is applicable to encourage female citizens to be more aware of and drive NGCs because they consider the economic aspects of cars to be important.

To achieve this objective, we suggest that the municipal government take advantage of a partnership with areas of the private sector that attract women. For instance, the municipal government has been working with Starbucks employees to provide eco-related workshops, such as making sleeves using recycled materials and promoting “cool sharing” (i.e. sharing an air-conditioned room with others to save energy) and “light down” (use of little light and electricity or only candles). Since most of the participants to the Starbucks events are young women, the municipal government should take advantage of this partnership and inform these female citizens of the above-stated benefits of driving NGCs.

Considering that the younger respondents may seem less aware of eco-policies than are older respondents, it is common to first rely on environmental education (EE) in formal schooling. EE in schools is often suggested as a way to improve environmental awareness, knowledge, attitudes, and behavior (de Carvalho and Leite 2016; Ernst, Blood, and Beery 2017; Fishman 2005; Gifford and Nilsson 2014; Hungerford and Volk 1990; Jose, Patrick, and Moseley 2017; Karatas and Gürbüz 2016; Lubomira 2004; Schild 2016; Varela-Losada et al. 2016). For instance, Gürdüz, Dagli, and Aslanova (2015) observed that EE is the most effective method to raise environmental awareness. Martinis et al. (2018) also commented that EE is one of the most important aspects of global, national, and local environmental policies. There is a great need for further awareness and education because, although responsible and environmentally sensitive citizens can only originate from environmentally aware young people, knowledge about the behavior and perceptions of young people is limited (Martinis et al. 2018).

Several studies have suggested that experiential learning, including project-based learning (PBL) and field trips, may be an effective way to increase environmental awareness (Genc 2015; Griffin and O’Cass 2004; Karatas and Gürbüz 2016; Schelly et al. 2012; Stern et al. 2014; Thorburn 2017). PBL is a constructive approach that requires students to be responsible for their decisions in solving real-world problems (Genc 2015). A field trip is defined as “a trip arranged by the school and undertaken for educational purposes, in which the students go to places where the materials of instruction may be observed and studied directly in their functional setting” (Krepel and Duvall 1981, p. 7). Experiential learning provides the students with unique and valuable opportunities by connecting sociocultural and natural components (Dunkley 2016). To increase motivation in addressing environmental issues, individuals need to be involved in tackling real-world environmental issues (Wals 1996). Experiential EE contributes to increasing students’ practical environmental literacy (Corscadden and Kevany 2017).

Experiential EE programs have already been implemented in many Toyota City schools. Following the EE guidelines set out by the municipal government, each
school is encouraged to implement its own initiatives and programs. For example, Tsuchihashi Elementary School transformed its building into a “smart house” with solar panels. To help students understand and address the heat island effect, Nishihirose Elementary School takes its students on four-day field trips annually to examine a particular habitat (for more details, see Ito and Kawazoe 2017). Experiential environmental learning such as these EE programs is effective in engaging students in addressing environmental issues partly because it provides a sense of self-efficacy and/or locus of control that allow students to feel that they can do something to protect the environment (Ampuero, Miranda, and Goyen 2015; de Vreede, Warner, and Pitter 2014; Ernst et al. 2017; Higgs and McMillan 2006; Schelly et al. 2012).

However, the current study suggested that the municipal government’s efforts to implement EE to promote its eco-policies may have not yet materialized (i.e. become visible) because the younger respondents under 30 years old are those who have received EE since 2009. This may be because the content of EE in formal schooling did not fully reflect the city’s eco-items. As Fishman (2005) observed, EE has traditionally “focused on teaching children about ‘pristine’ environments or ‘wilderness’” (p. 39), which may seem irrelevant to urban school children. Even if they discuss climate change in the classroom, e.g. the discussions may not include or focus on the topic of the heat island effect.

Among the eco-items comprising Toyota City’s eco-policies, the younger respondents tend not to be aware of Ecoful Town, smart houses, or the heat island effect, compared with the older respondents. For example, Ecoful Town exhibits smart houses and a main pavilion building greened with algae as a countermeasure against the heat island effect. Nonetheless, it does not seem to be an attractive place for young citizens to visit voluntarily. Regarding the smart houses, purchasing a new house or smart house may not be relevant to the lives of many young citizens yet because they cannot afford them. The heat island effect may not be interesting because younger citizens cannot take effective measures without their own houses or resources; therefore, it does not become a locus of control or self-efficacy that may enable them to believe that they can do something about improving their environment.

At school, it may be more feasible that teachers encourage students to elaborate on what they can suggest to their parents or other family members with resources (e.g. installing solar panels) or what they can do on their own (e.g. placing planters in available spaces or mizuuchi, i.e. sprinkling water on the street in front of their houses in an attempt to lower temperatures). Giving students assignments to consider why these specific eco-items were selected as part of Toyota City’s eco-policies may also be effective.

Given that Ecoful Town accommodates all the aforesaid eco-items comprising the eco-policies, it is recommended that the municipal government more strongly encourage all schools to take students on field trips to Ecoful Town in the experiential EE programs. Many schools currently take their students to Ecoful Town as part of social and/or science study tours, but some do not. These tours would likely help students improve their eco-awareness about the eco-items comprising the eco-policies.
Limitations and future research

Several limitations were present in this study. In particular, the study used self-reported awareness and participants were not asked to provide a definition of any item to explore their level of awareness. Therefore, this study is susceptible to social desirability bias in the questionnaire responses. However, it is not feasible to obtain much more detail on the study participants’ individual environmental awareness and understanding using a face-to-face on-street questionnaire without costly and intrusive measures.

Another limitation of the study is the scope of the questions. We asked about specific eco-items concerning Toyota City’s eco-policies instead of general environmental awareness. It is worth acknowledging that citizens may have some awareness of environmental issues that are not revealed by the questions in this study. We also did not ask respondents how they became aware of certain eco-items. For instance, how did those who were aware of smart houses become aware of them? Was it through Toyota City’s promotional activities, Ecoful Town, or a housing company’s advertisements? Also, how did female citizens become less aware of NGCs? Rather than the NGCs themselves, it may have been the involvement of female citizens in high-value purchases that drove the results. These pieces of information would help the municipal government to identify effective communications to inform its citizens of the eco-items. Thus, future research should ask the respondents how they became aware of certain eco-items or not and how they acted or did not act on these items.

Conclusion

This study analyzed the relationships between environmental awareness of Toyota City’s eco-policies and residence, time of research, age, and sex to identify and address segments of the population that are aware or unaware of Toyota City’s eco-policies. Regarding the relationships between residence, time of research, and environmental awareness, citizens were more likely to be aware of eco-policies than are noncitizens and respondents in recent years were more aware than earlier respondents. This suggests that the municipal government’s intervention during the research period was, at least to some extent, successful in terms of improving its citizens’ awareness of eco-policies. Concerning associations between age, sex, and environmental awareness, male respondents were more likely to be aware of eco-policies than female respondents, and older respondents were more likely to be aware of eco-policies than do younger respondents.

Given that citizens tend to decide whether to take actions on eco-items based on economic incentives and many female drivers feel that they should consider fuel costs in purchasing a car, the municipal government should take measures to inform its female citizens of the economic benefits of NGCs. This study suggests extending the current collaboration with Starbucks, which may facilitate promoting NGCs because many Starbucks customers and eco-related workshop participants are women. Experiential EE was also suggested for the improvement of younger citizens’ environmental awareness. While many schools have taken initiative and implemented EE, the municipal government’s efforts to promote its eco-policies through EE does not
appear to have been effective yet because the younger respondents under 30 years old tended to be less aware of the eco-items comprising the city’s eco-policies. This study suggests integrating these eco-items into EE inside and outside the classroom. With the support of TMC and other stakeholders (e.g. civil society), Toyota City has the potential to become an international exemplar of an eco-city. This study indicates that addressing younger and female citizens may facilitate the achievement of this objective.

The eco-items that comprise Toyota City’s eco-policies, such as NGCs, the heat island effect, and smart houses, are within general eco-policy themes, including developing transportation, the urban center, and public welfare and livelihood. Therefore, the identified issues and proposed solutions to address these issues in this study may also be common and transferable to other eco-cities.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Al-Sumaiti, A. S., M. H. Ahmed, and M. M. Salama. 2014. “Smart Home Activities: A Literature Review.” Electric Power Components and Systems 42 (3–4): 294–305. doi:10.1080/15325008.2013.832439

Ampuero, D. A., C. Miranda, and S. Goyen. 2015. “Positive Psychology in Education for Sustainable Development at a Primary-education Institution.” Local Environment 20 (7): 745–763. doi:10.1080/13549839.2013.869199

Aoyagi-Usui, M., H. Vinken, and A. Kuribayashi. 2003. “Pro-environmental Attitude and Behaviors: An International Comparison.” Human Ecology Review 10 (1): 23–31. doi: 10.1.1.472.9444

Awan, U., and A. S. Abbasi. 2013. “Environmental Sustainability through Determinism the Level of Environmental Awareness, knowledge and Behavior among Business Graduates.” Research Journal of Environmental and Earth Science 5 (9): 505–515. doi:10.7176/JJEES

Blair, D. 2009. “The Child in the Garden: An Evaluative Review of the Benefits of School Gardening.” The Journal of Environmental Education 40 (2): 15–38. doi:10.3200/JOEE.40.2.15-38

Bortoleto, A. P., K. H. Kurisu, and K. Hanaki. 2012. “Model Development for Household Waste Prevention Behavior.” Waste Management 32 (12): 2195–2207. doi:10.1016/j.wasman.2012.05.037

Cheung, L. T. O., L. Fok, E. P. K. Tsang, W. Fang, and H. Y. Tsang. 2015. “Understanding Residents” Environmental Knowledge in a Metropolitan City of Hong Kong, China.” Environmental Education Research 21 (4): 507–524. doi:10.1080/13504622.2014.898247

Corscadden, K. W., and K. Kevany. 2017. “The TREEhouse: A Hybrid Model for Experiential Learning in Environmental Education.” Applied Environmental Education & Communication 16 (1): 56–67. doi:10.1080/1533015X.2017.1282334

De Carvalho, M. R. B., and J. C. Leite. 2016. “Reverse Logistics and Selective Waste Collection: Environmental Education as an Auxiliary Tool on the Process of Recycling Domestic Electronic Waste.” Business Management Dynamics 5 (12): 22–41.

De Vreede, C., A. Warner, and R. Pitter. 2014. “Facilitating Youth to Take Sustainability Actions: The Potential of Peer Education.” The Journal of Environmental Education 45 (1): 37–56. doi:10.1080/00958964.2013.805710
Dunkley, R. A. 2016. “Learning at Eco-attractions: Exploring the Bifurcation of Nature and Culture through Experiential Environmental Education.” *The Journal of Environmental Education* 47 (3): 213–221. doi:10.1080/00958964.2016.1164113

Ernst, J., N. Blood, and T. Beery. 2017. “Environmental Action and Student Environmental Leaders: Exploring the Influence of Environmental Attitudes, locus of Control, and Sense of Personal Responsibility.” *Environmental Education Research* 23 (2): 149–175. doi:10.1080/13504622.2015.1068278

Fishman, L. 2005. “The Effects of Local Learning on Environmental Awareness in Children: An Empirical Investigation.” *The Journal of Environmental Education* 36 (3): 39–50. doi:10.3200/JOEE.36.3.39-50

Gao, R. D., Q. F. Xu, X. M. Li, and H. Wang. 2015. “Influence of Urban Heat Island Effect on Sulphate Attach on Concrete.” *Materials Research Innovations* 19:229–235. doi:10.1179/1432891715Z.0000000001972

Genc, M. 2015. “The Project-based Learning Approach in Environmental Education.” *International Research in Geographical and Environmental Education* 24 (2): 105–117. doi:10.1080/10382046.2014.993169

Gifford, R., and A. Nilsson. 2014. “Personal and Social Factors That Influence Pro-environmental Concern and Behavior: A Review.” *International Journal of Psychology* 49 (3): 141–157. doi:10.1002/ijop.12034

Gillard, R., and K. Lock. 2017. “Blowing Policy Bubbles: Rethinking Emissions Targets and Low-carbon Energy Policies in the UK.” *Journal of Environmental Policy & Planning* 19 (6): 638–653. doi:10.1080/1523908X.2016.1266931

Griffin, D., and A. O’Cass. 2004. “Social Marketing: Who Really Gets the Message?” *Journal of Nonprofit & Public Sector Marketing* 12 (2): 129–147. doi:10.1300/J054v12n02_07

Gürdüz, S., G. Dagli, and F. Aslanova. 2015. “Comparative Evaluation of the Environmental Consciousness Levels of High School Students in Northern Cyprus, Turkey, and Azerbaijan.” *The Anthropologist* 22 (3): 622–635.

Hassan, D., and G. P. Ratnakar. 2012. “A Study of Relationship between Environmental Awareness and Scientific Attitudes among Higher Secondary Students.” *Indian Journal of Applied Research* 1 (12): 57–61. doi:10.15373/2249555X/SEP2012/20

Higgs, A. L., and V. M. McMillan. 2006. “Teaching through Modeling: Four School Experience in Sustainability Education.” *The Journal of Environmental Education* 38 (1): 39–53. doi:10.3200/JOEE.38.1.39-53

Honda Access. 2018. *Research on female drivers’ car lives.* Tokyo: Honda Motor Corporation.

Hungerford, H. R., and T. L. Volk. 1990. “Changing Learner Behavior through Environmental Education.” *Journal of Environmental Education* 21:257–270. doi:10.1080/00958964.1990.10753743

Ito, H. 2014. “Toyota as an Environmental Model City: Is Its Eco-policy Recognized?” *Journal of Sustainable Development* 7 (2):70–77. doi:10.5539/jsd.v7n2p70

Ito, H., and N. Kawazoe. 2016. “A Review of Toyota City’s Eco-policy: Changes in Citizens’ Awareness between 2012 and 2015.” *Urban Research and Practice* 11 (1):19–36. doi:10.1080/17535069.2016.1254676

Ito, H., and N. Kawazoe. 2017. “The Associations between Socio-demographic Factors and Environmental Knowledge in the City of Toyota, Japan.” *Applied Environmental Education & Communication* 17 (3): 215–228. doi:10.1080/1533015X.2017.1395718

Ito, H. 2017a. “Underlying Gaps between Environmental Knowledge and Behavior in the City of Toyota.” *Asian Social Science* 13 (1): 82–88. doi:10.5539/ass.v13n1p82

Ito, H. 2017b. “Underlying Gaps between Environmental Knowledge and Behavior in the City of Toyota: Phase II.” *Asian Social Science* 13 (3): 117–125. doi:10.5539/ass.v13n3p117

Ito, H. 2017c. “Underlying Gaps between Environmental Knowledge and Behavior in the City of Toyota: Phase III.” *Asian Social Science* 13 (10): 23–30. doi:10.5539/ass.v13n10p23

Jensen, B. B. 2002. “Knowledge, action and Pro-environmental Behavior.” *Environmental Education Research* 8 (3): 325–334. doi:10.1080/13504620220145474
Jose, S., P. G. Patrick, and C. Moseley. 2017. “Experiential Learning Theory: The Importance of Outdoor Classrooms in Environmental Education.” *International Journal of Science Education, Part B* 7 (3): 269–284. doi:10.1080/21548455.2016.1272144

Karatas, A., and O. A. Gürbüz. 2016. “Environmental Education as a Tool for Increasing Environmental Awareness of Vocational School Students.” *The Anthropologist* 23 (3): 378–384. doi:10.1080/09720073.2014.11891958

Karuppannan, S., Z. Baharuddin, A. Sivam, and C. Daniels. 2013. “The Sustainable Design and Renewal of Water’s Edge Public Spaces in the Asia-Pacific Region: Sydney, Hong Kong and Singapore.” *Journal of Sustainable Development* 7 (1):1–16. doi:10.5539/jsd.v7n1p1

Kemp, R., J. Rotmans, and D. Loorbach. 2007. “Assessing the Dutch Energy Transition Policy: How Does It Deal with Dilemmas of Managing Transitions?.” *Journal of Environmental Policy & Planning* 9 (3-4): 315–331. doi:10.1080/15239080701622816

Kester, J. 2018. “Governing Electric Vehicles: Mobilizing Electricity to Secure Automobility.” *Mobilities* 13 (2): 200–215. doi:10.1080/17450101.2017.1408984

Kim, S.-K., S.-K. Lee, H. J. Kwon, and M. Ahn. 2015. “Zero-energy Home Development in Korea: Energy-efficient and Environmentally Friendly Design Features and Future Directions.” *Housing and Society* 42 (3): 222–238. doi:10.1080/08882746.2015.1121682

Kollmuss, A., and J. Agyeman. 2002. “Mind the Gap: Why Do People Act Environmentally and What Are the Barriers to Pro-environmental Behavior?.” *Environmental Education Research* 8 (3): 239–260. doi:10.1080/13504620220145401

Krause, R. M., B. W. Lane, S. Carley, and J. D. Graham. 2016. “Assessing Demand by Urban Consumers for Plug-in Electric Vehicles under Future Cost and Technological Scenarios.” *International Journal of Sustainable Transportation* 10 (8): 742–751. doi:10.1080/15568318.2016.1148213

Krepel, W. J., and C. R. Duvall. 1981. *Fieldtrips: a guide for planning and conducting educational experiences*. Washington DC: National Education Association.

Larson, K. L., and R. M. Edsall. 2010. “The Impact of Visual Information on Perceptions of Water Resource Problems and Management Alternatives.” *Journal of Environmental Planning and Management* 53 (3): 335–352. doi:10.1080/09640561003613021

Levy, A., N. Orion, and Y. Leshem. 2016. “Variables That Influence the Environmental Behavior of Adults.” *Environmental Education Research* 23 (3):1–19. doi:10.1080/13504622.2016.1148213

Liefländer, A. K., and F. X. Bogner. 2014. “The Effects of Children’s Age and Sex on Acquiring Pro-environmental Attitudes through Environmental Education.” *The Journal of Environmental Education* 45 (2): 105–117. doi:10.1080/00958964.2013.8755111

Lin, T., X. Guo, Y. Zhao, L. Pan, and L. Xiao. 2010. “A Study of Residents’ Environmental Awareness among Communities in a Peri-urban Area of Xiamen.” *International Journal of Sustainable Development & World Ecology* 17 (4): 285–291. doi:10.1080/13504509.2010.487995

Lubomira, D. 2004. “Environmental Education at Pre-School.” *International Research in Geographical & Environmental Education* 13 (3): 258–263. doi:10.1080/10382040408668520

Martinis, A., K. Kabassi, C. Dimitriadou, and G. Karris. 2018. “Pupils’ Environmental Awareness of Natural Protected Areas: The Case of Zakynthos Island.” *Applied Environmental Education & Communication* 17 (2): 106–123. doi:10.1080/1533015X.2017.1366883

McKenzie-Mohr, D. 2012. *Fostering sustainable behavior: an introduction to community-based social marketing*. British Columbia: New Society Publishers.

Mmojieje, J. 2015. “Strategies for Public Engagement on Environmental Matters: You Can Lead a Horse to Water. But Can You Make It Drink?” *Applied Environmental Education & Communication* 14: 232–245. doi:10.1080/1533015X.2015.1109485

Newman, T. P., and R. Fernandes. 2016. “A Re-assessment of Factors Associated with Environmental Concern and Behavior Using the 2010 General Social Survey.” *Environmental Education Research* 22 (2): 153–175. doi:10.1080/13504622.2014.999227
Ohta, H., S. Fujii, Y. Nishimura, and M. Kozuka. 2013. “Analysis of the Acceptance of Carsharing and Eco-cars in Japan.” International Journal of Sustainable Transportation 7 (6): 449–467. doi:10.1080/15568318.2012.688092

Rioux, L., and D. Pasquier. 2013. “A Longitudinal Study of the Impact of an Environmental Action.” Environmental Education Research 19 (5): 694–707. doi:10.1080/13504622.2012.749975

Robelia, B., and T. Murphy. 2012. “What Do People Know about Key Environmental Issues? A Review of Environmental Knowledge Surveys.” Environmental Education Research 18 (3): 299–321. doi:10.1080/13504622.2011.618288

Robles, R. J., and T. Kim. 2010. “Applications, systems and Methods in Smart Home Technology: A Review.” International Journal of Advanced Science and Technology 15:37–47. doi:10.2298/FUEE1603451D

Schelly, C., J. E. Cross, W. Franzen, P. Hall, and S. Reeve. 2012. “How to Go Green: Creating a Conservation Culture in a Public High School through Education, modeling, and Communication.” The Journal of Environmental Education 43 (3): 143–161. doi:10.1080/00958964.2011.631611

Sennes, V., S. Gombert-Courvoisier, F. Ribeyre, and M. Felonneau. 2012. “Citizens’ Environmental Awareness and Response at Local Level.” International Journal of Urban Sustainable Development 4 (2): 186–197. doi:10.1080/19463138.2012.694819

Stern, M. J., R. B. Powell, and D. Hill. 2014. “Environmental Education Program Evaluation in the New Millennium: What Do we Measure and What Have we Learned?” Environmental Education Research 20 (5): 581–611. doi:10.1080/13504622.2013.838749

Sudarmadi, S., S. Suzuki, T. Kawada, H. Netti, S. Soemantri, and A. Tri Tugaswati. 2001. “A Survey of Perception, knowledge, awareness, and Attitude in Regard to Environmental Problems in a Sample of Two Different Social Groups in Jakarta, Indonesia.” Environment, Development and Sustainability 3 (2): 169–183. doi:10.1023/A:1011633729185

Tayci, F., and F. Uysal. 2012. “A Study for Determining the Elementary School Students’ Environmental Knowledge and Environmental Attitude Level.” Procedia – Social and Behavioral Science 46: 5718–5722. doi:10.1016/j.sbspro.2012.06.504

Thornburn, M. 2017. “Moral Deliberation and Environmental Awareness: Reviewing Deweyan-informed Possibilities for Contemporary Outdoor Learning.” Journal of Adventure Education & Outdoor Learning 18 (1): 26–35. doi:10.1080/14729679.2017.1322000

Toyota City. 2009. Summary of action plans toward environmental model city. http://www.city.toyota.aichi.jp/division/an00/an06/1252190/02gaiyou.pdf

UNESCO-UNEP. 1977. “The Tbilisi Declaration.” Connect 3 (1): 1–8.

Varela-Losda, M., P. Vega-Marcote, U. Perez-Rodriguez, and M. Alvarez-Lires. 2016. “Going to Action? A Literature Review on Educational Proposals in Formal Environmental Education.” Environmental Education Research 22 (3): 390–421. doi:10.1080/13504622.2015.1101751

Van Woo, G. M. S., C. M. Mak, C. Y. Cheng, and J. Li. 2012. “The Conversion of a Hybrid Electric Vehicle into a Plug-in Hybrid Electric Vehicle.” Journal of International Council on Electric Engineering 2 (2): 178–186. doi:10.5370/JICEE.2012.2.2.178
Wals, A. E. J. 1996. “Back-alley Sustainability and the Role of Environmental Education.” *Local Environment* 1 (3): 299–316. doi:10.1080/13549839608725502
Williams, K. 2010. “Sustainable Cities: Research and Practice Challenges.” *International Journal of Urban Sustainable Development* 1 (1–2): 128–132. doi:10.1080/19463131003654863
Woodcock, M. 2012. “Steeling Ourselves for the Electric Vehicle Revolution.” *Ironmaking and Steelmaking* 39 (4): 254–257. doi:10.1179/0301923312Z.00000000064
Xiao, C., and A. M. McCright. 2007. “Environmental Concern and Sociodemographic Variables: A Study of Statistical Models.” *Journal of Environmental Education* 38 (2): 3–13. doi:10.3200/JOEE.38.1.3-14