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Green Spaces in Chinese Schools Enhance Children's Environmental Attitudes and Pro-Environmental Behavior

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Abstract
Previous research has asserted that promoting connection to nature can enhance children's environmental attitudes and cultivate their pro-environmental behavior. School green spaces and educational programs have been recognized as important interventions toward this goal, although empirical study examining their effectiveness, especially in China, is rare. This study collected data from 1,597 students (9–12 years old) in southwest China. The study used the Two Major Environmental Values scale to measure two dimensions of children's environmental attitude—preservation and utilization—and used a project-specific pro-environmental behavior scale to measure children's self-reported pro-environmental behavior. The results found that students' perceived school environment is consistent with objective measures of "green space quality." Meanwhile, students' perception of their school environment and their interactions with natural elements have a positive correlation with students' preservation attitude and pro-environmental behavior. School green activities have a negative correlation with a utilization environmental attitude. This study thus highlights the value of green campuses, and when supplemented by environmental pedagogical activities, they could significantly contribute to equipping children with environmental literacy.

Keywords: school green space, perception, environmental attitudes, pro-environmental behavior

Introduction

Interacting with nature benefits children in several ways (Chawla, 2015; Gill, 2014), including improved physical flexibility and balance (Fjørtoft, 2004; Sando & Sandseter, 2020), cognitive function (Dadvand et al., 2015; Ulrich et al., 2008), creativity (Samborski, 2010), social interactions (Baines & Blatchford, 2011; Titman, 1994), and mental health (Chawla, Keena, Pevec, & Stanley, 2014). Childhood interactions with nature also cultivate pro-environmental behavior (PEB) during both childhood and adulthood (Li & Chen, 2015; Whitburn, Linklater, & Abrahamse, 2020). Because of this, an increasing number of initiatives aim to enhance children's PEB by promoting natural observation, camping, exploration (Zhang, Zhao, & Chen, 2019), and the like. However, although children benefit from experiencing nature, today they have fewer opportunities to experience it (Louv, 2008). Rapid urbanization (Miller, 2005), changing lifestyles that prioritize computers and mobile phones over outdoor activity (Pergams & Zaradic, 2008), and parents' worries about outdoor safety (Dyment, 2005), lead to a deficit of nature experiences in children's lives. The deficit may lead to a lack of basic familiarity about the natural environment (Atran, Medin, & Ross, 2004; Nabhan & Trimble, 1994) as well as physical and cognitive problems (Bell, Wilson, & Liu, 2008; Dadvand et al., 2015; Huh & Gordon, 2008).

School campuses are vital to ameliorating this problem; school-age children spend most of their active time (eight hours per day on average) at school (Guo & Yang, 2008). Studies have shown that children who attend schools with green grounds have more opportunities to play (Boldemann et al., 2006; Jansson, Gunnarsson, Mårtensson, & Andersson, 2014; Malone & Tranter, 2003; Moore, 1996; Zamani & Moore, 2013), enjoy safer and less hostile outdoor environments (Dyment, 2005; Evans, 2001), develop enhanced social relations (Baines & Blatchford, 2011; Maller & Townsend, 2006; Titman, 1994), and have better cognitive development (Dadvand et al., 2015) and academic performance (Li, Chiang, Sang, & Sullivan, 2019; Kweon, Ellis, Lee, & Jacobs, 2017). Studies have also shown that teachers working at greener schools are more creative while designing their curriculum (Dyment, 2005; Moore, 1996). Other research has shown that green space provides important physical and psychological benefits to campus residents (Scholl & Gulwadi, 2018; Wee, 2017).

Global Green School Efforts

In recent decades, school green space development initiatives have been promoted around the world. In 1994, the Foundation of European Environmental Education developed the "Ecological School Plan," which encourages energy-efficient and sustainable schools and emphasizes student-led management of the school environment to transform student behavior (Lysgaard, Larsen, & Læssøe, 2015). Other initiatives, such as the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) for Schools in the United States, Green Star Education in Australia, and the Deutsche Gesellschaft für Nachhaltiges Bauen in Germany, emphasize schools' physical environments (Meiboudi, Lahijanian, Shobeiri, Jozi, & Azizinezhad, 2017). These efforts include increasing green space, improvement of indoor air quality and classroom acoustics, removal of toxic materials, sustainable waste management, and the like (Zhao, He, & Meng, 2015).

China began to promote green schools in 1996, when the government mandated their establishment to foster environmental education (Tan, Chen, Shi, & Wang, 2014; Wu, 2002). China's Green Schools project emphasized both the physical environment, including energy saving and sustainable development, and environmental education in schools (Wu, 2002). By October 2000, there were 3,207 schools at various levels in 16 provinces named "green schools" (Zhiyan, Hongying, & Xuhong, 2004). However, few studies have evaluated whether the program's outcomes have been successful.

Potential Benefits of School Green Space on Students' Environmental Orientation

Studies investigating the relationship between general school green space with students' environmental orientation are limited. A study that investigated the routines of students from 134 preschools in Stockholm found that among schools with similar demographics and teaching philosophies, those closer to urban green spaces had children who were more empathetic and concerned for other life forms and were more aware of human–nature interdependence (Giusti, Barthel, & Marcus, 2014). A quantitative study showed that in a school ground greening process, children's physical use of the school ground was important for establishing a positive and caring relationship with the landscaped area (Jansson et al., 2014). Another study found a positive relationship between sustainable facilities at school campuses and students' environmental attitudes and behavior (Tucker & Izadpanahi, 2017). Other research has demonstrated that students at an eco-school often showed higher environmental attitudes than students at a control school (Boeve-de Pauw & Van Petegem, 2013b).

Studies that have included the school physical environment as a variable have discussed the area of green coverage at the school (Dadvand et al., 2015), the existence of a school garden (Blair, 2009), or the green landscape visible out of the school windows (Kweon et al., 2017). To our knowledge, there is a deficiency of investigations on the effects of other potentially important variables such as degree of plant diversity (Lindemann-Matthies, Junge, & Matthies, 2010; Sivarajah, Smith, & Thomas, 2018), diversity in vegetation structure, or landscape richness (Määttä et al., 2019). Likewise, few studies have examined whether variations in a school's physical environment affect students' perception of green space (but see Akoumianaki-Ioannidou, Paraskevopoulou, & Tacho, 2016; Li, Ni, & Dewancker, 2019; Hart, 1979). More empirical studies are needed to understand the specific features that make a green school most effective and the ways a green environment affects students' environmental attitudes and pro-environmental behaviors.

In this study, we aimed to add to the understanding of these processes by expanding the school green space variables into a more comprehensive perspective, considering variables such as plant species diversity, vegetation structure diversity, and landscape possibility (richness). In addition, we hypothesized that other features such as potted plants in classrooms and corridors (van den Berg, Wesselius, Maas, & Tanja-Dijkstra, 2017), and the existence of recreational facilities (Akoumianaki-Ioannidou et al., 2016) are also important variables for the school physical environment. Considering these variables in combination, our aims for this study are to provide a clear vision on what makes a "good" school green space, and thereby to deliver suggestions on school green space practices.

Potential Variables Connecting School Physical Environment and Pro-Environmental Behavior

Environmental Perception

People make sense of the objective environment through their own perceptions. Environmental perception is an integral component of human-environment interaction, providing a link between the physical context and individuals' subsequent cognitive, affective, and behavioral responses (Ittelson, 1976; Stokols, 1978). Environmental perception has commonly been defined as awareness of, or feelings about, the environment, and as the act of apprehending the environment by the senses (Zube, 1999). It is also the first step in the process of developing environmental knowledge and awareness (Albuquerque & Alves, 2016).

Studies have shown that a well-designed school environment can foster a dynamic relationship between students and the environment (Orr, 1997; Taylor, 1993). The school physical environment has the potential to train and sharpen students' perception, enhance their sensitivity, and allow them to develop an aesthetic sense of the environment (Demirbaş & Demirkan, 2003). An empirical study found that students' aesthetic perception of green space is positively correlated to the students' feelings of security (Karimian, Samiei, & Kazemi, 2017). Students' perception of their school environment is a potential variable between the physical school environment and students' environmental attitudes and PEB.

Interaction with Natural Elements at School

Research suggests that adults' pro-environmental attitudes and behaviors are largely shaped by childhood experiences in nature (Chawla & Cushing, 2007; Hinds & Sparks, 2008; Li & Chen, 2015). Experiences in nature may consist of any number of interactions with natural elements, such as catching fish in a creek, observing a caterpillar on a leaf, smelling flowers, etc. A green environment at school may provide children such opportunities to interact with elements in nature, observing insects or plants in the parterre, reading books under the shadow of a tree, or growing plants in the school garden (Akoumianaki-Ioannidou et al., 2016). These kinds of activities may allow students to develop an emotional affinity to nature (Collado, Staats, & Corraliza, 2013), which in turn can enhance their positive environmental attitudes and pro-environmental behavior.

Environmental Attitudes

Environmental attitudes refer to a person's psychological tendencies when evaluating an environmental object (e.g., environmental protection, appreciation of nature, or the human-environment relationship) (Kaiser, Hartig, Brügger, & Duvier, 2013; Milfont & Duckitt, 2010). Many studies have reported strong correlations between environmental attitudes and PEB (Bamberg & Möser, 2007; Johnson &

Činčera, 2015; Pooley & o'Connor, 2000); however, a few other studies have found weak correlations (Gifford & Sussman, 2012; Müderrisoglu & Altanlar, 2011). There are two dimensions of environmental attitudes: preservation and utilization (Milfont & Duckitt, 2004; Wiseman & Bogner, 2003). The former refers to "a biocentric dimension that reflects conservation and protection of the environment," while the latter refers to "an anthropocentric dimension that reflects the utilization of natural resources" (Wiseman & Bogner, 2003, p.787). Studies have shown that the preservation dimension of environmental attitude has a positive relationship with PEB (i.e., students who scored higher on the preservation dimension performed more environmentally friendly behaviors in their daily life), while the utilization dimension has a negative relationship with PEB (i.e., students who scored higher on the utilization dimension performed fewer environmentally friendly behaviors in their daily life) (Johnson & Činčera, 2015; Pooley & o'Connor, 2000).

Environmental Education in Chinese Schools

Students' environmental attitudes and PEB depend not only on students' perception of their school environment and their interactions with natural elements, but on other variables as well. Among these, environmental education activities may have a positive influence on students' environmental attitudes and PEB (Collado et al., 2013; Soga & Gaston, 2016). Environmental education began to be integrated into China's basic education curriculum in 1987, and the country is experiencing a rapid growth in the field of environmental education (Tian & Wang, 2016). The "Green School Program" has been promoted throughout the country since 1992. The Ministry of Education requires schools to integrate environmental knowledge, attitudes, and values into the compulsory school curriculum, for example, by offering environmental education courses as an independent subject, fully integrating environmental education into school schedules, offering teacher training, and conducting research on environmental education pedagogies (Tian & Wang, 2016).

In addition to the efforts of the government and formal education systems, some Chinese schools also have opened their doors to environmental non-governmental organizations. According to an incomplete investigation, as of 2018, there were nearly 400 environmental education organizations in China, of which 54% were commercial companies and 21% were non-government organizations. Fifty-six of the organizations were newly established (Feng, Xiao, Zhou, & Wu, 2018). These environmental education organizations provide schools with more professional environmental-focused resources, such as natural observation tour guides in schools, themed course implementation, and undertaking school outings. Thus, a growing number of children have chances to participate in environmental education activities both within and outside of school, and we assume that Chinese children have benefited from this process.

Research Questions

Previous studies have outlined the relationship between school environment attributes and environmental attitudes and PEB (Tucker & Izadpanahi, 2017). However, few studies have explained the mechanisms by which this relationship can be built, and which factors among the campus green space variables are significant predictors of educational outcomes. This study aimed to fill this gap and examine whether and how a school green environment impacts students' environmental attitudes and PEB.

Here, we propose the following hypotheses:

- Hypothesis 1 (H1): A green school environment has a direct and positive influence on students' perception of their school environment (PSE).
- Hypothesis 2 (H2): Students' PSE and their interaction with natural elements (INE) have a direct positive effect on the preservation dimension of students' environmental attitude.
- Hypothesis 3 (H3): Students' PSE and INE have a direct negative effect on the utilization dimension of students' environmental attitude.
- Hypothesis 4 (H4): Students' PSE and INE have a direct positive effect on their PEB.

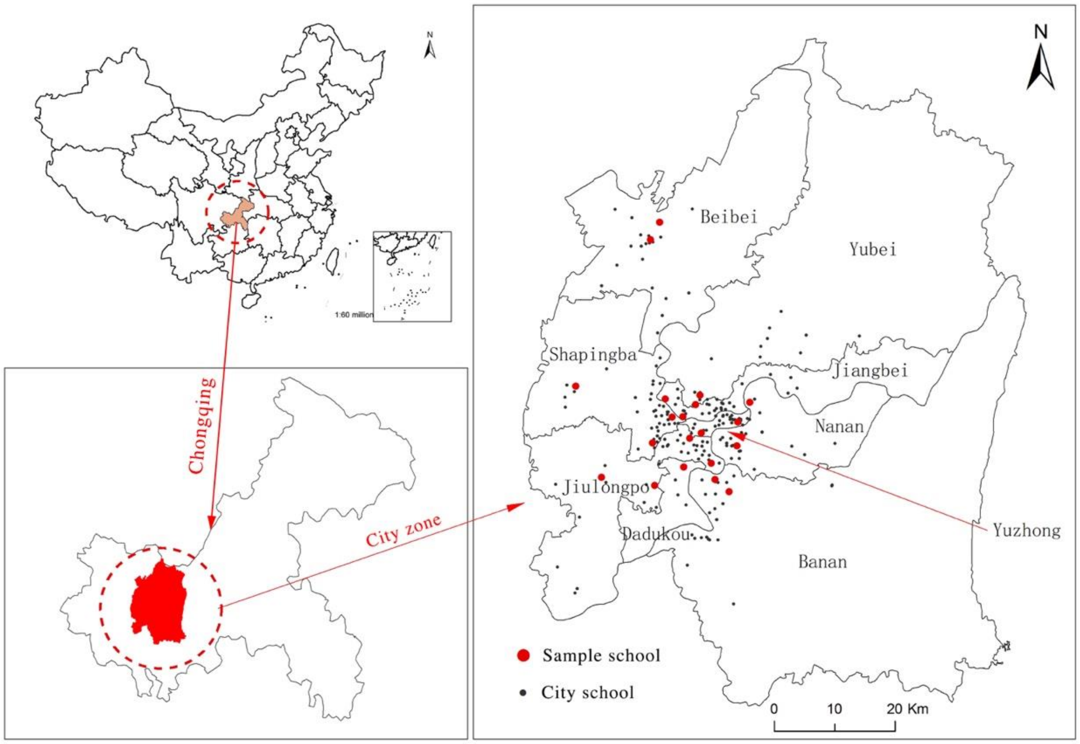
Materials and Methods

Geographic Context and School Selection

This study was conducted in the city of Chongqing, which is a central municipality city in southwest China in the Yangtze River upstream region. Chongqing has a humid subtropical monsoon climate, with an annual average temperature ranging from 16–18℃ and an average annual rainfall of 1000–1350 mm. Chongqing has more than 30.5 million permanent residents, and the urbanization rate is about 62.6%. The main body of the city includes nine districts with a total area of 5,472.68 km^2, and there is a 39.8% green coverage ratio as of 2016 (Chongqing Statistics Bureau, 2018).

In 2017, there were 425 primary schools in Chongqing, including 146 in rural areas and 279 in urban areas (Chongqing Statistics Bureau, 2018). Based on the school list from the local education department website, we randomly selected 20 schools for participation in this study. We then contacted the principal of each school, explained the purpose and contents of our study, and asked permission for surveying their schools. Three schools declined participation because of conflicts in schedule or distrust of us. We then selected another three to replace them. Figure 1 shows the geographic location of each school (red solid circles). (See Table 3 in Appendix A for basic information about the 20 participant schools.)

Figure 1. Map of participating schools



Data Collection

Physical Environment

Based on the findings of previous studies (Burns, 2010; China Green Building Council, 2013; Voigt, Kabisch, Wurster, Haase, & Breuste, 2014), we investigated eight variables regarding the school physical environment.

1) Green space area (GSA)

According to the Green Campus Evaluation Criteria (CSUS/GBC 04-2013) (China Green Building Council, 2013), school green space refers to "all kinds of green space within the scope of school land, such as public green space, dormitory green space, etc. The green space of primary and secondary schools should include concentrated green land, scattered green land, water surface, plantings for teaching practice, and small animal feeding gardens" (China Green Building Council, 2013, p. 33). We used Google Earth to calculate the area of the large green spaces at each school and field measurements to calculate the area of smaller green spaces. The total green space area (GSA) equals the area of the large green spaces plus the area of smaller green spaces.

2) Green space area per student (GSA/stu)

Green space area per student (GSA/stu) measures the ratio of total green space area to the total number of students at each school. This indicator can show how crowded green space is at a given school.

3) Plant species diversity (PD)
Studies have found that plant diversity has a positive influence on the perceived restorative properties and self-reported benefits of urban green spaces (Carrus et al., 2015; Zhao, Wu, & Wang, 2019). A more plant-diverse school ground has also been demonstrated to be more aesthetically appealing for students (Lindemann-Matthies & Köhler, 2019). In this study, we identified every plant species surrounding each school, including trees, shrubs, vines, grasses, aquatic plants, and herbs. We then took photos of each species to facilitate identification, which was accomplished with the help of a plant taxonomist.

4) Vegetation structure diversity (VSD)
Vegetation structure diversity (VSD) refers to the different types of plant communities on a school ground: a single large tree, a single small tree, groups of trees, rows of trees, lawn, flower beds, low vegetation, natural shrubs, aquatic plants, vine plants, and potted plants (Voigt et al., 2014). We counted the number of vegetation structure types for each school.

5) Landscape possibility (LP)
Nature realizes children's ten "central capabilities" in several ways (Chawla, 2015, p. 3; Nussbaum, 2011). The richer the interaction possibilities with the environment, the more likely children can benefit from it. Landscape possibility (LP) refers to the landscape's affordances of a wide variety of children's activity (Burns, 2010). According to Kyttä's definition, affordances are "the functionally significant properties of the environment that are perceived through the active detection of information" (Kyttä, 2002). Affordances include properties from both the environment and the acting individual, which means affordance is unique and relative for each child (Gibson, 2014). Researchers have found that each child adopts a different sensory learning modality (Smith, 1998). For example, according to Mahdjoubi and Akplotsyi (2012), children with a visual learning style prefer places with flowers, trees, landscaped fields, and multi-colored scenery. Meanwhile, children with an auditory learning style prefer environments such as bushy areas, where they can interact with their peers while remaining out of sight, and children with a kinesthetic learning style prefer spacious environments that encourage active exploration and movement. Children's perception of the environment is also affected by their social and cultural context (Kyttä, 2002; Albuquerque & Alves, 2016), so the same environment may have different affordances for different children. We assumed that a school with more landscape possibilities will meet more children's physical and psychological needs. We recorded the following landscape possibilities at each school: small gardens, woods, vegetation fields, roof gardens, pools, meadows, theme parks, vegetation gardens, backyard gardens, and single big trees. These landscape types are "non-prescriptive"; they stimulate the imagination and can be used in multiple ways.

6) Recreation facilities (RF)
For the purposes of this study, we included the following as recreation facilities, and counted the types at each school: flower beds with seats, stools, chairs, open-air theaters, reading galleries, calligraphy galleries, pergolas, terraces, and pavilions.

7) Green area of corridors (GAC)
We measured the green areas of the school's interior corridors (GAC) using tape measures. This includes the area of planted plants as well as potted plants in the corridors of the school buildings.

8) Indoor plants (IPlant)
We recorded the number of indoor potted plants in classrooms at each school and used the average to represent the indoor plants in the entire school.

School Green Activities
School green activities (GA) refer to educational activities related to the environment or nature, organized by schools with the goal of improving students' environmental literacy. In this study, the following types of activities are included: natural notes activity, cleaning hosted by the school, art performances related to the environment or environmental protection, lectures, science competitions, hand-written activities (such as themed compositions or freely designed hand-written papers), and recycling projects. We conducted interviews with teachers to record the number of green activities held in the last two years at each school.

Participants
We conducted a survey of two randomly selected Grade 5 classes at each school from September to November 2017. The informed consent protocols were approved by the participating schools, and school principals provided approval to approach classes. Students had the freedom to choose whether to complete the questionnaire or not, and only students who agreed to participate were handed the questionnaire. A total of 1,860 students finished the questionnaire; we excluded 170 invalid questionnaires, resulting in a validity rate of 90.8% and a sample size of 1,690. We also omitted the results of students who had been in the school for less than a year (n = 93); we felt that it was too short of a time for them to be affected by the school. This resulted in a final sample of 1,597 valid responses: 829 boys and 861 girls ages 8–12 (97.8% were ages 10–11). Of these, 89.9% had been at their current school for at least four years.

Self-Reported Variables
The survey asked students to report on their perception of the school environment, their interaction with natural elements at school, other environmental activity in which they participated outside of school, their environmental attitudes, and their pro-environmental behavior. Each of these variables is described below.

1) Perception of the school environment (PSE)
Environmental perception is the organization, identification, and interpretation of sensory information in order to represent and understand the environment (Gärling & Golledge, 1989). We relied on existing literature (Collado & Corraliza, 2012) to develop four items measuring students' perception of their school's physical environment (Table 1).

2) Interaction with natural elements (INE) at school
Interaction with natural elements at school refers to activities related to the natural environment in which students engage during school free time. We used four items to measure INE (Table 1).

3) Other environmental activity (OEE)
Apart from school, students' environmental attitudes are influenced by their environmental education activities or experiences outside of school. To measure this, we included five items to measure the environmental education activity students joined outside of school (Table 1).

4) Environmental attitudes
We used the Two Major Environmental Values model (2-MEV) scale developed by Bogner and Wiseman (2006) to measure students' environmental attitudes. This scale consists of two subscales: preservation and utilization. It has been determined reliable and valid in multiple countries (Braun, Cottrell, & Dierkes, 2018; Castéra, Clément, Munoz, & Bogner, 2018; Johnson & Manoli, 2010; Boeve-de Pauw & Van Petegem, 2013a). Liu and Chen (2020) developed a modification of this scale for us in China, and in this study, we use their 16-item Chinese version.

5) Pro-environmental behaviors (PEB)
We used existing scales to develop a project-specific pro-environmental behavior scale to measure children's self-reported PEB (Liu & Chen, 2020). This scale consisted of ten items and measured children's pro-environmental behaviors such as energy saving, resource saving and recycling, persuasion, and asking a teacher about environmental issues. Previous studies have reported on the reliability and validity of this scale (Liu & Chen, 2020).

For all five scales mentioned above, we used a 5-point Likert-type scoring system with responses ranging from 1 (strongly disagree) to 5 (strongly agree).

Data Analyses

We used principal component factor analysis to extract major factors of the eight school physical environment variables. We calculated the score of each school's principal factors based on an SPSS regression method and used these scores in linear regression models. To explore the influence of school environment and green activity on students' perceptions, we calculated the mean scores of students' perceptions of each school. We used linear regression models to test the standard estimate and significance of the influence.

Furthermore, to understand how students' perceptions, interactions with natural elements at school, and other environmental activities affected their PEB, we developed a pathway model using AMOS software. We used a bootstrap method with 5,000 resamples and bias-corrected 95% confidence intervals to estimate whether environmental attitudes significantly mediate the relationship between perception of the school environment, interaction with natural elements, and other EE activities and PEB (Preacher & Hayes, 2008). We assessed the model's goodness-of-fit using chi-square, root mean square error of approximation (RMSEA), and comparative fit index (CFI) (Hooper, Coughlan, & Mullen, 2008).

Table 1. Constructs and measurement items

Construct	Item code	Measurement items
Perception of school environment: Do you agree or disagree with the following statements? (Strongly disagree to Strongly agree)	PSE1	I feel there are diverse species of plants in our school
	PSE2	I think the plant species diversity in school is very high
	PSE3	I think the vegetation structure in school looks rich and beautiful
	PSE4	I think the environment of our school is very natural
Interaction with nature environment in school: Please indicate your frequency of conducing the following activities in school in your spare time (Never, Seldom, Sometimes, Often, Always)	INE1	Observing small animals
	INE2	Closely observing plants
	INE3	Playing under tree shadows
	INE4	Staying quiet and enjoying the tree shadows
Other environmental education activity: Please indicate your frequency of participating in the following activities in the past year (Never, Seldom, Sometimes, Often, Always)	OEE1	Participating in environmental education activities not organized by school
	OEE2	Going to the countryside or natural places
	OEE3	Going to city gardens
	OEE4	The time spent in housing estate gardens on average every day (zero, <0.5h, 0.5~1h, 1~1.5h, >1.5h)
	OEE5	Times visiting a zoo last year (zero, once, twice, three times, more than three times)
Environmental Attitudes—Preservation: Do you agree or disagree with the following statements? (Strongly disagree to Strongly agree)	P1	It upsets me to see the countryside taken over by building sites
	P2	I enjoy trips to the countryside (woods, meadow)
	P3	Humankind will die out if we do not live in tune with nature
	P4	Sitting at the edge of a pond watching dragonflies in flight is enjoyable
	P5	I save water by taking a shower instead of a bath
	P6	We must set aside areas to protect endangered species
	P7	It is interesting to know what kinds of creatures live in ponds or rivers
	P8	Dirty industrial smoke from chimneys makes me angry

Environmental Attitudes—Utilization: Do you agree or disagree with the following statements? (Strongly disagree to Strongly agree)	U1	We need to clear forests in order to grow crops
	U2	Our planet has unlimited resources (e.g., potable water, wood, coal, or oil)
	U3	Nature is always able to restore itself
	U4	Only plants and animals of economic importance need to be protected
	U5	Humans have the right to change nature as they see fit
	U6	People worry too much about pollution
	U7	Human beings are more important than other creatures
	U8	We should remove garden weeds to help beautiful flowers grow
Pro-environmental behavior: Please indicate your frequency of doing the following activities in the past year (never, seldom, sometimes, often, always) (Liu and Chen, 2020)	PEB1	When I played outside, I bought bottled water
	PEB2	I bought more food than I really needed at a restaurant
	PEB3	I consciously picked up the garbage on the playground or corridor
	PEB4	I looked at books about the environment (nature, trees, and animals)
	PEB5	I collected and recycled used paper
	PEB6	I consulted my teacher about the environment
	PEB7	I helped clean the neighborhood in my free time
	PEB8	I talked with friends about problems related to the environment
	PEB9	I pointed out unecological behavior to someone
	PEB10	I paid close attention to environmental issues in the media (newspapers, magazines, and TV)

Reliability of Scales
We applied descriptive analysis and reliability analysis to the five scales used to measure students' self-reported variables. The Cronbach's alpha of PSE is 0.710 (M = 3.89), of the INE is 0.773 (M = 2.75), of the OEE is 0.670 (M = 2.98), and of the PEB is 0.770 (M = 3.02). For the 2-MEV scale, which measured students' environmental attitudes, the Cronbach's alpha of the preservation subscale was 0.636 (M = 4.20) and of the utilization subscale was 0.682 (M = 2.28).

School Environment
Among the 20 schools sampled, there was great variation in the schools' physical green environment: green space area ranged from 1,155 to 19,080 m^2, the number

of plant species ranged between 21 and 135, and the vegetation structure diversity ranged between 4 and 11. Other variables are shown in Table 4 in Appendix B.

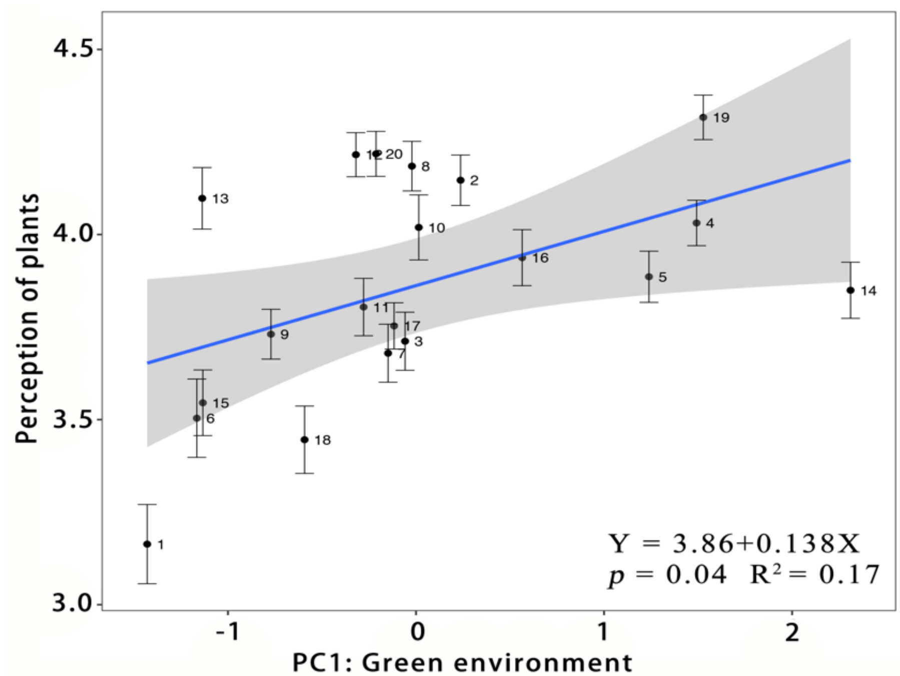
We found high correlations between GSA, GSA/stu, PD, VSD, and LP; the correlation coefficients ranged between 0.48 and 0.85 (see Table 5 in Appendix C). Our principle component analysis showed two principal factors (eigenvalue > 1). We used the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity (BTS) to verify that the data was amenable to being factor analyzed, and confirmed the suitability of the ensuing factor model with a KMO measure of 0.643 and a significant BTS statistic (approximately $\chi^2(28) = 96.40$, $p < 0.001$). The Principal Component 1 (PC1; "Green Environment") represented GSA, GSA/stu, PD, VSD, LP, and RF and explained 50.16% of the variance. The Principal Component 2 (PC2; "Indoor Green") represented Green Corridor Area and Indoor Plants and explained 21.13% of the variance. We calculated the scores of each principal factor for each school based on the regression method, and we used these scores to replace the original school physical environment in the following analysis (Table 2).

Table 2. Component matrix of principal component analysis of environmental variables

Variable	**PC1 (Green Environment)**	**PC2 (Indoor Green)**
GSA	**0.92**	0.22
GSA/stu	**0.799**	–0.047
PD	**0.887**	0.14
VSD	**0.79**	0.079
LP	**0.877**	0.236
RF	**0.538**	0.014
GCA	–0.033	**0.908**
Inplant	0.244	**0.856**
Proportion explained	50.16	21.125
Cumulative proportion	50.16	71.285

We used regression models to determine whether green environment (PC1) and indoor green (PC2) affected students' perception of the school environment. The results showed that PC1 had a significantly positive effect on students' perception of school environment, with a standard estimation $\beta = 0.46$ ($p = 0.04$, $R^2 = 0.17$). As Figure 2 shows, the greener the school environment, the higher students' perception of the environment. However, PC1 has not had any significant effect on the students' interaction with natural elements ($\beta = -0.05$, $p = 0.86$, $R^2 = -0.04$). PC2, meanwhile, had no significant effect on either students' perception of the school environment ($\beta = 0.15$, $p = 0.53$, $R^2 = -0.03$) or interaction with natural elements ($\beta = -0.14$, $p = 0.56$, $R^2 = -0.04$).

Figure 2. The influence of green environment on students' perception of the school environment and preservation score (n = 20)



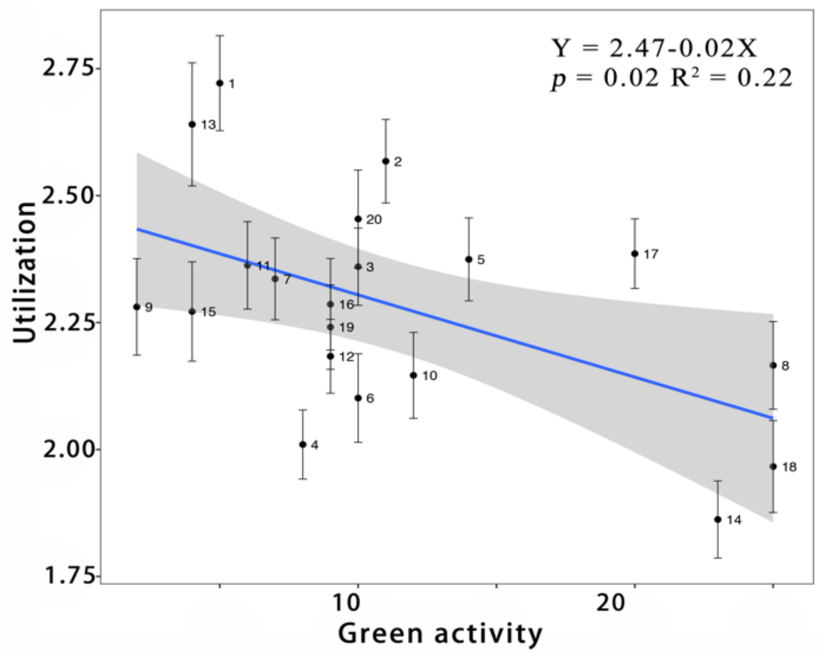
Note: every black spot represents one school with school code shown on the right; the error bar represents standard error; the estimation in the equation is nonstandard).

School Green Activity

Our interviews with teachers provided a list of 223 activities related to environmental protection held in schools over the last two years. Each school had held 2–25 green activities (see Appendix B for more details). The most popular type of activity was talking (26% of total activities), followed by hand-written activities (15%). Cleaning was least popular, only accounting for 6% of the total activities. The proportion of each activity type is shown in Figure 5 in Appendix B.

We built three regression models to determine whether the number of green activities at a school affected students' perception of the school environment and environmental attitudes. The results showed that green activities did not have any significant effect on the perception of the school environment, with $\beta = 0.07$ ($p = 0.78$, $R^2 = -0.05$). Green activities also did not significantly affect the preservation score, with $\beta = 0.03$ ($p = 0.91$, $R^2 = -0.05$). However, these activities significantly affected the utilization score, with $\beta = -0.51$ ($p = 0.02$, $R^2 = 0.22$). In other words, the more green activities, the lower the perception of nature as something to utilize (Figure 3).

Figure 3. The influence of green activities on students' utilization value (n = 20)

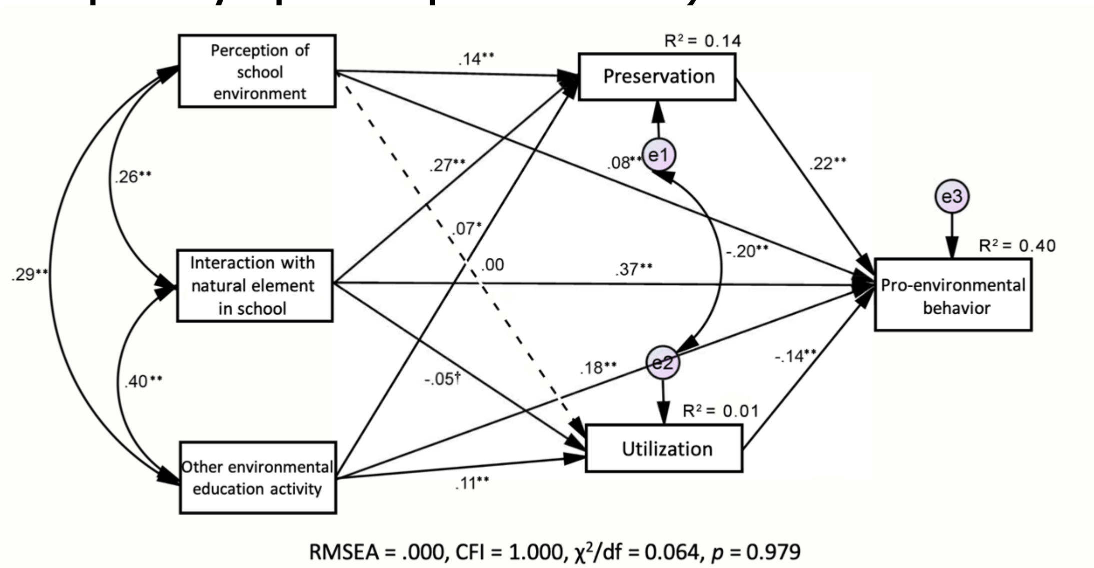


Note: every black spot represents one school with school code shown on the right; the error bar represents standard error; the estimation in the equation is nonstandard)

Students' Environmental Attitudes and Pro-Environmental Behavior

We developed a pathway model to understand how perceptions of the school environment and interaction with natural elements at school affect students' environmental attitudes and PEB. The fit indices for the pathway model are χ^2 = 0.193, df = 3, χ^2/df = 0.064 (p = 0.979), RMSEA = 0.000, CFI = 1, NNFI = 1, and indicate a good model fit. As Figure 4 shows, perception of the school environment has a direct positive influence on students' preservation score (β = 0.14, $p < .01$), which in turn significantly increases PEB (β = 0.22, $p < .01$). Meanwhile, perception of the school environment has a direct effect on PEB (β = 0.08, $p < 0.01$), as does interaction with natural elements at (β = 0.37, $p < 0.01$; Figure 4). Neither perception of school environment nor interaction with natural elements in school have a significant influence on the utilization score. The overall model explains 14% of the variance in preservation, 1% of variance in utilization, and 40% of variance in PEB. Tables 6-10 in Appendix D show the mean, standard deviation, correlations between constructs, standardized regression weights (direct effects), correlations, squared multiple correlations, and standardized regression weights (indirect effects) for the pathway model.

Figure 4. Pathway model showing the influence of students' perceptions of school green space, natural activity within school, and EE activity out of school on environmental values and pro-environmental behavior (n = 1,597; number on the pathway represents path coefficient)



Discussion

This study explores the influence of school green space on students' environmental attitudes and pro-environmental behaviors. The results show that students' perception of their school environment is positively correlated with the objective attributes of the school's green environment. Students' perception of the school environment and their interaction with natural elements at school have a direct, significant positive effect on their preservation environmental attitude and PEB. Among the four hypotheses we proposed, Hypothesis 1 (a green school environment has a direct and positive influence on students' PSE), Hypothesis 2 (PSE and INE have a direct positive effect on preservation), and Hypothesis 4 (PSE and INE have a direct positive effect on PEB) have been supported, whereas Hypothesis 3 (PSE and INE have a direct negative effect on utilization) has been rejected. The research thus has indicated that the green spaces in Chinese schools enhance children's environmental attitudes and pro-environmental behavior.

The study indicated that the school environment is perceptible. This result is consistent with some previous studies, which found that students can perceive the quality of a school's physical environment (Akpinar, 2016; Collado & Corraliza, 2012; Samborski, 2010). Children can learn through the physical environment: it sharpens students' perception, enhances their sensitivity, and assists them in developing an aesthetic sense (Demirbaş & Demirkan, 2003).

This study further demonstrates that children's perception of the school environment has a positive relation with PEB. In other words, students who attend a school with more green space, plant diversity, and landscape possibility will exhibit more pro-environmental behavior. Previous studies also showed that an adult's perceptions of a natural element's restorative qualities can predict the individual's environmental behavior (Hartig, Kaiser, & Bowler, 2001). Although the positive correlation does not necessarily mean a cause-effect relation, this study suggests that school managers and designers could construct the school green environment in ways that positively impact students' environmental orientation and behavior (Kong, Yaacob, & Ariffin, 2015).

Our results also indicated that students' interaction with natural elements at school was an important factor in cultivating students' environmental attitudes and PEB. Because school is the place where children spend the majority of their time when not at home, opportunities to experience and learn from nature provided at school can promote students' affinity with nature (Collado, Evans, Corraliza, & Sorrel, 2015). Therefore, teachers should consider how to promote students' interaction with the outdoor environment at school. As learning does not only happen in the classroom, teachers should try to encourage students' free-choice learning on the school ground, providing them with various opportunities to interact with natural elements while at school. Psychological studies show that children have different learning modalities (Smith, 1998). Children of different genders, ages, and personalities have different preferences for how they engage with different environmental characteristics and activities (Barbour, 1999; Bell et al., 2008). Schools must therefore seek to meet the needs of all children; the richer the environmental structure, the stronger its affordances, which can enable more children to enjoy the school green environment.

This study found that students' PSE and INE can explain their attitude toward preservation of the environment, but cannot explain their attitude toward utilization of the environment. The logic behind this might be that students' preservation attitude originated from their appreciation of the beauty of their school green space, and this appreciation stimulated them to have more interaction with the environment. People tend to protect what they find beautiful or perceive to be good. Regarding students' attitude toward utilization, PSE and INE cannot explain the variations in it, but the school's green activities can (with a $R^2 = 0.22$). This "contradictory" result could be attributed to the lack of one variable in the pathway model: students' self-reported gains from the green activities held in school. Previous research on the pedagogical approach of eco-schools found that they had an impact on students' attitude toward utilization (Boeve-de Pauw & Van Petegem, 2013b), which is consistent with our results. Eco-schools' pedagogical approach involves school-based educational projects or activities that are related to the sustainable development of the school environment, which are similar to the green activities in this study.

Together with the results of previous studies, this study has surfaced some interesting implications: to improve the preservation dimension of students' environmental attitude, an appreciation activity such as experiencing nature might be effective. At the same time, to improve the utilization dimension of students' environmental attitude, more pedagogical activities should be added, such as lectures, hands-on activities, and eco-school-like projects. We can perhaps better understand this from the psychological essence of the two environmental attitudes:

the preservation attitude is a positive mental activity, often conveyed as "make the good things stay"—that is, because nature is beautiful, we should protect it. On the other hand, utilization of nature is an antidromic mental activity that requires denying primitive human desires—"We should not eat wild animals," or "we should not use too much of the woods." To overcome these, more mental strength is needed, so more intensive, pedagogical interventions must be applied. Preservation and utilization are not contrary to each other (Johnson & Manoli, 2008; Liu & Chen, 2020; Wiseman & Bogner, 2003), so we cannot judge environmental education's success solely on the basis of students having improved preservation attitudes. To some degree, beautiful school environments and educational approaches are equally important for cultivating students' environmental literacy.

This study did not find any strong relationship between green activities and students' perception of the school environment or interaction with nature at school. This presumably indicates problems with the current green activities at schools: our interviews show that most of the green activities were not based on school grounds, such as lectures or hand-written activities. Instead, the activities were disconnected from the school environment. Previous studies have shown that school grounds and classrooms are powerful tools that influence teaching and learning (Orr, 1997). The physical environment and environmental education should not be two separate identities; teachers and school managers may need more training on how to use the school environment as a teaching tool.

Despite many interesting findings in our research, this study also has some limitations. First, we used principal factor analysis to reduce the school physical environment variables and obtain the principal component factor of the "green environment." This included many interesting variables, such as landscape possibility, plants species diversity, plant structural diversity, etc. However, this method does not indicate the potential influence of any individual attribute on students. Future studies could dive into these individual attributes, and we expect such research will lead to more suggestions about the design and construction of school environments. Second, the reliability of the OEE and 2-MEV scale used in this study has not met the often cited standard (< 0.7) (Nunnally, 1978), but they were very close to 0.7, hence still tolerable; however, we assume that those two scales need further improvement with reference to the reliability coefficient in future studies. Third, the 20 primary schools randomly sampled do not represent the current trends in school environment innovation. Most studies have focused on innovative school design, including participatory (Wake & Eames, 2013) and permaculture design (Holmgren, 2002; Skanavis & Manolas, 2015). Such studies find that these designs may provide a better environment for children (Macnab et al., 2014). Future studies should engage in more detailed comparisons of schools with different design philosophies and explore the roles of different spaces in the school environment. In addition, some schools in our study were more restrictive of students' activities due to safety considerations, which greatly affects the role of the school environment (Wang, 2013). Future studies could pay more attention to this factor.

Despite these limitations, our findings indicate that a school's physical environment does have a positive influence on students' environmental attitudes and PEB via their perceptions, as does students' interaction with natural elements at school. These findings highlight the importance of the school physical environment and students' interactions with the environment. School designers, principals, and teachers should consciously include the school physical environment in their pedagogy to better cultivate students' environmental literacy.

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Appendix A.

Table 3. Basic information about selected schools

School Code	District	Funding Year*	Number of Students	Number of Classes	School area (m^2)
1	Shapingba	1966	570	12	4,071
2	Jiangbei	2008	1200	36	23,847
3	Shapingba	1936 (2010)	1150	24	12,446
4	Yubei	2005	1665	37	32,966
5	Shapingba	1970 (2011)	1170	23	18,182
6	Yuzhong	1957	1158	47	7,072
7	Jiulongpo	2008	1600	27	14,540
8	Jiulongpo	1998	1552	32	13,120
9	Jiulongpo	1988	1398	27	10,755
10	Dadukou	1963 (2013)	2098	42	11,294
11	Jiangbei	2002	721	17	5,503
12	Yubei	1993	1442	26	13,306
13	Banan	2015	1055	25	11,959
14	Nanan	2006	3100	74	30,091
15	Banan	1941 (2007)	934	20	5,035
16	Yubei	2013	1198	33	21,716
17	Nanan	1999	572	23	3,597
18	Yuzhong	1911	1090	26	7,055
19	Yubei	1922 (2010)	1500	30	19,308
20	Beibei	2007	480	12	10,589

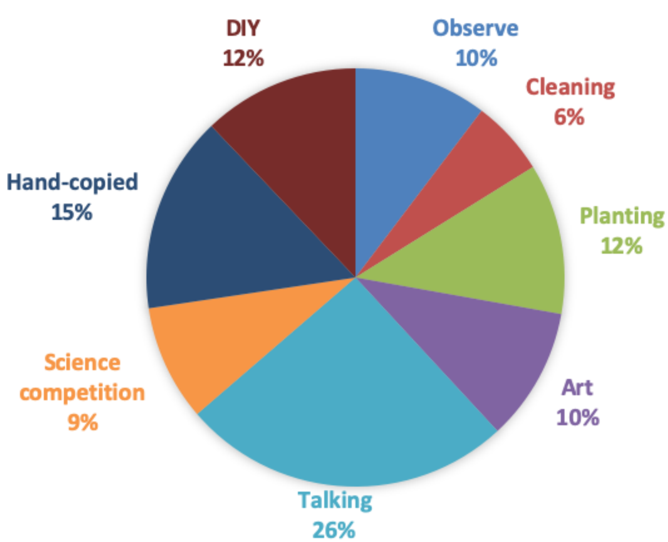
*Renovation year shown in parentheses

Appendix B.

Table 4. Environmental variables and green activities (GA) held in the last two years at each school

School code	GSA (m^2)	GSA/stu (m^2)	GR (%)	PD	VSD	LP	GCA (m^2)	RF	Inplant	GA
1	1,155	2.03	28.4	21	7	1	0	1	3.5	5
2	11,192	9.33	46.9	74	10	4	0	2	6.5	11
3	4,129	3.59	33.2	76	6	6	0	2	2.5	10
4	17,677	10.62	53.6	135	9	7	230	8	17.5	8
5	6,726	5.75	37.0	88	9	6	0	8	3	14
6	2,775	2.40	39.2	50	5	0	35	1	0	10
7	4,375	2.73	30.1	43	9	3	15	4	0	7
8	4,714	3.04	35.9	61	7	4	50	4	22.5	25
9	2,811	2.01	26.1	80	4	2	55	3	4.5	2
10	2,623	1.25	23.2	56	7	4	156	7	2.5	12
11	2,211	3.07	40.2	52	7	2	102	2	12.5	6
12	3,480	2.41	26.2	55	7	2	15	3	4	9
13	3,165	3.00	26.5	47	7	3	473	0	24	4
14	19,080	6.15	63.4	113	11	10	203	3	17.5	23
15	1,462	1.57	29.0	41	6	1	15	0	1	4
16	6,760	5.64	31.1	86	7	4	64	3	6	9
17	1,855	3.24	51.6	67	8	3	105	4	8	20
18	2,450	2.25	34.7	47	6	3	313	5	1	25
19	8,246	5.50	42.7	92	9	6	9	4	2.5	9
20	4,490	9.35	42.4	59	7	3	0	0	0.5	10

Figure 5. Proportion of each type of green activity held in schools



Appendix C.

Table 5. Correlation coefficients of environmental variables (the upper triangle represents the coefficient of significance)

	GSA	GSA/stu	PD	VSD	LP	RF	GCA	Inplant
GSA	1	<0.001	<0.001	<0.001	<0.001	0.06	0.25	0.04
GSA/stu	0.75	1	0.001	0.003	0.007	0.23	0.43	0.21
PD	0.85	0.68	1	0.015	<0.001	0.01	0.35	0.08
VSD	0.73	0.59	0.48	1	<0.001	0.07	0.45	0.11
LP	0.83	0.55	0.81	0.70	1	0.01	0.22	0.05
RF	0.35	0.17	0.52	0.34	0.49	1	0.34	0.431
GCA	0.16	-0.04	0.10	0.03	0.18	0.10	1	0.003
Inplant	0.41	0.19	0.33	0.28	0.37	0.04	0.59	1

Appendix D.

Table 6. Means, standard deviation, and correlations of constructs in the pathway model

Construct	Mean	SD	PSE	INE	OEE	PRE	UT
PSE	3.89	0.73	1				
INE	2.75	0.93	0.26**	1			
OEE	2.98	0.84	0.29**	0.40**	1		
PRE	4.23	0.55	0.23**	0.34**	0.22**	1	
UT	2.28	0.80	0.02	–0.01	0.09**	–0.18**	1
PEB	3.02	0.66	0.28**	0.53**	0.39**	0.43**	–0.16**

** means <0.01

Table 7. Standardized regression weights (direct effects) for the pathway model, with 95% confidence intervals (CI) and *p*-values

Independent variable		Dependent variable	Estimate	Lower 95% CI	Upper 95% CI	*p*-value
PRE	<---	PSE	0.142	0.092	0.193	0.004
PRE	<---	INE	0.272	0.228	0.319	0.004
UT	<---	INE	–0.053	–0.112	0.003	0.075
UT	<---	OUT	0.112	0.052	0.169	0.004
UT	<---	PSE	–0.003	–0.069	0.05	0.814
PRE	<---	OUT	0.07	0.014	0.119	0.013
PEB	<---	PSE	0.081	0.032	0.123	0.004
PEB	<---	INE	0.368	0.336	0.399	0.004
PEB	<---	OUT	0.179	0.136	0.226	0.004
PEB	<---	PRE	0.217	0.199	0.234	0.004
PEB	<---	UT	–0.135	–0.179	–0.095	0.004

Table 8. Correlations for the pathway model, with 95% confidence intervals (CI), and *p*-values

Parameter			Estimate	Lower 95% CI	Upper 95% CI	*p*-value
PSE	<-->	INE	0.259	0.221	0.296	0.004
INE	<-->	OUT	0.403	0.361	0.445	0.004
PSE	<-->	OUT	0.288	0.247	0.328	0.004
e1	<-->	e2	–0.196	–0.245	–0.146	0.004

Table 9. Squared multiple correlations for the pathway model, with 95% confidence intervals (CI) and *p*-values

Parameter	Estimate	Lower 95% CI	Upper 95% CI	*p*-value
UT	0.011	0.003	0.024	0.004
PRE	0.14	0.113	0.173	0.004
PEB	0.401	0.365	0.44	0.004

Table 10. Standardized regression weights (indirect effects) for the pathway model, with 95% confidence intervals (CI) and *p*-values

Independent variable	Dependent variable	Mediator	Standardized regression weight	Lower 95% CI	Upper 95% CI	*p*-value
OUT	PEB	PRE	0	-0.017	0.015	0.978
		UT				
INE	PEB	PRE	0.066	0.052	0.081	0.004
		UT				
PSE	PEB	PRE	0.031	0.017	0.046	0.004
		UT				