A Study on the Plant Sketching Practice for the Enhancement of People's Intention for Pro–Environmental Behavior

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ABSTRACT

Background and objective: Many scholars agree that the key to mitigating the environmental crisis lies in altering human behavior. To better understand this linkage, it is crucial to identify the psychological determinants of one’s pro–environmental behavioral intention (PEB) and examine the process through which such behavior is generated. This study focuses on one such process, drawing of plants. We test whether visually representing plants by engaging in freehand drawing would influence actual behavioral intentions to improve the quality of our environment and whether this association is mediated by the key environment–psychological factors (attitude toward plants and affection to the natural environment).

Methods: To answer this question, we conducted a quasi–experiment with 235 students from selected colleges in Seoul by dividing them into control and treatment groups. The control group participated in regular outdoor activities during a field trip while the treatment group engaged in drawing of plants during the trip. Survey answers and drawings were analyzed to examine the effect of plant drawing practice on PEB and the mediative role of the psychological constructs.

Results: Our T–test and the partial least squares structural equation model (PLS–SEM) test revealed the following findings: (1) Engaging in plant drawing practice is more effective in developing positive attitudes toward plants and affection to the natural environment than engaging only in normative outdoor experience. (2) Analytical–observational drawings are influential to PEB by mediating through plant attitude, and expressive–subjective drawings are influential to PEB by mediating through environmental affect. (3) Gender was a critical factor in determining plant attitude, environmental attitude, and PEB.

Conclusion: In sum, the findings suggest that plant drawing experience has a significant impact on developing PEB, and thus, it can be an effective means to foster a biospheric mindset as well as nature–protective behavior.

Keywords: environmental affect, environmental psychology, pro–environmental behavioral intention, freehand plant drawing, plant attitudes

Introduction

Scholars agree that overcoming the current environmental crisis requires people’s responsible behavior toward the environment, and this pro-environmental behavior is associated with a deep sense of connection with nature (Schultz et al., 2004; Hinds and Sparks, 2008). The more we immerse ourselves in an experience with the natural environment, the deeper our psychological bond is with nature (Kaplan and Kaplan, 1989). Clearly, a large portion of our nature experience consists of interactions with plants because plants are the quintessential property of our ecosystem (Lewington, 1990; Diaz et al., 2006), and more fundamentally, they are the essential agency of the human-nature relationship (Van Der Veen, 2014). Thus, researchers have pondered upon the way in which our conservation behavior can be motivated and increased by interactions with plants (Wells and Lekies, 2006; Collado et al., 2013; Soga and Gaston, 2016; Lacoeuilhe et al., 2017).

Plants enrich our memories of the natural world with...
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The power to instill in others appreciation, emotions, and wonder (Ryan, 2013). Despite the importance of plants in human life and the ecosystem, people are increasingly disconnected from their daily interactions with plants because of the diminishing of green space (Pyle, 2002) and more indoor activities due in part to heavy usage of electronic media (Miller, 2005). Notably, younger generations' attitudes toward plants are seemingly apathetic due to infrequent exposure to plant-related experiences (Wandersee and Schussler, 1999; Uno, 2009; Fančovičová and Prokop, 2010). Lack of experience with observing, cultivating, and caring for plants results in insensitivity to the value of plants, and to a larger extent, loss of emotional attachment to the larger ecosystem (Kahn, 1997; Pyle, 2002; Turner et al., 2004). Thus, many researchers believe that young people's sensory interactions with plants through various types of hands-on experiences are imperative for environmental sustainability (Kahn, 1997; Miller, 2005; Lindemann-Matthies, 2006; Balding and Williams, 2016).

Among many approaches to fostering engagement with plants, 'drawing plants' is one of the least explored but has great potential to motivate biophilic attitudes and actions. Traditionally, especially in the biological research fields, drawing of living plants has been widely recognized as a method that enables learning of the taxonomy and morphology of plants (Reeds, 2004; Sanders, 2007). In particular, meticulous observational-investigative freehand drawing of a plant specimen has been identified as an essential learning tool for describing, interpreting, and identifying the natural world. Such a method is believed to lead to discovering the underlying general principles of natural phenomena (Dempsey and Betz, 2001). Besides natural science, the plant drawing method can reach a broader field of environmental studies. Indeed, researchers have demonstrated that the drawing of plants deepens the empathic connection to plants (Wandersee and Schussler, 1999) and develops a holistic view of the natural world (Babaian and Twigg, 2011).

Despite the purported potential of plant drawing in developing a cognitive and affective connection with nature, the scope of research into the role of plant drawing is very narrow in the existing literature. Only a few studies have explored the possibility of plant drawing as a methodology in the domain of environmental psychology or education (e.g., Loureiro and Dal-Farra, 2017; Villanueva and Villarroel, 2021), and moreover, the current literature regarding plant drawing is found mostly in biological studies (e.g., Dempsey and Betz, 2001), with a focus tangential to our discussions in this paper. In our study, we fill this gap in the literature by presenting scientific evidence that shows freehand plant drawing has a significant impact on developing people's environmental mindset, and further, altering their intention for pro-environmental behavior.

Based on the insights from previous studies, we broaden the scope of research by incorporating the elements of arts into the traditional approaches to environmental studies. We designed a theoretical model that captures the relationship between plant drawing and people's intentions for pro-environmental behavior (henceforth referred to as PEB), mediated by their attitudes toward plants and concern about the natural environment. In other words, our model hypothesizes the relations of three different variables as follows: plant drawing → mediators (plant attitude and environmental affect) → PEB. This conceptual model is validated via a statistical analysis, thus demonstrating the potential of plant drawing as a vehicle for alleviating the impact of wider environmental concerns. Detailed concepts and relations are demonstrated in the following sections.

Environmental affect and pro-environmental behavioral intention

Pro-environmental behavior is of the utmost concern in many environmental studies. It generally refers to the "actions that consciously seek to minimize one's negative impact on the natural world (Kollmuss and Agyeman, 2002, p. 240)." PEB is defined by a behavior that actually impact the environmental changes, such activities as recycling, use of public transport and advocating environmental protection actions, but its definition also includes one's intention to execute such actions (Stern, 2000). It has been documented in the literature that one of the significant psychological properties that engage in PEB is an affective (or emotional) factor (Kaplan and Kaplan, 1989; Chawla, 1999; Kals et al., 1999; Kaiser et al., 1999; Pooley and O'Connor, 2000; Hinds and Sparks, 2008; Liu and Lin, 2015; Villanueva
and Villarroel, 2021). Admittedly, an affective connection with the environment, henceforth referred to as environmental affect, is crucial in shaping one's positive attitudes towards the environment and his/her intention to act accordingly (Chawla, 1999). Environmental affect is defined as "one's enduring feelings about the environment, in particular, emotional reaction to environmental degradation (Liu and Lin, 2015, p.25)." This means that the more people feel a connection to nature, the greater the chances that they act proactively for the betterment of the environment.

Ajzen's (1985) Theory of Planned Behavior (TPB) provides an appropriate theoretical framework for understanding this relationship. TPB explains that the best predictor of an individual's actual behavior is his/her intention to engage in such behavior, and in turn, the intention is influenced by his/her attitude. Hence, when TPB is applied to the environmental studies, an intention for environmentally responsible behaviors is predicted by the attitude towards the environment (Lacarelli et al., 2021). Here, the attitude consists of affective, cognitive, and behavioral dimensions (Eagly and Chaiken, 1993). Among them, affective domain has been often addressed in the environmental-behavioral researches because the cognitive domain (knowledge) alone is not sufficient to produce changes in environmental attitude and thus behavior (Specca and Iozzi, 1984).

Extensive bodies of studies have upheld these theoretical propositions by providing empirical evidence of the impact of affective dimensions on the environmental attitude to the behavioral commitment within the TPB model. For example, Kaiser et al. (1999) accounted for multiple dimensions that constitute the attitude towards the environment, and suggested that the environmental affect is one of the critical concepts of the psychological constructs that influence ecological behavior. Hinds and Sparks (2008) tested the hypothesis that the sense of affective connection and identification with the natural environment would predict people's intentions toward PEB. The findings in these studies commonly demonstrate that the significant amount of variabilities in the behavioral intentions were explained by the factors related to the affective bond to nature. The present study embraces these findings and premises that the environmental affect is the significant predictor of actual nature protective behavior.

### Attitude toward plants and pro-environmental behavioral intention

Because of their ubiquity, plants have strong ties to human emotion. Sensory interactions with plants are likely to influence development of an attitude toward the environment. According to Ryan (2013), an act of describing plants goes beyond bringing up with its visual imageries; it further involves a sensory, bodily, and emotional mode of remembering. As such, botanical memory is not a pure cognitive construct in one's psyche but a complex interaction with corporeal senses (e.g., smell, taste, and touch), emotional impressions, and embodied memories of time and space. Therefore, it is reasonable to assume that one's attitude toward plants formed by interactions with plants is an important determinant of his/her environmental affect (e.g., Kahn, 1997; Kellert, 2002; Hinds and Sparks, 2008). Additionally, as was shown in the affect-PEB relations, the affect would determine the extent to which people would behave pro-environmentally.

Positive attitudes toward plants are formed by past and present exposure to plants (Lohr and Pearson-Mims, 2005; Fančovičová and Prokop, 2010; Çil, 2016). Previous empirical studies have examined close correlations between the positive attitudes toward plants and the degree to which people engage with plants. For example, Lohr and Pearson-Mim (2005) showed that both active (e.g., gardening, tree planting) and passive interaction with trees (e.g., taking classes, playing in parks) in childhood positively influence the sensitivity and commitment toward trees in adulthood. With this background, Fančovičová and Prokop (2010) have devised the Plant Attitude Scale (PAS) that measures people's attitudes toward plants. This assessment tool was used to examine whether having gardens and participating in outdoor activities focusing on plants are associated with positive attitudes towards plants. The results showed that the positive attitudes toward plants increased with the presence of plant-related programs. Applying PAS to experimental research, Çil (2016) reported that integrating instructional activities about plants derived from botany, chemistry, and art increased positive attitudes toward plants.

Findings in the past empirical studies suggest that a person's positive attitude toward plants not only influences environmental affect but also leads to behavioral changes.
For instance, Nord et al. (1998) found a significant correlation between the frequency of recreational activities in the forest and PEB, such as attending a public meeting concerning environmental problems or voting for/against politicians regarding their environmental issues. Zhang et al. (2014) demonstrated that exposure to visually attracting plants increased prosocial behaviors moderated by positive emotions. Whitburn et al. (2019) measured whether people’s participation in tree planting in a private garden or neighboring green space was associated with their psychological connection to nature as well as PEB. These findings in the literature have confirmed that people behave in environmentally responsible ways when they gain an emotional bond with nature through long-term or short-term experiences with plants. In particular, all these studies empirically support our thesis that a positive attitude toward plants is an essential stimulus for increasing the affective bond to nature and strengthening the behavioral intention to conserve an environment.

**Plant drawing and pro-environmental behavioral intention**

The aforementioned researches bring our attention to what kind of plant experience would instill emotional affinity to nature, and eventually, would inspire the intention to engage in conservational actions. Drawing on the positive effect of plant-related experience on the attitude-behavioral consistency toward the natural world, we hypothesize that freehand manual drawing of plants would increase the biophilic attitudes toward the natural environment and PEB. It has been documented that psychosomatic experiences of plants, which involve touching, observing, and smelling plants by letting people spend time exploring plants in gardens or parks, are effective methods for increasing the positivity of plant attitude (Çil, 2016). Many studies examined the experience-attitude relationship of plants based on 'normative' and passive stimuli, such as visual observations of plants, engaging in recreational activities in a forest, or participating in gardening, that have been replicated in the literature. However, relatively few studies have examined the role of more active engagement with plants, which potentially instills the affective dimension of nature with different modalities (Iared et al., 2016). As Strgar (2007) has argued, a different approach is desired that could bring new perspectives and knowledge. It is in this context that, in this study, we highlight one of the under-researched mechanisms that enable direct and visceral experience of the natural world: the act of drawing plants.

The empirical and theoretical underpinnings of the inclusion of the plant drawing method that form the basis of our study are reported in Fazio and Zanna’s (1981) and Millar and Millar’s (1996) research on attitude development. According to their studies, direct, active experiences with an object (e.g., playing with an object) are more likely to produce affective-based attitudes than indirect, passive experiences (e.g., reading or hearing about an object), which are associated with cognitive-based attitudes. These findings further suggest that affective-based attitudes predict intrinsically motivated behavior, in contrast to cognitive-based attitudes which relate more to extrinsically motivated behavior. In particular, Fazio and Zanna (1981) conclude that direct experiences engender attitudes that are more likely to lead to behavioral changes than do indirect experiences.

Therefore, the established theories indicate that direct experiences with live objects from nature—through activities such as careful observations and drawing of the objects—would strongly influence the shaping of an affective connection to the natural environment (e.g., Chipeniuk, 1995; Bogner, 1998; Wells, 2000; Dempsey and Betz, 2001; Duerden and Witt, 2010; Chorpening, 2014). In this study we define ‘drawing’ as a process of manual marking to produce images, the most basic and fundamental visualization technique for describing an object. Manual drawing is one of the means by which an investigator could move beyond initial assumptions about an object to focus on its physical details (Leslie, 1981; Dirnberger et al., 2005). Drawing also interacts with one’s analytical, communicational, and problem-solving inquiries (Lerner, 2007; Fan, 2015; Quillin and Thomas, 2015), and more importantly, deepens emotional apprehension of a subject through senses (Tarr, 2008; Chorpening, 2014).

Traditionally, plant drawing has been one of the basic tools used to train natural scientists to understand the morphology and identification of plants (Blunt and Stearn,
The positive role of plant drawing as a vehicle to observe, explore, and understand plants has been documented in recent studies. For example, Stagg and Verde (2018) examined the contribution of labeled drawings of plants, along with a written description of the plants, in identifying and recognizing the species' morphological characteristics. The results showed that drawings captured substantially more morphological information about the plants compared to written descriptions, partly due to participants' affective engagement in the drawing. In another study, Anderson et al. (2014) investigated whether young children's conceptual understanding of plant structure and functions would improve through drawing. The findings of the research showed that the drawing method allowed children to clarify their knowledge of plants, resulting in meta-cognitive growth.

Plant drawing contributes to gaining of an increased sense of biophilia and a multitude of interlacing attitudes of organisms, thus developing a "whole-brain thinking toward living systems" (Babaian and Twigg, 2011, p. 217). This insight serves as an inspiration for our research, as we examine the extent to which exploration of plants through drawing would facilitate people's affective bond with nature as well as its influence on people's PEB. The role of plant drawing has received attention by other researchers. For instance, Dirnberger (2005) asserts that introducing freehand plant drawing to a classroom "increases their familiarity, understanding, and positive attitudes regarding the natural environment (p. 38)." Balding and Williams's study (2016) suggests that drawing plants promotes an intimate relationship as well as an empathic connection with plants. Loureiro and Dal-Farra (2017) explored the relationship between young students' plant drawings and their environmental concerns. The result from this study showed that letting students design their artistic representation of plants allowed them to develop their individual expressions as well as deepen a more comprehensive assessment of their understanding of nature, and eventually, raise their own voices about the ecological environment. Grounded in the previous studies on the positive association of biophilic attitude with the actions towards the environment (Chipeniuk, 1995; Wells, 2000; Lohr and Pearson-Mims, 2005; Lindemann-Matthies, 2006; Duerden and Witt, 2010; Gungor et al., 2018), in this study we develop a theoretical model that features plant drawing as a critical vehicle that initiates the process of establishing such an association. We then present the analysis of an experiment designed to test the hypotheses generated by the model.

In incorporating plant drawing in our model, it is important to recognize the fact that a drawing involves one's cognitive and affective modes of perception and disposition. Given that drawing of plants is an expression of one's aesthetic experience of nature, both conscious and subconscious components should be accounted for during an assessment. In this sense, 'non-representational' expression in a drawing, which often involves affective, pre-reflective, and somesthetic values (Iared et al., 2016), has to be embraced when assessing the drawing. According to Iared et al. (2016), invisible, interpretive, corporal disposition in the aesthetic experience have been relatively undervalued in the researches compared to the cognitive, reflective, and representative approaches. Hence, these ontological-epistemological tensions within the drawing practice should be reflected in the methodological considerations of research.

In his theory of pedagogy of drawing, Riley (2008) proposes the mixture of 'empiricist' and 'humanist' approaches to the drawing practice. The former takes an objective stance that focuses on the subject's measurable and observable elements, while the latter takes a subjective stance that explores an individual's emotional responses to the subject. This 'blending' provides opportunities to openly engage in different disciplines and philosophical underpinnings, allowing students to challenge their ontological or epistemological assumptions in the aesthetic experience of nature, and thus, creating discussions about the merits between cognitive-analytic and emotional-expressive representations (Lyon et al., 2018). In accordance with this thinking, in our theoretical model we consider two different modes of analyzing drawings, namely the analytical-objective approach and the subjective-expressive approach.

Our theory-building is complemented by an analysis of data generated from an experiment. One of the key variables we examine is the experimental subjects' gender, which could be an influential factor for differentiating the results in our model because past studies have demonstrated women's higher degree of concerns and intentions regarding en-
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Environmental conservation than men. For example, Zelezny et al. (2000) attribute women's high degree of PEB to their tendency of socialization inherent in women. According to the study, women have a stronger social ethic of care for taking responsibility for ameliorating social tensions. Similarly, Stern et al. (1993) contend that women's stronger beliefs about detrimental consequences to people and the biosphere caused by environmental degradation predict more environmentally significant behavior. Hence, in our study we test the significance of the gender variable in the context of our theoretical model.

Research purpose and hypothesis

The present study's primary research question is whether visually representing plants by engaging in freehand drawing would influence actual behavioral intentions to improve the quality of our environment and whether this association is mediated by the key environmental-psychological factors. In short, the purpose of this paper is to demonstrate that plant drawing fosters environmentally responsible actions. To accomplish our objective, we set the following hypothesis:

Hypothesis 1: Compared with passive interactions with plants (e.g., seeing, walking along, doing recreational activities within), engaging with live plants through freehand drawing positively influences the attitude toward plants, emotional bond to the natural environment, and the intentions of PEB.

Hypothesis 2: The positive influence of plant drawing on the formation of the PEB intention is mediated through two environmental-psychological determinants, attitudes toward plants and affective concern with the natural environment.

Hypothesis 3: Two different modes of engaging with plants drawings, the analytical-observational approach and subjective-expressive approach, explain the variability in PEB with different degrees of effect.

Hypothesis 4: Gender is one of the key differentiating factors of our model.

Research Methods

Experimental trials

To test all the hypotheses, we recruited subjects and asked them to conduct a drawing task and participate in a paper survey. The experiment took place in every April over four consecutive years, from 2015 to 2018, on two different college campuses in Seoul. Early to mid-April was selected as the experimental period because it is when flowers and leaves begin forming recognizable shapes, which is ideal for outdoor drawing activities. The participants were arts-majoring freshmen college students (n = 235) who were enrolled in Drawing Fundamentals classes, one of the foundational core curricula offered in Spring semesters. Each class had around 30 students. Collected drawings and survey answers were assessed with authorized referees in the fields.

Our research was comprised of two parts. First, to test Hypothesis 1, students were divided into the control group (those who engaged only in normative interaction with plants) and the treatment group (those who engaged in plant drawing), and then, measured the statistical differences of the mean scores in the measurement criteria from each group (Study 1). Second, to test Hypotheses 2 and 3, we created a conceptual statistic equational model (SEM) that assumed a correlational flow of relations between the constructs. The model consisted of two predictive constructs (analytical-observational objectivity and expressive subjectivity) and three dependent constructs (plant attitude, environmental affect, and pro-environmental behavioral intention) where the plant attitude and the environmental affect became mediating constructs of PEB (Study 2) (Fig. 1). The model was built based on the theoretical accounts and empirical models proposed in relevant literatures. Hypothesis 4 was tested in both Study 1 and Study 2.

Study 1

For the experiment, students were divided into control (n = 122) and treatment groups (n = 113). The control group students went on an hour-long, walking-and-seeing guided tour along natural fields adjacent to college cam-
puses, while the students in the treatment group participated in 'plant drawing task' session in which they were tasked with visualizing live plants through freehand drawing. After the field trip and drawing sessions, students in both groups participated in a paper survey that measured their attitudes toward plants and affective affinity to the environment. The control group's outdoor field trip route was designed around the creeks, reservoirs, hillsides, and gardens where spring flora and fauna could be observed. Special instructions were given to observe plants carefully and keep an eye on the discovery during the observation.

Study 2

The students in the treatment group went to a designated natural area around the campuses where various tall trees and shrubs were planted. They were free to choose their own drawing materials. A map identifying all the plant names was offered to the students so that they became knowledgeable about the plants while drawing plants. Having arts students in the drawing session was conducive to the study because they generally had low anxiety towards freehand drawing, unlike non-art majors who may encounter obstacles due to inexperience (e.g., Mohler, 2007; Baldwin and Crawford, 2010; Chorpening, 2014; Quillin and Thomas, 2015).

Before the plant drawing task session, an instructor gave a short introduction explaining the general backgrounds and objectives of the session. The instruction was necessary because many students had a somewhat narrow conception of observational drawing as being an accurate figural portrayal of an object. Hence, the instructor first introduced

Fig. 1. Hypothesized model of the relationship between the types of plant drawing representations and PA, EA, PEB. X1–X6 are scoring items for assessing AO and ES (see Table1) and Y1–Y12, Y13–Y21, Y22–Y33 are survey items for measuring PA, EA, PEB. The original 26 items for assessing PA were condensed into 12 items (Y1–Y12) using the item parceling technique (refer to Research Methods section and Appendix for details). Note. AO: analytical-observational objectivity; ES: expressive subjectivity; PA: plant attitude; EA: environmental affect; PEB: pro-environmental behavioral intention.
A concept of 'looking' as a complex cognitive interplay between one's senses and objects, and then, suggested a range of notions of drawing in which a bodily movement and critical thinking constantly negotiates. Subjective interpretation of the plants through drawing allows engaging with them through such affective dimensions as evocative, metaphorical, emotional, and reflective schemes (Lyon et al., 2018). A total of 113 drawings were collected out of the same number of students who participated in the treatment group sessions.

Survey instruments

A paper survey was administered after the field trips and plant drawing tasks. The survey questionnaires were designed to assess three components: students' attitudes toward the plants (e.g., Fančovičová and Prokop, 2010), emotional affection for the natural environment, and pro-environmental behavioral intention (Ajzen, 1985). Students rated each questionnaire on a five-choices, Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Plant attitude (PA)

The questionnaires for the plant attitude were based on Fančovičová and Prokop's (2010) Plant Attitude Scale consisting of 29 items formed by four factors that measure cognitive, affective, and behavioral dimensions of the attitude towards plants. The factors include 'interest and enjoyment of plants (Interest)', 'importance of the plants for life of humans and other lifeforms (Importance)', 'cost and benefit associated with urban trees (Urban trees)', and 'material benefits from plants in the industry (Utilization)'.

Environmental Affect (EA)

Environmental Affect measures the extent of one's emotional connectivity to the environment. The questionnaires for measuring EA were based on Maloney et al.'s (1975) and Liu and Lin's (2015) Ecological Scale. For the study, we adopted Liu and Lin's 21-items scale, a revised and simplified version from Maloney et al.'s original 45-items scale. A higher score indicates a higher level of emotional bond to the environment.

Pro-environmental behavioral intention (PEB)

PEB measures one's willingness to take any action concerning sensitive environmental issues in the private and public sectors. A higher score is indicative of a higher degree of intentions toward ecological commitment. The questionnaires for PEB were adopted from Moloney et al. (1975) and Liu and Lin's (2015) Ecological Scale.

Before the research began in 2015, our original 49-items of PA, EA, PEB questionnaires were pilot-surveyed to the freshmen students in both colleges (n = 66). The author and two referees first checked conceptual and idiomatic consistency between Korean-translated questionnaires and the original ones during a calibration session (e.g., Selvi, 2012). Inconsistencies in the definition of the words were resolved and some of the outdated environmental issues (e.g., 'I am deeply concerned about local environmental issues such as the building of a massive chemical plant.') were replaced with current ones (e.g., 'I am deeply concerned about local environmental issues such as deforestation on a mountains or destruction of habitats'). While the questionnaires showed a good overall internal consistency (Cronbach's $\alpha = .94$ for total questionnaires), three items from PA and one from EA were excluded due to the respondents' polarized responses ('Furniture can be made from plants.'; 'We utilize plants as fuel.'; 'It frightens me to think that much of the food I eat is dangerous because of environmental contamination.'). After the pilot survey, a revised, 46-items scale was used for the experiment. Confirmatory factor analysis (CFA) revealed that four factors in PA consistently fitted with Fančovičová and Prokop's original constructs (2010) and factors that consist of EA and PEB were consistent with Liu and Lin's constructs (2015). These results confirmed the structural validity and reliability of our survey questionnaires (Appendix).

Evaluation of plant drawings

The purpose of the drawing assessment was to examine whether the degree to which the students engaged with the plant drawing would relate to the level of their attitude toward plants, affective bonds with nature, and behavioral intention toward the environment. All of the drawings were
rated according to the degree to which the qualities of objectivity or subjectivity were expressed. Three specialists holding Ph.D. degrees in the arts, botany, and landscape architecture fields were invited to score drawings in three calibration meetings (e.g., Liu and Lin, 2015).

The specialists, along with the authors, developed scoring rubrics for the drawing assessment. The conceptual base of the assessment criteria was Riley's (2008) classifications of drawing. Riley classified drawings into four categories based on the principal concepts presented in Western art history: analytical objectivity, observational objectivity, subjective expressionism, and relative constructivism. Among them, analytical-observational objectivity and subjective expressionism were appropriate frameworks for our assessment because the graphic techniques that appeared in students’ drawings generally fit in with these traits. In the tradition of visual arts, analytical and observational objectivity are associated with the empirical traditions whose notions are rooted in the belief that the reality is revealed by reasoning or empirical observation (Laughton, 1986) (e.g., William Coldstream's teaching at the Euston Road School and John Ruskin's 'the innocence of the eyes', Ruskin, 1876, p.22). This type of drawing is served by graphical representations that share a physical resemblance with the object that the drawing depicts (Meter and Garner, 2005). Based on the above considerations, we rated the empirical, analytical, anatomical, and objective qualities of the drawings within the category of analytical-observational objectivity. The rating items were three aesthetic measurements that were referred to by John Ruskin's empirical approach to drawing (Ruskin, 1876) and Riley's ontological and epistemological attitudes to drawing (Riley, 2008, p.155) (Table 1).

By contrast, some of the collected drawings showed relatively less analytical-observational but more expressive or non-representational qualities. These aspects were quite natural because each individual's different visual styles reveal the way in which one makes internal sense out to the external world (John-Steiner, 1997). Riley's (2008) definition of 'subjective expressionism,' in which the drawing qualities are premised upon personal and emotional factors, fits in with these traits. More specifically, Van Der Veen (2012) analyzed these patterns and categorized them as 'recognizable or abstract symbols' and 'metaphorical or analogical figures', in which the figures capture the gestalt of an object or manifest allegorically pictorial scenarios. For the measurement of such expressive qualities, Ives (1984) and Picard and Gauthier (2012) have proposed the types of graphical cues that appeared in expressive drawings: literal (e.g., crying face to show sadness), content (e.g., barren trees to express sadness), and abstract (e.g., dark colors and heavy lines to express sadness). In these, the content and the abstract, which were jointly termed 'metaphorical expression,' were assessed by a range of expressive formal properties (i.e., expressive line, color, composition, and overall balance) that appeared in a drawing. This expressive cue relates to the plant drawings in our study because students have depicted images of a plant by visual observation.

In light of the findings and discussions from the above studies, we devised a scoring rubric to quantify the dra-

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<th>Themes</th>
<th>Assessment criteria</th>
<th>Scoring items (1-5 points for each item)</th>
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<tr>
<td>Analytical-observational objectivity (AO)</td>
<td>• Graphical representation of plants featuring empirical/analytical/anatomical/objective qualities</td>
<td>AO-1 The author's attitude on the plant is objective.</td>
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<td>• A degree to which morphological characteristics of plants are accurately drawn</td>
<td>AO-2 The drawing empirically depicts the plant.</td>
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<td>AO-3 The drawing analyses the morphological characteristics of the plant.</td>
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<tr>
<td>Expressive subjectivity (ES)</td>
<td>• Graphical representation of plants' metaphorical expression</td>
<td>ES-1 The author's attitude on the plant is subjective.</td>
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<td></td>
<td>• A degree to which the expressive formal properties are contained in a drawing.</td>
<td>ES-2 The drawing reflects the author's emotional responses toward the plant.</td>
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<td></td>
<td>ES-3 The drawing contains expressive formal properties which attributes include line, color, composition, and overall balance.</td>
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Table 1. The criteria for plant drawing assessment
wing's expressive qualities within the expressive subjectivity domain. Three measurement items were developed to rate the drawing's subjective, metaphorical, symbolic, and formal attributes (Table 1). To rate the drawings' analytical-observational traits, each drawing was assessed according to; (1) the degree to which the plant's morphological characteristics were reflected and (2) the intensity by which the assessment criteria were expressed. For (1), the raters were given a set of 'plant morphological characteristics checklists' and were instructed to score the drawings according to whether the plant's morphological traits were empirically or expressively reflected in the drawing. The checklists consisted of a set of morphological characteristics of the 21 plant species that grow in campus areas (e.g., Anderson et al., 2014; Wilson and Bradbury, 2016; Stagg and Verde, 2018) (Fig. 2).

For the drawings' expressive-subjective attributes, the raters assessed (1) content expression by evaluating the extent to which the expressive themes and subjects were depicted and (2) expressive formal property that included color (expressive vs. realistic color), composition (the plants' size, placement, balance within the dimensions of the page), and line (use of shape, direction, thickness, texture, and shading) (Rose and Jolley 2016). All the items in the rubric were rated with 5-point scales for each measure. The higher the score, the greater the level of engagement of each item. Figs. 3 and 4 show examples of the scoring sheet, students' drawings, and rated scores.

In the first calibration meeting, each rater scored 10 randomly selected sample drawings using the rubric, and then discussed such issues as clarifying scoring criteria. Difficulties in achieving consensus on the conceptual definitions of these criteria arose, primarily due to the diversity of the raters' fields of study. For example, because the proportion of depicted plant characteristics varied across species, the raters deliberated on the definition of 'accuracy.' A similar issue was evident in defining 'expressiveness' because some drawings were on a fine line between active expression and spontaneous doodling. Upon resolving the issues, the raters repeated the scoring with another remaining ten randomly chosen samples to achieve a better consensus. During the second and third meetings, the raters

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<tbody>
<tr>
<td>1. Palmate Maple</td>
<td>Acer palmatum Thumb.</td>
</tr>
<tr>
<td>2. Chinese Juniper</td>
<td>Juniperus chinensis L.</td>
</tr>
<tr>
<td>3. Tulip Tree</td>
<td>Liriodendron tulipifera L.</td>
</tr>
<tr>
<td>4. Magnolcyan</td>
<td>Magnolia kobus DC.</td>
</tr>
<tr>
<td>8. Sawleaf Zelkova</td>
<td>Zelkova serrata (Thumb.) Makino</td>
</tr>
<tr>
<td>9. Red-bark Dogwood</td>
<td>Cornus alba L.</td>
</tr>
<tr>
<td>10. Gaemari</td>
<td>Forsythia koreana (Rehder) Nakai</td>
</tr>
<tr>
<td>11. Burning Bush Spindle Tree</td>
<td>Euonymus alatus (Thumb.) Siebold</td>
</tr>
<tr>
<td>12. Evergreen Spindle Tree</td>
<td>Euonymus japonicus Thumb.</td>
</tr>
<tr>
<td>13. Azalia Indica</td>
<td>Rhododendron indicaun</td>
</tr>
<tr>
<td>14. Korean Azalia</td>
<td>Rhododendron halliaeense</td>
</tr>
<tr>
<td>15. Korean Early Lilac</td>
<td>Syringa oblata var. dilatata (Nakai) Rehder</td>
</tr>
<tr>
<td>16. Kentucky Bluegrass</td>
<td>Poso prostrum L.</td>
</tr>
<tr>
<td>17. Asian Greater Celandine</td>
<td>Chelidonium majus var. asiaticum (Hara) Otti</td>
</tr>
</tbody>
</table>

Fig. 2. A list of 21 plant species for the plant drawing task (left) and a sample of a plant morphology checklist (right). Each checklist is comprised of six to twelve common and unique morphological characteristics of the plant species. The characteristics were referenced by the plant information in Korea Biodiversity Information System (http://www.nature.go.kr/).
discussed resolving the issues similar to the ones discovered in the first meeting. In particular, discerning anatomical drawings and the drawings of imaginative objects was a concern. After attaining consensus, they then scored.

**Fig. 3.** Sample scoring sheet for the drawing of Korean early lilac (*Syringa oblata var. dilatata* (Nakai) Rehder).

**Fig. 4.** Sample scores for four different drawings of Palmate Maple tree (*Acer palmatum* Thunb.).
all 113 drawings independently. Because the percentage of agreement among the raters reached only 61% (Cohen's kappa = 0.55), the discrepancies were discussed again. Thereafter, the final scores of the entire 113 drawings were decided in the final consensus meeting.

Data analysis

Study 1

Independent T-tests were used to examine the effect of the treatments and gender (fixed factors) on the experimental and control groups' PA, EA, and PEB scores (dependent variables). Jamovi 1.2.27 software was used for statistical measurement.

Study 2

Structural equation modeling was used to test relations and effect sizes among the variables. Because our study's sample size was small and the main research objectives were on developing a new theory rather than on confirming existing theories, we applied a partial least square structural equation modeling process (PLS-SEM) and tested its statistical validity using Smart PLS 3.3.3 program.

In developing the scales that measure the plant drawing qualities, specifying explanatory constructs in the measurement model, either reflective or formative, was an issue. Generally, reflective modeling is determined when observed indicators direct toward a latent variable, covary with each other, are mutually interchangeable, and share the same antecedents and consequences (Jarvis et al., 2003). Upon analyzing the proposed model, we found that all the indicators in the model met the above criteria: the indicators' conceptual causality flew from the construct to the measure, covariance values were moderate to high (for analytical-observational objectivity, the values of Spearman Correlation ranges from 0.65 to 0.76, for expressive subjectivity, from 0.52 to 0.64), each indicator was seemingly interchangeable (e.g., "the author's attitude on the plant is subjective"; "The contents of the drawing reflect the author's emotional responses toward the plant"), and have a common underlying idea. As such, our measurement model, including the two explanatory constructs, has reflective indicators.

In contrast to covariance-based SEM (CB-SEM), a partial least squares-based model approach in PLS-SEM is widely applied when the sample size is small and the research objective is theory development rather than theory confirmation (Hair et al., 2017; Hair et al., 2019; Usakli and Rasoolimanesh, 2023). Methodologically, PLS-SEM aims at maximizing the explained variance of the latent variables in any regression run in the model, and thus, it suits complex path models whose purpose is to explore and predict a theory (Chin, 1998). Also, PLS-SEM is considered a "soft modeling approach" that requires no strong assumptions, such as distribution, sample size, and measurement scale. Hence, this method is more oriented toward optimizing predictions than seeking accurate estimates (Esposito Vinzi et al., 2010, p.48). Considering that our theoretical model was tested with small-size samples and the model has a complex sequence of relationships in an explorative, PLS-SEM was an appropriate analytical method for our research.

In developing the scales that measure the plant drawing qualities, specifying explanatory constructs in the measurement model, either reflective or formative, was an issue. Generally, reflective modeling is determined when observed indicators direct toward a latent variable, covary with each other, are mutually interchangeable, and share the same antecedents and consequences (Jarvis et al., 2003). Upon analyzing the proposed model, we found that all the indicators in the model met the above criteria: the indicators' conceptual causality flew from the construct to the measure, covariance values were moderate to high (for analytical-observational objectivity, the values of Spearman Correlation ranges from 0.65 to 0.76, for expressive subjectivity, from 0.52 to 0.64), each indicator was seemingly interchangeable (e.g., "the author's attitude on the plant is subjective"; "The contents of the drawing reflect the author's emotional responses toward the plant"), and have a common underlying idea. As such, our measurement model, including the two explanatory constructs, has reflective indicators.

The item parceling technique was applied to the observed items in the plant attitude construct due to their large numbers (a total of 26 items). Aggregating items into parcels reduces standard error in a construct, and thereby the underlying latent factor can be distilled and the stability of estimation increases (Matsunaga, 2008). Hence, we combined two items into one, resulting in a total of 12 items in the plant attitude construct (Rogers and Schmitt, 2004). Since the parceling items were within the same conceptual domains (e.g., Interest; Importance; Urban trees; Utilization) (Fančovičová and Prokop, 2010) and CFA results were satisfactory, the prerequisite for using the parceling technique was met (Matsunaga, 2008).

Results

Study 1

Study 1 results showed that the mean scores of all three dependent variables (PA, EA, and PEB scores) in the experimental groups were higher than those of the control
group. The T-test results reported that the scores were statistically significant in PA and EA, but not in PEB. Thus Hypothesis 1 was partly supported. Cohen's $d$ values were $d = .76$, $.33$, and $.18$, respectively, suggesting that differences in the mean scores that favor the experimental group were large in PA, moderate in EA, and small in PEB scores (Cohen, 1988) (Table 2). There was a significant difference in the mean scores between males and females in all three dependent variables, with females showing better scores than males (Fig. 5). Cohen's $d$ values were $d = 1.14$, $.82$, $.81$, respectively, suggesting that the differences in the mean scores favoring female students were large in all the dependent variables. This pattern of results support Hypothesis 4.

**Study 2**

Table 3, Table 4, and Fig. 6 presents the testing results of the structural model. The validity and reliability of the measurement model in the SEM were assessed according to Hair et al.'s (2017) guidelines for the reflective measurement. At first, a total of five items in which the indicator loadings were significantly less than 0.708 were removed for the convergent validity (Rogers and Schmitt, 2004). The remaining items' average variance extracted values (AVE) were higher than 0.5, which indicates that each construct explains more than half of the indicators' variance, thus providing acceptable convergent reliability. The values of the composite reliability (CR) met the recommended thresholds (above 0.6 and below 0.95) (Usakli and Rasoolimanesh, 2023) thus the indicators' internal consistency reliability was also acceptable. In addition, the values of the Heterotrait-Monotrait ratio of the correlations (HTMT) were below 0.9, indicating that each construct is conceptually distinct from the others, thus the model's discriminant validity has been met (Henseler et al., 2015; Voorhees et al., 2016). VIF values of each indicator were less than 5, suggesting

![Fig. 5. The gender difference between the mean scores of PA, EA, PEB scales. (female $n = 132$, male $n = 103$). Student's t scores of all the criteria were statistically significant. Cohen's $d$ values were $1.14$, $0.82$, $0.81$, respectively.](image)

**Table 2.** Comparison of the mean scores of PA, EA, PEB scales between the control ($n = 122$) and experimental groups ($n = 113$) and between gender (female $n = 132$, male $n = 103$). Independent samples T-tests and Cohen’s $d$ results. (total $n = 235$).

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>$df$</th>
<th>$t$ (student's or Welch's)</th>
<th>$p$ value</th>
<th>Cohen's $d$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plant attitude score (PA)</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Experimental group</td>
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<td>.64</td>
<td>233</td>
<td>5.78</td>
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<td>.76</td>
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<td></td>
<td>183</td>
<td>8.56</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental group</td>
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<td>.83</td>
<td>216</td>
<td>2.52</td>
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<td>.33</td>
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<tr>
<td>Control group</td>
<td>3.29</td>
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<td></td>
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<td></td>
<td></td>
</tr>
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<td>Gender</td>
<td></td>
<td></td>
<td>233</td>
<td>6.27</td>
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<td>.82</td>
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<tr>
<td><strong>Pro-environ. behavioral intention score (PEB)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Experimental group</td>
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<tr>
<td>Gender</td>
<td></td>
<td></td>
<td>233</td>
<td>6.18</td>
<td>.00</td>
<td>.81</td>
</tr>
</tbody>
</table>
that multicollinearity was not an issue. The result of a 5000-sample bootstrap (Hair et al., 2019) was indicative of the statistical significance of all the indicators' outer loadings and relevance are satisfactory (indicator loadings > 0.5, \( p < 0.05 \)) (Henseler et al., 2015). Measurement model results are summarized in Table 3.

Following the test of the measurement model, we assessed the significance and relevance of the structural model relationships. At first, the variance inflation factor (VIF) values of all the constructs were around and below 3, suggesting that multicollinearity was not an issue (Usakli and Rasoolimanesh, 2023). The value of the explained variance (\( R^2 \)) was 0.12 for the plant attitude (PA), 0.59 for the environmental affect (EA), and 0.54 for the pro-environmental behavioral intention (PEB). According to Henseler et al. (2009) and Hair et al. (2019), \( R^2 \) values of 0.25, 0.50, and

### Table 3. Reliability / validity of the measurement model

<table>
<thead>
<tr>
<th>Analytical objectivity (AO)</th>
<th>Composite reliability</th>
<th>AVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expressive subjectivity (ES)</td>
<td>.93</td>
<td>.82</td>
</tr>
<tr>
<td>Plant attitude (PA)</td>
<td>.89</td>
<td>.73</td>
</tr>
<tr>
<td>Environmental affect (EA)</td>
<td>.95</td>
<td>.60</td>
</tr>
<tr>
<td>Pro-environmental behavioral intention (PEB)</td>
<td>.90</td>
<td>.61</td>
</tr>
</tbody>
</table>

### Table 4. The structural model results

(a)

<table>
<thead>
<tr>
<th>Structural relationships</th>
<th>( \beta )</th>
<th>( p )</th>
<th>97.5% Confidence interval</th>
<th>( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>AO ( \rightarrow ) PA</td>
<td>.23</td>
<td>.01</td>
<td>.01 .40</td>
<td>.12</td>
</tr>
<tr>
<td>ES ( \rightarrow ) PA</td>
<td>.17</td>
<td>.06</td>
<td>-.00 .35</td>
<td></td>
</tr>
<tr>
<td>AO ( \rightarrow ) EA</td>
<td>-.04</td>
<td>.59</td>
<td>-.18 .10</td>
<td></td>
</tr>
<tr>
<td>ES ( \rightarrow ) EA</td>
<td>.19</td>
<td>.00</td>
<td>.06 .33</td>
<td>.59</td>
</tr>
<tr>
<td>PA ( \rightarrow ) EA</td>
<td>.70</td>
<td>.00</td>
<td>.60 .80</td>
<td></td>
</tr>
<tr>
<td>PA ( \rightarrow ) PEB</td>
<td>.32</td>
<td>.00</td>
<td>.17 .53</td>
<td>.54</td>
</tr>
<tr>
<td>EA ( \rightarrow ) PEB</td>
<td>.44</td>
<td>.00</td>
<td>.25 .61</td>
<td></td>
</tr>
</tbody>
</table>

(b)

<table>
<thead>
<tr>
<th>Structural relationships</th>
<th>( \beta ) indirect</th>
<th>( p )</th>
<th>97.5% Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>AO ( \rightarrow ) PA ( \rightarrow ) PEB</td>
<td>.07</td>
<td>.04</td>
<td>.01 .14</td>
</tr>
<tr>
<td>AO ( \rightarrow ) EA ( \rightarrow ) PEB</td>
<td>-.02</td>
<td>.60</td>
<td>-.09 .05</td>
</tr>
<tr>
<td>PA ( \rightarrow ) EA ( \rightarrow ) PEB</td>
<td>.07</td>
<td>.04</td>
<td>.01 .15</td>
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<tr>
<td>ES ( \rightarrow ) EA ( \rightarrow ) PEB</td>
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<td>.02</td>
<td>.02 .16</td>
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<tr>
<td>ES ( \rightarrow ) PA ( \rightarrow ) PEB</td>
<td>.06</td>
<td>.11</td>
<td>.00 .13</td>
</tr>
<tr>
<td>ES ( \rightarrow ) PA ( \rightarrow ) EA ( \rightarrow ) PEB</td>
<td>.05</td>
<td>.09</td>
<td>.00 .12</td>
</tr>
</tbody>
</table>

*Note. \( \beta \): path coefficient; **\( p < .05 \), ***\( p < .001 \). Table (a) shows direct effect and Table (b) shows indirect effect. The testing of the hypotheses was based on the 95 percent confidence interval of 5000 bootstrapped estimates.*
0.75 can be considered weak, moderate, and substantial explanatory power of the PLS-SEM, respectively. Hence, the current model’s predictive ability ranges from weak to moderate (Table 4(a)).

The results of a 5000 sample bootstrapped estimates revealed that the model explained 54% of PEB variance and demonstrated that two drawing constructs, the analytical-observational objectivity (AO) and the expressive subjectivity (ES), are associated with PEB (Fig. 6). However, testing of direct and indirect effects among the constructs (Nitzl et al., 2016) showed that all the drawing-related variables and PEB are indirectly associated (Table 4(b)). Analytical-observational drawings were reliably correlated with PEB indirectly via two different routes: the first route was via plant attitude ($\beta_{indirect} = .07$, 97.5% CI = (.01, .14)), and the second route was via plant attitude and environmental affect ($\beta_{indirect} = .07$, 97.5% CI = (.01, .15)). These results imply that the increment of the analytical-observational drawing scores correlates to the greater PA, EA, and PEB rubric scores. The correlation between the expressive-subjective drawings and PEB was statistically valid when environmental affect mediated this association ($\beta_{indirect} = .08$, 97.5% CI = (.02, .16)), suggesting that the higher the scores in the expressive-subjective drawings, the greater the EA and PEB rubric scores. Given the results that the plant drawing activity and the formation of PEB were positively associated and that the degree of the effects differed depending on the drawings’ graphic techniques, our Hypotheses 2 and 3 were clearly supported. In addition, the testing of the model also revealed that the environmental affect had the strongest direct association with PEB ($\beta = .44$, $p < .00$, 97.5% CI = (.25, .61)), which reflects previous findings in an extensive body of literature (Hinds and Sparks, 2008; Pooley and O’Connor, 2000). This construct also had an indirect association with PEB via plant attitude, suggesting that the environmental affect is a route by which the plant attitude’s effect on PEB become greater.

We also examined whether gender difference yields statistically different results, as presented in Hypothesis 4. PLS-based multigroup analysis method (PLS-MG) (Henseler et al., 2009) was applied to compare the results in the male and female group. This method is a non-parametric significance test for the difference between the groups that do not rely on distributional assumptions thus suited for our relatively smaller-sampled SEM model. The MGA results reported that females ($n = 65$) showed statistically stronger path coefficient than males ($n = 48$) in the expressive subjectivity $\rightarrow$ plant attitude association ($\beta_{female - male} = .53$, $p = .01$, 97.5% CI$_{female} = (.05, .54)$, 97.5% CI$_{male} = (-.66, .07))$, and the males showed statistically stronger coefficient than females in the plant attitude $\rightarrow$ environmental affect association ($\beta_{male-female} = .23$, $p = .02$, 97.5% CI$_{male} = (.65, .89)$, 97.5% CI$_{female} = (.35, .72)$). We then ran a multi-group mediation model to examine statistically distinct indirect associations with PEB in different gender groups. The results indicated that the double-mediation path between the expressive subjectivity and PEB (ES $\rightarrow$ PA $\rightarrow$ EA $\rightarrow$ PEB) was statistically significant, and females showed stronger association with PEB via that route than males ($\beta_{indirect (female-male)} = .20$, $p = .04$, 97.5% CI$_{female} = (.02, .23)$, 97.5% CI$_{male} = (-.40, .03)$). Summarizing PLS-MGA results, female students’ pro-environmental behavioral intention was distinct when their plant drawings were expressively and subjectively visualized, and this association was clearly explicable when their attitudes toward plants and the affective concerns with the environment were accounted.

**Discussion**

Experience of plants is important not only for one’s aesthetic satisfaction or psychological affinity toward the vegetation but for a broad range of ecological concerns (Whitburn et al., 2019). Employing these perspectives into psychological and educational arenas, the present study explored whether direct contact with plants, especially through sketching methods, would influence the following three attributes: attitude toward the plants, affective affinity to the natural environment, and the intentions to act pro-environmentally. Summarizing the discussions from the last section, the two studies of our experiment tested the following hypotheses: Study 1 tested whether sketching practice would influence three given parameters more than the normal recreational activities (Hypothesis 1; see Section 2 for the descriptions of all hypotheses). Study 2 tested whether
the extent to which the plant drawings were graphically depicted would explain dependent variables differently (Hypothesis 2 and 3). In addition to the above studies, we also tested whether the results were influenced by the gender difference (Hypothesis 4). We now present the interpretations of these findings.

Impact of plant drawing to the development of PEB

Study 1 results partly support Hypothesis 1. The T-test results provide clear evidence that the plant sketching practice has a greater impact on influencing the attitudes on plants and the emotional responses to the environment than do the usual types of sensory or physical interactions with plants. Although the effects of plant drawing were significant for both plant attitude and environmental affect, Cohen's d values show that the impact on plant attitude was relatively greater than on environmental affect. These results support our assumptions that the plant drawing experience strengthens an empathic connection with plants (Balding and Williams, 2016) and natural environments (Leslie, 1981; Dempsey and Betz, 2001; Dirnberger et al., 2005; Ainsworth et al., 2011; Quillin and Thomas, 2015; Loureiro and Dal-Farra, 2017). As many authors have contended, manually depicting morphological traits of the plants not only promotes understanding of botanical knowledge but also gives rise to biophilic sensibilities because, as Tarr (2005), Chorpening (2014), Lyon et al. (2018) have contended, observational drawing deepens emotional responses to the subjects.

Although drawing activity was proven to be an effective treatment in terms of developing plant attitude and environmental affect, the difference in the mean scores of PEB between control and treatment groups were not statistically significant, suggesting that some of the assumptions in the first hypothesis should be reconsidered. Recall that our prediction that the manual plant drawing would be a better stimulus for predicting PEB than nature-related recreational outdoor activities was based on the following two assumptions: hand-drawing of plants increases biophilic attitudes toward the environment because manual drawing gives rise to deep and extensive understandings of a subject. Insofar as the intention of PEB is often predicted by an affective bond to nature, the extent to which plant drawing influences PEB would be greater than other types of interactions with plants. While these assumptions are conceptually valid, the fact that statistical significance was not obtained suggests PEB scores was affected by additional independent factors.

Factors that might have influenced PEB other than the given variables in our model would have entered through students' past experiences. Supporting this view, many studies have addressed the importance of interaction with a green environment during childhood, which leads to increased sensitivity toward plants (Lohr and Pearson-Mims, 2005), positive affective connections with nature (Kahn, 1997; Kals et al., 1999; Kellert, 2002), and strengthened behavioral intentions in adulthood (Chawla, 1999; Hinds and Sparks, 2008). These studies commonly report that participants from a rural childhood develop a stronger psychological affinity to nature and greater behavioral intentions than do participants with urban childhoods. In conjunction, having an amount of vegetation cover in one’s neighborhoods or participating in tree-friendly activities is also an influential factor for greater engagement with PEB (Whitburn et al., 2019). Given that the present study did not include the past experiences as measurable variables, it is plausible that the pattern of results obtained in our study was influenced by the students' different past exposure to the natural environment that was unobserved by us. Thus, future research should consider the inclusion of these factors in predicting PEB.

Significance of attitudes toward plants and affective concern with the natural environment for the relationship between plant drawing and PEB

The structural model tested Hypotheses 2 and 3. The results showed that drawing-related variables explained approximately half of the variance in PEB (R² = .54) and the relationship was significant under the condition that it was mediated by the plant attitude and the environmental affect (Table 4(b)). The results imply that our hypotheses are clearly supported. These results complement the inconsistency between theoretical assumptions and statistical results regarding the plant drawing-PEB relationships that
were presented in Study 1. The findings in Study 2 corroborate the theoretical undertones in our research hypotheses. Namely, manually visualizing plants directly reaches a person's emphatic sensitivity toward plants (Wandersee and Schussler, 1999; Babaian and Twigg, 2011; Balding and Williams, 2016; Loureiro and Dal-Farra, 2017), and deepens biophilic affection toward the environment, and as predicted by literature, this causal flow would lead to the development of PEB (Kaiser et al., 1999; Hinds and Sparks, 2008).

Influence of analytical–observational and subjective–expressive plant drawing approaches to PEB

The causal flow between plant drawing and PEB in the SEM model was differently yielded by the types of drawing (Table 4 and Fig. 6). First, analytical-observational drawings explained relatively a small portion of variability in the plant attitude ($R^2 = .12$). Nevertheless, we believe that the effect is still meaningful considering the overall pattern of correlations. The process by which plant attitude becomes a mediating variable in the relationship of the analytical-observational drawings and PEB needs more explanation. According to Lerner (2007) and Fan (2015), observational-representational drawings interact with cognitive functions of learning that are core to our reasoning and communication. Considering that attitude toward plants was measured by the plant attitude scale (PAS), which consists of a cognitive, affective, and behavioral index of attitudes (Fancovičová and Prokop, 2010), we infer that the cognitive dimension in PAS was a critical attribute associated with the analytical-objective drawings. This inference explains the modest $R^2$ value (.12) in the PA construct: the unexplained variance (.88) corresponds to the affective and behavioral attitudes within the 26 items of PAS. In theories of attitudes, cognitive components in an attitude commonly refer to the beliefs and thoughts associated with an object (Haddock and Maio, 2008), and the belief is formed by the inferences following probabilistic reasoning (Ajzen and Fishbein, 1975). As analytical-observational drawings involve criticalities, inferences, and reasoning (Lerner, 2007; Fan, 2015), the flow of causation where analytical-objective drawings influence PEB is largely underpinned by such a cognitive process. This inference is consistent with Duerden and Witt's (2010) insights that the strength of correlation between direct experience and behavior is rather complex than as had been previous argued.

Second, although the drawings' subjective and objective attributes are not mutually distinct, our structural model shows that the drawings wherein the expressive-subjective qualities are salient were associated with PEB through the environmental affect that mediate the two. This result supports the assertion that drawing activities make a positive impact on people's affective process (Meter and Garner, 2005; Drake, et al., 2016). Expressive drawings closely relate to people's affective state, and this is consistent with Picard and Gauthier's (2012) and Rose and Jolley (2016) observations that the extent of one's emotional states can be elicited from metaphorically expressive drawings. However, contrary to analytical-objective drawings, the association between expressive-subjective drawings and plant attitude was not significant. Indeed, the students who have drawn plants in an expressive manner were less likely to have rated high on the survey items in the plant attitude scale. Supposedly, these results are due to cognitive attributes latent in the plant attitude thus the result resonates with Lyon et al.'s (2018) claim that drawing is rather subconscious (emotional states) than a conscious process (cognitive reasoning).

Importantly, the testing of the model showed that both objective and subjective drawings influence environmentally significant behavior, mediated through the environmental affect. This finding concurs with the arguments in an extensive body of researches that show affective connection to the natural environment contributes significantly to the prediction of people's pro-environmental intention (Chawla, 1999; Kals et al., 1999; Pooley and O'Connor, 2000; Hinds and Sparks, 2008). Our findings offer an additional support for this view by demonstrating that plant drawing-based experience, an activity that received little attention in the literatures, can help form one's affective connection with the environment and intention to protect it. Our findings are also congruent with theoretical studies on the role of direct experiences to an affective dimension (46, 47) and the studies demonstrating the importance of affective factors in Ajzen's (1985) TPB model.
Impact of the gender difference in the proposed model

The results of Study 1 indicate that female students have greater mean scores in PA, EA, and PEB than males, suggesting female students' stronger response to all three parameters. These results are broadly consistent with many studies that highlight more pronounced reactions to the plants as well as more positive environmental attitudes and actions by females than males (Lohr and Pearson-Mims, 2005; Stern et al., 1993; Zelezny et al., 2000). With regard to the multi-group analysis of the SEM model (Study 2), the results showed that female students' strong tendency in PEB was closely associated with their expressively and subjectively rendered plant drawings, and that PA and EA are crucial psychological agents of such association. Apparently, women's expressive tendency on drawings (Picard and Gauthier, 2012) and psychological inclination toward plants (Lohr and Pearson-Mims, 2005) explain female students' high coefficient in an association between expressive drawings and plant attitude in our study. Picard and Gauthier (2012) demonstrate that women were more likely than men to express appreciation for the social and intrinsic values of trees.

It is important, however, that these results be interpreted with caution. Generalizing our findings about gender orientation toward environmentalism presents limitation because gender-related issues in environmentalism are still open to debate. For instance, some studies reported no significant gender differences in attitudes toward plants (Lindemann-Matthies, 2006; Fančovičová and Prokop, 2010). Moreover, there are inconsistencies in the literature in regard to the concern of gender differences on environmental issues, particularly on undertaking environmentally responsible behavior (Hinds et al., 1986-1987).

Summing up the results obtained from Study 1 and 2, as theoretically expected, the results of Study 1 affirm that the plant sketching fosters positive botanical and biophilic attitudes better than the stimuli from the usual types of outdoor recreational activities. In our study gender was a critical factor in predicting the power of plant drawing on PEB because females have shown a greater extent of intentions of nature conservation than males. However, whether plant drawing inspires one's innate intentions to act pro-environmentally better than normal outdoor recreational activities requires more data collection and analysis. Although we do not address this issue directly because our study was focused on establishing the relationship between the plant drawing method and pro-environmental behavioral intention, future research may be able to provide further insights if appropriate data can be obtained.

In summary, the results of Study 2 indicate that plant drawing serves as a stimulus for shaping one's attitude toward plants and affective connection to the environment, critical components in developing pro-environmental behavioral intentions. While one's analytical or expressive penchant may affect PEB differently, people who have more expressive orientations in the drawing expressions, in particular, are likely to exhibit pro-environmental behaviors, primarily affected by their emotional affiliation to nature. In addition, the research showed that gender is a critical component that may affect the psychological process wherein plant drawing inspires pro-environmentalism. While we found that plant attitude and affective concern for the environment are common psychological factors that influence PEB for both women and men, women are found to be more inclined to produce expressive drawings and their interaction with the psychological factors inspire stronger pro-environmental actions than men.

Limitations

The goal of the present study is to explore the possibility of a plant drawing as an effective intervention for improving the intentions of environmentally responsible behavior. Our findings confirm the fact that observational manual visualization of plants is the powerful psychosomatic experience with nature thus become an effective vehicle for motivating environmental actions. Alongside the strengths of these findings in our study, there are several shortcomings.

First, while the study employed a method (PLS-SEM) that suits our theory development using small sample size, the results of our statistical test on SEM model would have undoubtedly been sharper if the sample size were larger. Nevertheless, given that the aim of the present research is to explore a new theory rather than confirming an exist-
ing model, we believe that our findings would inspire subsequent research in the future. Second, despite our effort to develop a generalized theory, our sample consisted of fairly demographically homogenous participants (i.e., college students). Moreover, our analysis did not include some important factors, such as participants' home location, socioeconomic status, and their past experiences (e.g., Kollmuss and Agyeman, 2002), as of measurement variables. This limitation was partly due to the survey protocols set by academic institutions aimed at protecting students' privacy. Although there are studies that highlight the importance of longitudinal aspects on PEB (e.g., Lohr and Pearson-Mims, 2005), we did not include these variables in the study in order to focus our research on the direct impact of a plant drawing on PEB and associated environmental variables. Future research is recommended to examine the role of these variables for predicting PEB in relation to plant drawing. Lastly, despite our best effort to delineate the types of drawings that reflect students' objective and subjective concerns, a gray area still remains. In fact, analytical and expressive representations are not mutually exclusive properties in the domain of arts, therefore strict categorization may be problematic. However, we believe that our categorization offers an effective conceptual framework for quantifying potentially diverse aspects of manual drawings.

Conclusion

In recent decades, there has been a pervasive decline in interactions with the natural world among people due to sprawling urbanization and diminishing local green spaces (Turner et al., 2004). This phenomenon, known as the "extinction of experience (Pyle, 2002, pp. 312-313)," is one of the greatest threats to environmental sustainability, and this tendency has accelerated in the past years due to the impact of COVID-19 (Kazdin and Vidal-González, 2021). As global-scale environmental degradation becomes obvious, more and more people accept the ecologically barren condition as normality, losing sympathy toward nature. In response, a substantial body of studies seeks to find an effective means to increase the level of people's ecological literacy, emotional bond to nature, and most importantly, environmentally responsible actions. Among them, direct interaction with plants is particularly important because it elicits a wide scope of environmental overtones that are embedded in individual or collective memories (Ryan, 2013); it provides with critical stimuli for developing psychological bond to nature. Nevertheless, people do not sufficiently notice or value the plants in their surroundings and in the biosphere due to diminished contact with them (Wandersee and Schussler, 1999; Uno, 2009; Balding and Williams, 2016).

Given these backgrounds, in this study we focused on discovering the effectiveness of a drawing method as a means to foster a biospheric mindset as well as nature-protective behavior, by conducting a series of experimental research and performing a statistical analysis. The results of the experimental trials provide evidence that manual drawing, one of the direct and visceral interactions with the natural world, instill an ecologically sensitive mindset, and consequently, help promote individual or collective actions for environmental conservation.

The insights from our experimental trials and outcomes are particularly conducive to further research and serve as a motivation for a new research design. Although observational, investigative, and contemplative drawing of a natural specimen is historically recognized as an appropriate means to attain emotional and cognitive attitude toward the natural environment, little scientific evidence has been presented to establish this linkage. The theoretical model and the research methods developed in this study can guide further systematic efforts to explore a number of related theoretical and practical questions regarding the role of plant drawing.

We also expect that our model would offer a framework for addressing a variety of educational demands on ecological concerns, especially since the promotion of pro-environmental attitude and behavior has been a long-sought agenda in environmental education and associated government policies. Because of recent strong demands for novel methods to reconnect students with nature in the post-pandemic era, our proposed model would particularly be useful in organizing classroom activities. Moreover, with younger generation of students becoming alienated from the nature
due to increased use of digital technologies, our model offers insights on devising policies that enhance environmental literacy among these groups. Incorporating arts-based teaching methods in environmental education, which would allow for alternative pathways to express understandings of the environment, may develop deeper insight into the subjects in nature. By observing and drawing plants, students would be able to better communicate ideas and insights about them, a central part of environmental education. Through such activities, students would function not merely as passive repositories of information but as active participants in the creation of meaningful outcomes, and consequently, would develop their own biophilic worldview. We believe that our research paves the way for producing such outcomes and actions.

References


Appendix

Survey questionnaires were adopted from Fančovičová and Prokop's (2010) Plant Attitude Scale and Maloney et al.'s (1975) and Liu and Lin's (2015) Ecological Scale. Some of the outdated environmental issues in the original questionnaires (9 items) have been updated with current ones; these revisions are indicated by italics in the table below.

<table>
<thead>
<tr>
<th>Survey Questionnaires (46 items)</th>
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<tbody>
<tr>
<td><strong>Plant Attitude (PA): 26 items</strong></td>
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<tr>
<td><strong>Interest</strong></td>
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<tr>
<td>1. <em>I am interested in reading books or articles about plants.</em></td>
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<tr>
<td>2. I would like to cultivate plants.</td>
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<tr>
<td>3. <em>I like visiting plant garden exhibitions.</em></td>
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<td>4. I enjoy house plants.</td>
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<td>5. I like spending time in the nature during my leisure time.</td>
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<tr>
<td>6. I would like to have a small garden in the future.</td>
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<td>7. I am relaxed within plants.</td>
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<td>8. We should learn more about importance of plants in school.</td>
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<tr>
<td>9. I like walking in forest.</td>
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<tr>
<td><strong>Importance</strong></td>
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<tr>
<td>10. Life is impossible without plants.</td>
</tr>
<tr>
<td>11. Trees are very important in a town center because they provide cooling and shade.</td>
</tr>
<tr>
<td>12. The town should take care of green space.</td>
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<tr>
<td>13. <em>Plants creates habitats for many organisms.</em></td>
</tr>
<tr>
<td>14. <em>Plants produce oxygen and absorb carbon dioxide.</em></td>
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<tr>
<td>15. Pollution of the environment influences the life of plants.</td>
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<tr>
<td>16. Plants are very important for medicine.</td>
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<tr>
<td>17. Plants should be planted in towns to increase attractiveness of the environment.</td>
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<tr>
<td>18. Plants also suffer from diseases.</td>
</tr>
<tr>
<td><strong>Urban trees</strong></td>
</tr>
<tr>
<td>19. Plants should not be planted along streets because their leaves and fruits pollute surroundings and fall down on cars (R).</td>
</tr>
<tr>
<td>20. Plants should be taken away from the town because they impair electric lines (R).</td>
</tr>
<tr>
<td>21. Plants should not be planted in town because they increase criminal behavior (R).</td>
</tr>
<tr>
<td>22. Plants should not be planted in towns because their roots destroy paths (R).</td>
</tr>
<tr>
<td>23. Plants should not be planted close to business centers because they block signs (R).</td>
</tr>
<tr>
<td>24. Plants in towns are a problem because they cause allergies (R).</td>
</tr>
<tr>
<td><strong>Utilization</strong></td>
</tr>
<tr>
<td>25. Clothes are made of plants.</td>
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<tr>
<td>26. Furniture can be made from plants.</td>
</tr>
<tr>
<td><strong>Environmental Affect (EA): 9 items</strong></td>
</tr>
<tr>
<td>1. <em>I feel people worry too much about global warming (R).</em></td>
</tr>
<tr>
<td>2. It genuinely infuriates me to think that government does not do more to control environmental problems.</td>
</tr>
<tr>
<td>3. <em>I feel fairly indifferent about the statement: “The world will be dead in 40 years if we don't take actions to current environmental crisis.” (R)</em></td>
</tr>
<tr>
<td>4. I become incensed when I think about the harm being done to plant and animal life by human activities.</td>
</tr>
</tbody>
</table>
Survey Questionnaires (46 items)

5. I am usually not bothered by so-called "global climate change."(R).
6. *I am deeply concerned about local environmental issues such as deforestation on a mountains or destruction of habitats.*
7. When I think of the ways industries are polluting, I get frustrated and angry.
8. The whole issue about environmental degradation has never upset me too much since I feel it's somewhat overrated (R).
9. I rarely ever worry about the loss of biodiversity since it's part of natural selection (R).

Pro-environmental Behavioral Intention (PEB): 11 items

1. I'm not interested in joining a group or club which is concerned solely with ecological issues (R).
2. I'm not willing to buy energy efficient products as they are normally more expensive (R).
3. I would be willing to donate a day's pay to a foundation to help improve the environment if I have income.
4. I would be willing to stop buying products from companies guilty of polluting the environment, even though it might be inconvenient.
5. I'd be willing to give my vote to a congressman candidate who stresses on environmental issues.
6. I strive to learn as much as possible about environmental issues.
7. *I would keep track of the Ministry of Environment's agenda relate to environmental issues.*
8. *I would be willing to buy an electric car to reduce greenhouse gas emission even if it were more expensive than gasoline car.*
9. I would probably never attend a meeting related to environmental issues (R)
10. I would be willing to learn more about what I can do to improve the local environment.
11. I would be willing to join a local environmental group to make a difference.

*Note.* The original survey questions were written in Korean. R: reverse question