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# Influence of Limitedly Visible Leafy Indoor Plants on the Psychology, Behavior, and Health of Students at a Junior High School in Taiwan

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There is growing evidence to support the notion that contact with nature is helpful for emotional states, attention, mental fatigue, behavior, and personal health. This study adopts a quasi-experimental approach to investigate the effects of limitedly visible indoor plants on students' psychology, physiology, and behavior and uses a control-series design covering one semester. Two classes of sophomores at a Taiwanese junior high school (eighth grade, $N = 76$), of which one served as the experimental group and the other as control, were surveyed once every 2 weeks. After six plants were placed at the back of the classroom, the experimental group had immediately and significantly stronger feelings of preference, comfort, and friendliness as compared to the control group. Also, the experimental group had significantly fewer hours of sick leave and punishment records due to misbehavior than the control group. In addition to the visual and psychological mechanisms that contributed to restoration, there may have been other factors at work.

***Keywords:*** *preference; comfort; friendliness; sick leave; misbehavior*

## Introduction

Modern life, especially urban living, is often characterized by competition and a hectic pace, which can cause a great deal of pressure (Francis & Cooper Marcus, 1991; Lewis, 1990). According to research, feelings of

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pressure, anxiety, and stress have a negative impact on psychological and physiological health (Evans & Cohen, 1987; Francis & Cooper Marcus, 1991). It is estimated that the United States spends more than $100 billion each year on medication for stress-related illnesses (O'Donnell & Harris, 1994; Satuter, Murphy, & Harrell, 1990). In addition, an overload of information, excessive stimulants, and a lack of tranquility in modern urban life can cause continual distraction and a shortened attention span. As early as 1978, Simon pointed out that attention was a limited and valuable resource for humans in modern civilization. The exhaustion of that attention has been termed "mental fatigue" by Kaplan and Kaplan (1989). Generally speaking, mental fatigue can cause distraction and reduced performance (Cohen & Spacapan, 1978; Glass & Singer, 1972; Neuchterlein, Parasuraman, & Jiang, 1983; Parasuraman, 1986), negative emotions (Cimprich, 1992; Kuo & Sullivan, 2001b) such as irritability and tension (Warm & Dember, 1986), impulsiveness and hostility (Donnerstein & Wilson, 1976), or even behavior such as aggression and violence (Kuo & Sullivan, 2001b). Mental fatigue can also impede cognition, such as a lessened ability to take in information and to interpret and react (Cohen & Spacapan, 1978; Mackworth, 1948; Parasuraman, 1986).

Students, in particular, frequently need to focus their attention on studying, doing assignments, and preparing for examinations despite outside distractions and wandering thoughts. Therefore, they are highly vulnerable to the risk of increasing mental fatigue. This is typically the case in Taiwan. After completing the 9 years of mandatory education, most students in Taiwan will spend another 3 years at senior high schools or vocational schools and possibly another 4 years at universities or colleges. In addition, deeply influenced by the tradition of Confucianism, people in Chinese societies attach great importance to academic performance (Hau & Salili, 1991; Lee, 1996; Wong, 1991a). As a result, students in Chinese societies may face substantially more pressure regarding studying, examinations, and educational competition than students in Western societies (Biggs, 1991; Morris, 1985; Wong, 1991b). Accordingly, the research of Tennessen and Cimprich (1995) shows that after taking an examination, college students show a reduced capacity for attention and an increase in mental fatigue. Not surprisingly, attention deficiency is the major reason for unsatisfactory academic performance (Mantzicopoulos, 1995; Rowe & Rowe, 1992). Studies have also shown that the classroom environment plays a role in influencing students' learning and academic performance (Fraser, 1986, 1991, 1994; Goh & Fraser 1997). Therefore, an ideal learning environment should promote attention focusing, reduce mental fatigue and psychophysiological stress, and ideally even improve health and encourage better learning and/or examination scores, though in actuality little attention has been paid to the physical factors of learning environments (Gifford, 1997).

Recent studies have indicated that contact with nature, even if only visual, is beneficial for mood, aids recovery from mental fatigue, and improves behavior and health (Faber Taylor, Kuo, & Sullivan, 2001; Hartig, Mang, & Evans, 1991; Kaplan, 1995; Wells, 2000). The state of reduced mental fatigue and recovery of attention is referred to as a "restorative experience" (Kaplan & Kaplan, 1989). In a broad sense, contact with nature is defined as having some natural elements—such as vegetation, bodies of water, or blue skies—within one's sight (Kaplan, Kaplan, & Ryan, 1998). The contact period is generally not specified, as even a short contact period with nature can provide temporary relief from attention depletion and psychophysiological stress in ordinary daily life, producing a microrestorative experience.

If natural elements can actually reduce mental fatigue and psychophysiological stress, then vegetation in a learning environment should be able to help students decrease negative emotions, increase positive feelings, relieve physical stress, enhance attention, and even improve examination scores and reduce sick leave and misbehavior. Nonetheless, very few existing studies have explored these possible effects on students, excepting the research by Lohr, Pearson-Mims, and Goodwin (1996) as well as Hung and Chang (2002). The former study focused on the influence of interior plants at a computer laboratory on college students' task performance, attention, and stress reduction. The latter one aimed at the influence of classroom greenness on the attention span of kindergarten children. In addition, given that most of the studies on the benefits of nature or vegetation only focus on short-term and/or immediate responses of participants, researchers have advocated the necessity of studying longer term effects (Hietanen & Korpela, 2004). Moreover, the existing studies and theories primarily focus on the benefits of visual contact with nature and seemingly ignore the positive effects of exposure to live plants. Vision and/or psychological mechanisms might not be the only factor contributing to human well-being and/or health (Fjeld, Veiersted, Sandvik, Riise, & Levy, 1998; Lohr & Pearson-Mims, 1996). This study, therefore, examines the effects of limitedly visible plants in a classroom on students' psychology, behavior, and health, and explores the influence patterns of the indoor plants over a longer period of time.

## Empirical Research of the Psychophysiological Benefits of Nature on Humans

According to recent studies of human–environment interaction, nature—particularly vegetation—has positive effects on emotion, physiology, cognition, behavior, and health (Han, 2003; Hartig et al., 1991; Kaplan, 1995). The following is a summary of sampled findings.

## Effects on Emotion

Two surveys conducted in Sweden indicated that visual and/or physical access to and use of natural settings at either workplaces or near homes reduced the level of experienced stress, irrespective of gender, age, or socioeconomic factors ($N$ = 953, Grahn & Stigsdotter, 2003; $N$ = 656, Stigsdotter, 2004). Hartig et al.'s (1991) research indicated that both prolonged and shortened periods of interaction with nature (simulated or actual) were conducive to stress recovery as measured by affective self-reports. Stiles (1995) investigated the perceptions of hospital patients in a large waiting room under two conditions: with and without interior plants. The results showed that patients perceived the waiting room with plants as significantly more relaxing, welcoming, and cheerful and less stressful. In addition, a field experiment randomly exposed 81 participants to different amounts of plants in an office. This experiment indicated that indoor office workers' emotions were more positive when real plants were present than when no plants were present (Larson, Adams, Deal, Kweon, & Tyler, 1998).

## Effects on Physiology

Orsega-Smith, Mowen, Payne, and Godbey (2004) collected data from 100 elderly American adults (age >50) regarding their park visits and psychophysiological states for 5 days using a diary survey. They found that those who stayed in the parks longer had lower systolic blood pressure as measured by an electric sphygmomanometer and that this relationship was independent of daily stress level. Nakamura and Fujii (1990) measured unstressed participants' EEG in the alpha frequency range while they viewed four kinds of images: potted plants with or without flowers, the same pot without plants, or a cylinder similar to the pot. They found that the participants' alpha activity was greater when viewing potted floral plants, second-most active when observing potted plants without flowers, and least active when seeing the pot without plants. This result suggested that participants were less aroused physiologically and more relaxed but wakeful during exposure to natural simulations. Similarly, a laboratory experiment conducted by Chang and Chen (2005) in Taiwan compared 38 college students' psychophysiological reactions to slides of an indoor office with the presence of window views (none, city, and nature) as well as with the presence of indoor plants. Their results suggested that participants exposed to nature were less nervous, as indicated by the objective measure of blood volume pulse and the subjective measure of state anxiety. In addition, Lohr et al. (1996) conducted an experiment using 96 undergraduates as participants at a windowless college computer lab with plants either present or absent. They found that the participants had lower systolic blood pressure readings when plants were present than when they were not present.

## Effects on Cognition

An Internet survey in the United States collected parental evaluation of the symptoms for children with attention deficit/hyperactivity disorder (ADHD) with respect to the children's activity environments. The results obtained from 452 responses indicated that "green" outdoor settings significantly reduced ADHD symptoms even when the variations of activities and demographic factors, such as gender, age, income, residency, and disorder severity, were taken into account (Kuo & Faber Taylor, 2004). An experiment conducted by Shibata and Suzuki (2002) in Japan found that 146 college students performed better on an association task when presented with real plants than when none were present. Similarly, the results of Lohr et al.'s (1996) experiment indicated that the participants were 12% faster in reaction time on a computer task that objectively measured their mental processing and reported more perceived attention when with indoor plants than when none were present. Ottosson and Grahn (2005) conducted a field experiment at a geriatric care center in Sweden. They found that the 15 elderly residents (average age 86) performed better on cognitive tasks after visiting a nearby garden than after resting in their rooms. Moreover, Kuo and Sullivan (2001b) and Kuo (2001) reported that among the 145 inner-city residents of a Chicago public housing area, those who lived in green conditions had higher scores on a cognitive test than their counterparts living in more barren settings. Hung and Chang (2002) observed children's behavior at a kindergarten in Taiwan and found that the vegetation in the classroom increased the children's attention and reduced distraction.

## Effects on Behavior

Mooney and Nicell (1992) compared the behaviors of Alzheimer residents at two types of healthcare facilities in Canada: with and without gardens. As indicated by the nurses' records, the rate of violence and behavioral incidents were decreased in the institutions with gardens, whereas they increased considerably in the institutions without gardens. Kuo and Sullivan (2001b) found that the 145 interviewed residents who lived in apartments with more nature nearby reported less aggression and violence against their family members than those who lived in comparatively barren buildings, as indicated by a self-report scale. Faber Taylor, Wiley, Kuo, and Sullivan (1998) reported that among 262 children observed, those who played in green courtyards had higher levels of creative play than those in comparatively barren outdoor spaces. Similarly, other studies suggested that the greener those outdoor open spaces were, the larger and more mixed were the groups of residents that used them (96 observations, Coley, Kuo, & Sullivan, 1997) and that greener environments engendered more socializing or neighborly activities in nearby residents ($N = 145$, Kuo, Sullivan, Coley, & Brunson, 1998b; $N = 91$, Kweon, Sullivan, & Wiley, 1998; 758 observations, Sullivan, Kuo, & DePooter, 2004). Also, Kuo and Sullivan (2001a) found that of 98 apartments in Chicago, where the apartments had more surrounding nature, residents reported fewer property and violent crimes to the police.

## Effects on Health

The results of surveying 3,144 senior residents in Tokyo indicated that after 5 years the survival rate of the respondents who had green spaces nearby was significantly higher than that of those who did not, and that this effect was independent of socioeconomic variables (Takano, Nakamura, & Watanabe, 2002). In Moore's (1982) study, prisoners whose windows looked out on nearby farmlands and forests reported fewer sick calls than those whose window views looked out on the prison courtyard. Similarly, West (1985) found that prisoners having window views of natural settings had fewer stress-related physical symptoms, such as headaches and indigestion, than the prisoners having window views restricted to other prison buildings. Furthermore, Fjeld and associates (1998) recruited 51 healthy indoor office workers at a Norwegian company to participate in their experiment. They found that the participants reported significantly less neuropsychological and mucous membrane symptoms when their offices had plants present. Also, Ulrich (1984) compared health outcomes of 23 matched patients who had undergone gall bladder surgery and were recovering in a room with one of two types of window views. The postoperative patients whose rooms had a window facing a natural setting dominated by trees took fewer potent analgesics and were released from the hospital sooner than those whose windows overlooked a man-made setting dominated by brown brick walls.

## Major Theories of the Psychophysiological Benefits of Nature on Humans

Currently there are two major theories concerning the benefits of nature for humans. One is the Kaplans' attention restoration theory (Kaplan & Kaplan, 1989). The other is Ulrich's psychological–evolutionary theory (1983). Despite small differences, these two theories share many similarities because both of them are in line with evolutionary theory, Berlyne's psychobiology (1960, 1963, 1971), and information processing concepts (Hartig, 1993; Parsons, 1991).

According to evolutionary theory, owing to millions of years of evolution in natural environments, humans have developed a psychological mechanism of adaptive responses to nature. Particularly, humans react most favorably to certain contents and patterns of the natural environment, such as vegetation and water (Ulrich & Parsons, 1992, p. 96). Also, both theories adopt a psychological perspective of human–environment interaction as a means to search for suitable habitats that provide necessary resources such as water and vegetation, contain low risk factors, and can sustain survival, reproduction, and well-being. All this vital environmental information is perceived visually by humans. Thus, quick responses to visual information, such as preference, attention, and reaction, are conducive to human survival and evolution. Both theories further hypothesize that in addition to visual aesthetic responses, contact with nature can evoke more diversified positive reactions, feelings of well-being, and effective functioning. The subtle differences between these two theories are summarized below.

### Attention Restoration Theory

Kaplan and Kaplan's theory emphasizes that to ensure effective daily functioning, humans need to maintain cognitive clarity, which requires directed attention. However, each individual has a limited store of attention that is depleted by extensive use. In general, attention fatigue results in lowered competence and functioning efficiency (Hartig et al., 1991). Fortunately, attention depletion can be restored. A place where mental fatigue can be restored is referred to as a restorative environment (Kaplan et al., 1998). Restorative environments include a wide range of settings from wilderness to indoors, and are found on a variety of different scales. Nevertheless, environments that contain natural components, particularly vegetation and water, seem to be especially helpful for the reduction of mental fatigue (Kaplan, Bardwell, & Slakter, 1993; Kaplan et al., 1998).

Kaplan and Kaplan identify four features of restorative environments: being away, extent, fascination, and compatibility. If an individual spends sufficient time in an environment possessing these four components, he or she will experience four progressive levels of restoration. The first level is referred to as “clearing the head,” which allows random thoughts to wander in the head and gradually fade away (Kaplan & Kaplan, 1989, p. 196; cf. Kaplan et al., 1998). At the second level, the depleted attention is gradually recharged. At the third level, one can hear unattended thoughts or matters on one’s mind, owing to the reduced internal noise and enhanced cognitive quiet, which are facilitated by “soft fascination.” The final and the deepest level is one that tends to evoke “reflections on one’s life, on one’s priorities and possibilities, on one’s actions and one’s goals” (Kaplan & Kaplan, 1989, p. 197).

## Psychoevolutionary Theory

Ulrich argues that restoration is derived from the reduction of stress, instead of from the replenishment of directed attention fatigue (Hartig et al., 1991). According to him, when people encounter an event or a situation, they first perceive or appraise it in terms of its influence on their well-being. If an event or situation is judged or appraised as harmful, threatening, or challenging, then stress occurs, which usually is accompanied by other negative emotions (Brannon & Feist, 1997). Under aversive conditions, the internal equilibrium in body systems is disrupted (Evans & Cohen, 1987). The physiological functioning in response to stress also consumes energy and resources, which consequently causes fatigue (Ulrich et al., 1991). In addition, stress influences behaviors such as avoidance or abnormal performance (Cohen, Evans, Stokols, & Krantz, 1986).

Restoration from stress includes recovering from excessively high or low physiological and psychological conditions and recharging of the energy consumed in response to stress. According to Ulrich’s theory, if landscapes, which often contain vegetation and water, can immediately evoke feelings of mild to moderate interest, pleasure, and calmness, then they are conducive to restoration from stress (Hartig, Book, Garvill, Olsson, & Garling, 1996). When exposed to these kinds of settings, one’s attention is easily attracted, which may block pessimistic thoughts, replace negative emotions with positive ones, and reequilibrate physiological disturbances (Parsons, 1991). After the positive changes in emotions, reduced cognitive functioning or performance may be regained (Ulrich, 1993).

## Importance and Contribution of This Study

The importance and contribution of this study for human–nature interactions include five aspects. First, most of the existing research on similar topics was conducted in Western societies, which focused on adults and college students, with only a few of them recruiting children (Faber Taylor et al., 2001; Wells, 2000) or adolescents. This study used junior high school students in Taiwan as the participants. Second, unlike previous studies, this research collected the participants' data on human responses covering emotion, physiology, cognition, behavior, and health simultaneously by using both subjective and objective measures. Third, this study covered a relatively longer period of time of contact with nature and explored the change in the influences of nature through time. Fourth, most of the past studies were conducted at laboratories and adopted an experimental design that involved simulating outdoor settings. In contrast, this study focused on indoor environments and adopted a quasi-experiment in actual classrooms. So far, there are not many discussions in the literature on the influences of indoor plants on humans, particularly with respect to classroom greenness. Lastly, unlike previous studies that often focused on visual contact of photos and slides, or window views of natural scenery as the treatment, this research used real natural elements of a specified amount of living plants at the classroom, but which were only limitedly visible to students. In so doing, the contributed means and/or mechanisms of contact with nature might be further explored. In sum, this study could complement the insufficiency of past studies in the above-mentioned five aspects and might shed light on or serve as a pilot for future studies.

## Research Method

### Hypotheses

Based on the above-mentioned research findings and theories concerning the influence of nature on human emotion, physiology, cognition, behavior, and health, we are particularly interested in the benefits of exposure to indoor leafy plants beyond the solely visual aspects. Accordingly, the hypotheses of this study are as follows:

*Hypothesis 1:* Limitedly visible leafy indoor plants can reduce the psychophysiological stress of the students.

*Hypothesis 2:* Limitedly visible leafy indoor plants can enhance cognitive functioning, focus attention, and even improve academic performance of the students.

*Hypothesis 3:* Limitedly visible leafy indoor plants can reduce student misbehavior.

*Hypothesis 4:* Limitedly visible leafy indoor plants can reduce hours of student sick leave.

*Hypothesis 5:* The influences of limitedly visible leafy indoor plants on students' psychology, behavior, and health will change through time.

## Research Design

This study adopted a quasi-experimental approach with repeated measures. Specifically, it was a control-series design that included one experimental group and one control group covering both a baseline phase and a manipulation phase (Frankfort-Nachmias & Nachmias, 1996). The study lasted for one semester (from June 6, 2005, to January 21, 2006). During the study, two groups of students were surveyed using self-administered questionnaires about every other week for a total of 10 responses per student. In addition to the self-reported questionnaires, objective data for each participant were collected, including term examination scores, sick leave hours, and punishment records due to misbehavior. This research was divided into two phases: the baseline phase (lasting for approximately 1.5 months with four pretests) and the manipulation phase (lasting for about 2.5 months with six posttests after plants had been placed at the classroom of the experimental group). Before the study began, the students and their parents signed forms of consent.

There were three purposes of using the control-series design in this study. The first one was to compare the experiment and the control groups during the baseline phase to see if there were any differences. This was particularly important because this study was a quasi-experiment conducted in the actual classroom, and could therefore not control all conditions and provide precisely identical experimental conditions. The second was to investigate whether any differences existed after the treatment within the experimental group. The third was to test if there were any differences between the experimental and the control groups in the perceptions of their classroom environments and their academic performance during the manipulation phase. The selection of the experiment and the control groups was randomly decided. The same research assistant conducted the 10 questionnaire surveys for each group. The two groups of students filled out the questionnaires during their regular class meetings, which were scheduled at the same hour on the same day. Each time, it was randomly decided which group would take the questionnaire survey first. Each questionnaire survey took about 10 minutes to complete.

## Participants

There were three major considerations of participant selection in this study. First, both groups should have male and female students. Second, both groups should be similar in education level. Third, both groups should have similar physical environments in the classroom, such as size, shape, furniture arrangement, location, lighting, ventilation, noise level, and window views. The Ching Cheng High School in Changhwa County, Taiwan, met the above criteria and provided two classes of sophomore students of its junior high school division as participants (eighth-graders). The classrooms of these two classes were both located on the fourth floor of the same building and were immediately adjacent to each other. The experimental group had 35 students (26 male and 9 female), with an average age of 13.6. The control group had 41 students (32 male and 9 female), with an average age of 13.5. As indicated by the results of an independent *t* test, both groups were not significantly different in age ($p > .05$).

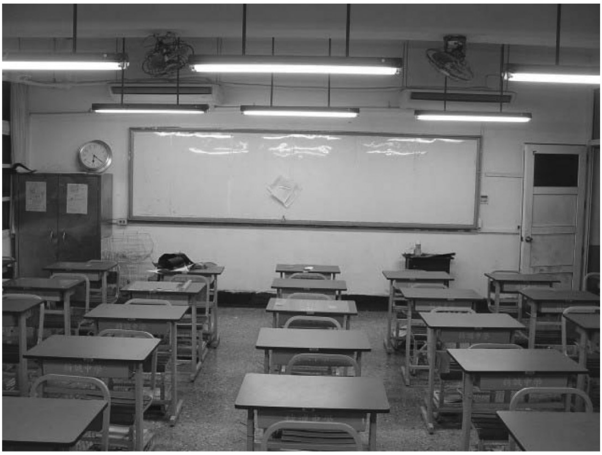
## Experiment Treatment

The treatment in this study was six Botel Tobago cinnamon trees (*Cinnamomum kotoense* Kanehira et Sasaki) with an average height of 135 cm and a mean canopy width of 80 cm, in total occupying 6% of the classroom floor plan. These relatively oval-shaped plants were placed in a row at the back of the classroom of the experimental group, so as to provide to the students a limited visibility of greenness (Figure 1). The Botel Tobago cinnamon tree is a small evergreen tree of the Lauraceae family. Both photophilous and shade-tolerant, this plant thrives at temperatures ranging from 22 °C to 30 °C. It is strongly adaptive to its environment, with relatively low vulnerability to pests and diseases. It has dense foliage with shiny green leaves, which together form a moderate texture. This species does not have obvious flowers, fruits, or fragrance (Xu & Lv, 1984).

Given that there is no study currently available that has reported which plant is most beneficial to human psychology, behavior, and health, the major reason for using the Botel Tobago cinnamon tree in this study was it is highly adaptive, strong, and easy to take care of. These six plants did not have any blossom or fruit during the experimental period. Their growth was measured every 1.5 months during the study. According to the results of ANOVA with repeated measures, the heights and the canopy widths of the plants did not differ significantly ($p > .05$) through time. Therefore, if there was any variation in students' reactions, it was not possibly caused by the

**Figure 1**
**Classroom Environments**

Experiment Group



plant growth. In addition, the plants were taken care of by assigned staff whose responsibilities included cleaning fallen leaves, watering plants, and moving the plants out of the classroom for sunlight during weekends. The students were not required to take care of the plants, which might have had its own effect on the students, such as that found in horticultural therapy (Davis, 1994; Hewson, 1994). Nonetheless, we observed that the students still interacted with the plants by putting small decorations on the foliage, such as plastic flowers and colored ribbons.

## Measurement Tools

The data in this study were mainly collected through questionnaire surveys that included (a) basic information of the students; (b) the State Anxiety Inventory (STAI) by Spielberger, Gorsuch, Lushene, Vagg, and Jacobs (1983); (c) the Restorative Components Scale (RCS) by Laumann, Garling, and Stormark (2001); (d) the Restoration Scale (RS) by Han (2003); (e) the Well-Being Measures (WBM) by Kaplan (2001); and (f) students' perceptions of their classroom environments in terms of preference, attraction, comfort, and friendliness. Using other scholars' scales that have proven reliable and valid saved the effort of developing and testing a new scale. Given that most of the scales were originally written in English, they were translated into Chinese for the use of this study. To ensure the Chinese translations were comprehensible to the participants, a pilot study recruiting seven 1st-year junior high school students was conducted. These students reported no particular difficulty or problem using these scales. In addition, because there might be other factors that could influence students' reactions, this study collected data on the positive and negative events, for example winning awards or having accidents, that occurred during the study period as controlling variables.

The STAI is a psychological scale frequently used in clinical practice and research to measure the immediate anxiety perceived by individuals. It is a 4-point scale containing 20 statements, such as "I feel calm" and "I feel nervous," among which nine statements are negatively worded (Spielberger et al., 1983). In calculating the state anxiety of the participants, the scores of the nine negatively worded statements were first reversed. Then all scores were summed to form the final index score. A higher index score meant greater anxiety felt by the participants. The reliability (Cronbach's $\alpha$) of the STAI for the two participant groups for 10 surveys in this study ranged from .699 to .946.

The RCS is mainly used to measure if an environment is helpful for individuals to reduce mental fatigue. This scale is based on the four factors of the Kaplans' theory. It is a 7-point scale containing 22 statements, for example "I am in a different setting than usual," "All the elements constitute a larger whole," "There are many objects here that attract my attention," and

"I am capable of meeting the challenges of this setting." The scores of each of the four factors (being away, extent, fascination, and compatibility) were averaged to produce a composite score, respectively. The four composite scores were then averaged to produce the index score. A higher index score meant greater perceived potential for attention restoration (Laumann et al., 2001). According to the data collected in this study, the reliability (Cronbach's $\alpha$) of this scale for the 20 surveys ranged from .770 to .954.

The RS is designed to measure the influences of environments on the psychophysiological stress of individuals. Integrating the theories of the Kaplans (1989) and Ulrich (1983), this 9-point scale contains eight statements covering the four factors of emotion, physiology, cognition, and behavior, such as "anxious–relaxed," "My breathing is becoming faster," "I am interested in the present scene," and "I would like to stay here longer." To obtain the index score, the composite score of each of the four factors was calculated first. Before these four composite scores were averaged, the composite score of the physiological arousal had to be reversed. A higher index score meant greater perceived potential for stress recovery (Han, 2003). As indicated by the data collected in this study, the reliability (Cronbach's $\alpha$) of the RS for the 20 surveys ranged from .725 to .871.

The WBM is developed according to the Kaplans' theory (Kaplan & Kaplan, 1989), which covers three factors (effective functioning, at peace, and distracted). This 5-point scale contains 26 statements indicating, for example, being "able to get really absorbed in a task," "irritable," and "losing or misplacing things," among which 10 are negatively worded. To calculate the index score, the scores of the 10 negatively worded statements were first reversed. Then the composite scores of the three factors were averaged. A higher index score meant greater overall well-being perceived by the participants (Kaplan, 2001). According to the data of this study, the reliability (Cronbach's $\alpha$) of the WBM for the 20 surveys ranged from .698 to .965.

Preference was measured from the statement "I like this setting very much." Attraction was referenced from "I am attracted to this environment very much." Comfort was indicated from "I am very comfortable in this setting." Friendliness was evaluated from "this environment makes me feel very friendly." There was only one statement using a 9-point scale for each of the four items in the questionnaires. Higher scores meant greater perceptions of the items by the participants. Because there was only one question for each of these four items, it was not a multiquestion scale. Therefore, the reliability could not be calculated.

In addition to the data obtained from the self-reported surveys, this study collected objective records of each participant to avoid subjectivity. The objective data included the scores of three term examinations during the semester, hours of sick leave, and records of punishment due to misbehavior in the study semester and in the previous semester. Each of the term examinations covered seven subjects: Mandarin, English, mathematics, civil ethics, history, geography, and chemistry and physics. Because the difficulty of the questions of each subject might be varied across the examinations, the scores of the seven subjects were first standardized (Neuman, 2006) and then were averaged to form the students' academic performance.

## Data Screening

To ensure the validity of the questionnaire data, invalid data on the scales in which (a) the participants indicated the same scores on all questions; (b) the scores of the statements showed a regular pattern, such as a Z shape; or (c) the answers to the positively worded and those to the negatively worded questions were contradictory, were discarded. All the collected subjective and objective data were analyzed using SPSS 12.0 for windows. The major statistical analyses included ANCOVA, ANCOVA with repeated measures, *t* tests, nonlinear regression, and correlation.

# Results

## Differences of Subjective Perceptions Between Groups

*Baseline phase.* Whether or not the two participant groups had equivalent states was examined by running ANCOVAs with repeated measures. Each of the eight perception scores of the four pretests was specified as a dependent variable. The participant group was used as an independent variable. The means of both the positive and the negative incidents during the baseline phase were specified as covariates to control the influences of other extraneous variance. Before an ANCOVA is conducted, it is necessary to ensure that the regression slopes of the factors are parallel (Fon, 1992; Chang, Chang, & Lin, 2003). The regression slope analyses showed that this premise was met, at which point the eight ANCOVAs were run. As the results indicated, except for the RS—experimental group mean = 5.250, control group mean = 4.288, $F(1, 37) = 7.684$, $p = .009$—there were no significant differences between the two groups in terms of the other seven perceptions. STAI: $F(1, 39) = 1.591$, $p = .215$; RCS: $F(1, 40) = 0.006$, $p = .939$;

WBM: $F(1, 25) = 0.098$, $p = .756$; preference: $F(1, 60) = 1.487$, $p = .228$; attraction: $F(1, 61) = 1.186$, $p = .280$; comfort: $F(1, 61) = 2.623$, $p = .110$; friendliness: $F(1, 61) = 2.213$, $p = .142$. That is, except for the RS, the two classes of students had equivalent states of the seven perceptions during the baseline phase despite not having the same teachers. Given that the participant groups differed in the RS, the comparisons of this response between the two groups were excluded in the later analyses. In addition, it was found that when negative events (mean = 0.769) were taken into account, the variations of the STAI were significantly reduced and therefore increased the precision of the analysis.

*Immediate effects.* Past research has focused on the short-term responses of the participants, and found an immediate and positive effect of vegetation on human perceptions of the environment. Therefore, after the placement of the six plants at the classroom, the first posttest was intended to measure the immediate effects of the greenness in this study. The seven perception scores of the first posttest, except for the RS, were used as dependent variables, respectively. The participant group was specified as the independent variable. The mean of each of the perceptions of the four pretests, respectively, and the means of the positive and the negative events during the first posttest period were used as covariates to control the influences of the baseline phase and other extraneous variance on the participants. The regression slope analyses showed that none violated the premise of parallel slopes. The results of the seven ANCOVAs indicated that there was no significant difference between the experimental and the control groups in the STAI, RCS, WBM, and in attraction. However, the experimental group had significantly higher scores than the control group in preference, comfort, and friendliness. This indicated that six indoor plants had immediate and positive effects on these three perceptions (Table 1). In addition, it was found that when the means of the seven perceptions of the pretests (STAI: 46.984; RCS: 3.518; WBM: 3.044; preference: 4.249; attraction: 3.995; comfort: 4.545; friendliness: 4.532) were taken into account, they reduced the variations and could therefore enhance the accuracy of the ANCOVAs.

*Manipulation phase.* Whether or not the treatment had positive influences on the participants over a longer period of time was examined by running ANCOVAs with repeated measures. The scores of the seven perceptions of the six posttests were used as dependent variables. The participant group was specified as the independent variable. The means of the

**Table 1**
**Comparisons of the First Posttest**

| | Means | | ANCOVAs | |
|---|---|---|---|---|
| Subjective Perceptions | Experimental Group | Control Group | *F* | *p* |
| STAI | 45.426 | 42.574 | 1.633 | .208 |
| RCS | 3.513 | 3.502 | 0.007 | .934 |
| WBM | 3.215 | 3.202 | 0.013 | .909 |
| Preference | 4.699 | 3.726 | 7.827 | .007** |
| Attraction | 4.184 | 3.881 | 0.910 | .344 |
| Comfort | 5.381 | 4.238 | 10.342 | .002** |
| Friendliness | 5.369 | 4.391 | 5.269 | .025* |

Note: STAI = State-Trait Anxiety Inventory; RCS = Restorative Components Scale; WBM = Well-Being Measure.
*$p < .05$. **$p < .01$.

perception scores during the baseline phase and the means of the positive and negative incidents during the manipulation phase were used as covariates. The regression slope analyses showed that all seven perceptions met the premise and were suitable for running ANCOVAs. The results of the ANCOVAs with repeated measures indicated that there was no significant difference between the two groups. STAI: $F(1, 23) = 0.095$, $p = .761$; RCS: $F(1, 27) = 2.207$, $p = .149$; WBM: $F(1, 13) = 1.110$, $p = .311$; preference: $F(1, 48) = 0.001$, $p = .974$; attraction: $F(1, 48) = 0.202$, $p = .655$; comfort: $F(1, 48) = 0.019$, $p = .890$; friendliness: $F(1, 48) = 0.360$, $p = .552$. This suggested that the students of both groups were not significantly different in their long-term perceptions of their respective classroom environments.

## Differences of Objective Records Between Groups

*Baseline phase.* The questionnaire surveys were subjective opinions of the participants, whereas the term examination scores and records of punishments due to misbehavior were objective evaluations. The results of *t* test with independent samples showed that there was no significant difference ($p = .881$) between the experimental and the control group in their academic performance in the first term examination during the baseline phase. Given that Ching Cheng High School compiled data of students' sick leave hours and punishment records only by semesters, the sick leave hours and punishment records of the two student groups in the previous semester were also analyzed using *t* tests with independent samples. The results indicated that these two groups were not significantly different in both records (sick leaves: $p = .273$; punishments: $p = .589$). Therefore, all of these tests suggested that the experimental and control groups had equivalent levels in terms of their academic performance, sick leave hours, and behavioral records before the treatment, even though the two classes of students had different teachers.

*Academic performance during the manipulation phase.* As previous studies have found that contact with nature was conducive to attention restoration and cognitive functioning, we were interested in examining whether or not indoor plants might, therefore, improve students' academic performance. An ANCOVA with repeated measures was conducted, in which the academic performance of the first term examination was used as a covariate, the academic performance of the second and the third term examinations were specified as dependent variables, and the participant group was used as the independent variable. The results indicated that (a) the premise of the parallel regression slopes was satisfied; (b) the two groups were not significantly different in academic performance, $F(1, 75) = 0.660$, $p = .419$; (c) though not significantly different, the experimental group had better academic performance than the control group (means: 0.036 vs. –0.032); and (d) taking into account the academic performance of the first term examination (mean: 0.000) could reduce the variations and enhance the precision of the analysis.

*Sick leave hours and punishment records.* Two ANCOVAs were conducted to examine if there were any differences between the two groups in their sick leave hours and punishment records due to misbehavior. The sick leave hours and the punishment records due to misbehavior in the previous semester were used as covariates, respectively. The sick leave hours and the punishment records during the study were specified as dependent variables, respectively. The participant group was used as the independent variable. The results showed that (a) the premise of equal regression slopes was met, (b) the experimental group had significantly fewer sick leave hours and punishment records than the control group (Table 2), and (c) using covariates (sick leave hours mean: 2.320; punishment records mean: 0.160) could reduce the variations and increase the accuracy of the analyses. Therefore, the above findings suggested that classroom vegetation had positive effects on students' health and behavior.

**Table 2**
**Comparisons of the Objective Data**

| Objective Data | Means | | ANCOVAs | |
|---|---|---|---|---|
| | Experimental Group | Control Group | *F* | *p* |
| Sick leave hours | 2.149 | 5.984 | 11.329 | .001** |
| Punishment records | 0.015 | 0.522 | 5.208 | .025* |

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

## Within the Experimental Group

*Differences between the baseline and the manipulation phases.* The four pretests of the eight perception scores were averaged to serve as the students' overall perceptions of the classroom environment during the baseline phase. Likewise, the six posttests of the eight perception scores were averaged to serve as the students' overall perceptions of the classroom environment during the manipulation phase. Then eight paired *t* tests were conducted. The results showed that the experimental group had improvements in these eight perceptions after the plants were placed in the classroom, but these improvements were not statistically significant (STAI: $p = .499$; RCS: $p = .116$; RS: $p = .331$; WBM: $p = .282$; preference: $p = .479$; attraction: $p = .606$; comfort: $p = .833$; friendliness: $p = .438$). Similarly, a paired *t* test compared the academic performance of the first term examination in the baseline phase and the mean of the academic performance of the second and the third term examinations in the manipulation phase. The results showed that the academic performance was better during the manipulation phase (mean: 0.020) than the baseline phase (mean: –0.018) but this improvement did not reach the level of statistical significance ($p = .559$).

*Change patterns.* The trend of the influences of the indoor plants on the participants over a longer period of time was explored. Using the six posttest scores of each of the eight perceptions as the dependent variable, respectively, and the time sequence as the independent variable, eight nonlinear regression analyses for curve estimation were performed. All the default options of the SPSS were selected, which included linear, quadratic, cubic, logarithmic, inverse, power, compound, *S*, logistic, growth, and exponentials, to examine if there was a certain pattern of changes through time. The results indicated that (a) the model of cubic curve explained the greatest variations in the

**Table 3**
**Regression Models of the Restorative Components Scale**

| Equation | $R^2$ | *F* | *df* 1 | *df* 2 | *p* | Constant | b1 | b2 | b3 |
|---|---|---|---|---|---|---|---|---|---|
| Cubic | .978 | 7.476 | 3 | 2 | .120 | 3.197 | 0.600 | –0.202 | 0.022 |
| Compound | .663 | 7.865 | 1 | 4 | .049 | 3.530 | 1.022 | | |
| Growth | .663 | 7.865 | 1 | 4 | .049 | 1.261 | 0.022 | | |
| Exponential | .663 | 7.865 | 1 | 4 | .049 | 3.530 | 0.022 | | |
| Logistic | .663 | 7.865 | 1 | 4 | .049 | 0.283 | 0.979 | | |

Note: b1, b2, and b3 are parameter estimates.

STAI, RCS, RS, preference, attraction, comfort, and friendliness, of which their $R^2$ values ranged from 66% to 94%, none of which was significant ($p >$ .05); (b) the models of compound, growth, and exponentials were significant ($p < .05$) as the RCS and their $R^2$ values were all 66%; and (c) it was not clear which model was suitable for the WBM because all models explained an extremely low and statistically insignificant variation ($R^2$ values ranged from 0.8% to 4%). All of these suggested that these eight perceptions fluctuated over time without definite change patterns. Nonetheless, among the eight perceptions, the STAI, RCS (Figure 2, Table 3), RS, preference, and attraction increased, in general, over time, whereas the WBM (Figure 3, Table 4) and comfort relatively decreased through time. Friendliness showed equivocal trends of either upward or downward movement (Figure 4, Table 5). Because there were only three measures of academic performance for the students' term examinations, this was not sufficient for the curve estimation of the nonlinear regression analyses.

## Subjective Perceptions and Objective Records

Correlation analyses using the participants' data on subjective perceptions and objective records were conducted. The results indicated that the relationships between the eight perceptions and the sick leave hours and misbehavior records were all insignificant and weak ($|r| < .4$; $p > .05$) for both groups of the participants (Table 6).

# Discussion

For students, a learning environment is regarded as a setting full of authority, rules and regulations, as well as a place for social recognition

**Figure 2**
**Estimated Curves of the Restorative Components Scale**

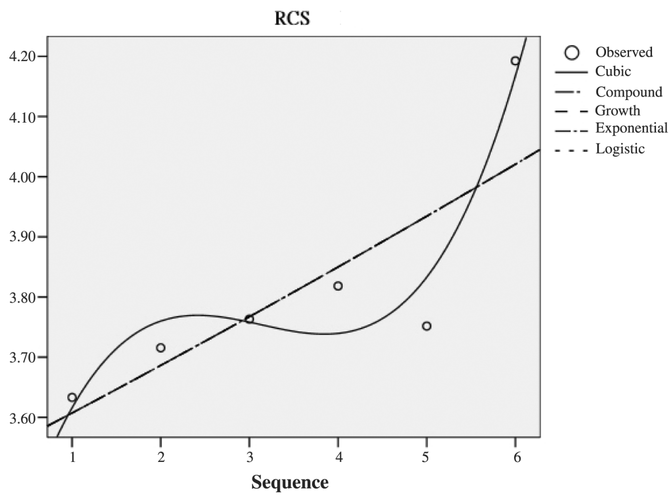



**Figure 3**
**Estimated Curves of the Well-Being Measure**

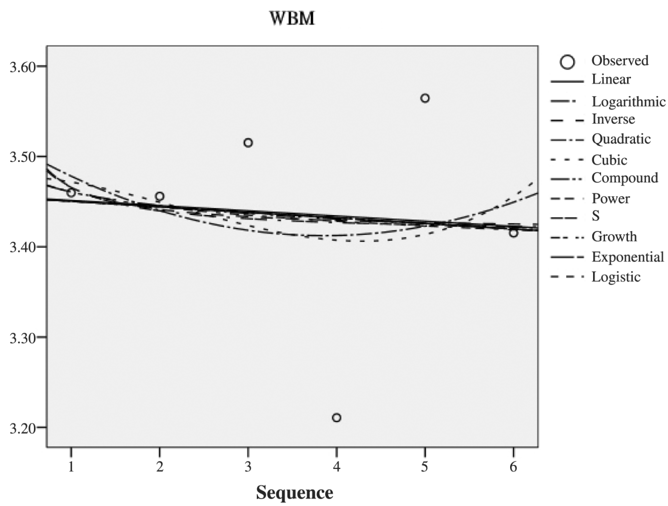


**Table 4**
**Regression Models of the Well-Being Measure**

| Equation | $R^2$ | $F$ | *df* 1 | *df* 2 | *p* | Constant | b1 | b2 | b3 |
|---|---|---|---|---|---|---|---|---|---|
| Linear | .008 | 0.031 | 1 | 4 | .868 | 3.457 | –0.006 | | |
| Logarithmic | .014 | 0.056 | 1 | 4 | .824 | 3.461 | –0.022 | | |
| Inverse | .016 | 0.063 | 1 | 4 | .814 | 3.417 | 0.049 | | |
| Quadratic | .040 | 0.063 | 2 | 3 | .940 | 3.532 | –0.062 | 0.008 | |
| Cubic | .044 | 0.031 | 3 | 2 | .991 | 3.478 | 0.007 | –0.015 | 0.002 |
| Compound | .008 | 0.034 | 1 | 4 | .862 | 3.457 | 0.998 | | |
| Power | .015 | 0.062 | 1 | 4 | .815 | 3.461 | –0.007 | | |
| *S* | .017 | 0.070 | 1 | 4 | .804 | 1.228 | 0.015 | | |
| Growth | .008 | 0.034 | 1 | 4 | .862 | 1.240 | –0.002 | | |
| Exponential | .008 | 0.034 | 1 | 4 | .862 | 3.457 | –0.002 | | |
| Logistic | .008 | 0.034 | 1 | 4 | .862 | 0.289 | 1.002 | | |

Note: b1, b2, and b3 are parameter estimates.

**Figure 4**
**Estimated Curves of Friendliness**

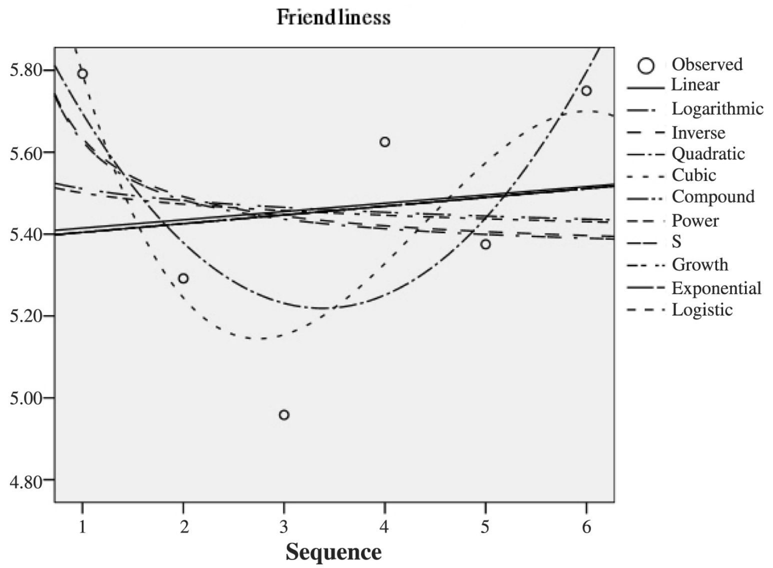


**Table 5**
**Regression Models of Friendliness**

| Equation | $R^2$ | *F* | *df* 1 | *df* 2 | *p* | Constant | b1 | b2 | b3 |
|---|---|---|---|---|---|---|---|---|---|
| Linear | .014 | 0.057 | 1 | 4 | .823 | 5.394 | 0.020 | | |
| Logarithmic | .007 | 0.030 | 1 | 4 | .871 | 5.511 | –0.041 | | |
| Inverse | .078 | 0.340 | 1 | 4 | .591 | 5.349 | 0.285 | | |
| Quadratic | .533 | 1.713 | 2 | 3 | .319 | 6.179 | –0.568 | 0.084 | |
| Cubic | .664 | 1.317 | 3 | 2 | .459 | 6.986 | –1.583 | 0.420 | –0.032 |
| Compound | .015 | 0.062 | 1 | 4 | .816 | 5.383 | 1.004 | | |
| Power | .006 | 0.026 | 1 | 4 | .881 | 5.500 | –0.007 | | |
| *S* | .074 | 0.321 | 1 | 4 | .601 | 1.676 | 0.052 | | |
| Growth | .015 | 0.062 | 1 | 4 | .816 | 1.683 | 0.004 | | |
| Exponential | .015 | 0.062 | 1 | 4 | .816 | 5.383 | 0.004 | | |
| Logistic | .015 | 0.062 | 1 | 4 | .816 | 0.186 | 0.996 | | |

Note: b1, b2, and b3 are parameter estimates.

(Taylor, Peplau, & Sears, 2006). Chinese societies in particular attach great importance to academic performance. Under the influence of a traditional Chinese culture with such sayings as "There is nothing more important than studying," the classroom might indeed be a major source of psychophysiological stress for students at junior high schools. The results of this study showed that the effects of six limitedly visible plants on students were not as influential as expected and that the influences did not seem to have any certain pattern of changes through time. The following are discussions of these findings, which also attempt to shed some light on the theories and/or mechanisms of restoration.

## Influences of the Indoor Plants

*Visibility and greenness.* This study found that even six limitedly visible plants in the classroom had an immediately significant and positive influence on the students' perceptions of preference, comfort, and friendliness. Previous studies made similar findings of the immediate effects of more visible vegetation. Nevertheless, an overall positive effect of the greenness on the eight perceptions and the academic performance of the participants was not found for the entire manipulation phase. Maybe this was because the positive effects of the plants did not last through time. Another possible reason was that vision is indeed the major factor responsible for the positive effects of nature to occur as the Kaplans (1989) and Ulrich (1983) advocate. Although the placement of the vegetation provided limited visual

**Table 6**
**Correlations Between Two Objective Records and Eight Perceptions**

| | STAI | RCS | RS | WBM | Preference | Attraction | Comfort | Friendliness |
|---|---|---|---|---|---|---|---|---|
| Experimental group ($n = 35$)[a] | | | | | | | | |
| Sick leave hours | –.106 | –.295 | –.185 | –.230 | –.315 | –.268 | –.227 | –.214 |
| | .532 | .081 | .274 | .171 | .058 | .109 | .177 | .152 |
| Control group ($n = 41$) | | | | | | | | |
| Sick leave hours | –.074 | –.023 | .067 | .155 | .028 | .003 | –.010 | –.072 |
| | .645 | .888 | .676 | .332 | .862 | .986 | .949 | .654 |
| Punishment records | .060 | .050 | –.062 | .087 | .250 | .256 | .189 | .194 |
| | .709 | .755 | .699 | .588 | .116 | .106 | .236 | .225 |

Note: The correlations are based on the objective records of the whole semester and the means of the 10 surveys of the perceptions. STAI = State-Trait Anxiety Inventory; RCS = Restorative Components Scale; RS = Restoration Scale; WBM = Well-Being Measure.
a. Because the punishment records are constant, correlations cannot be calculated.

access to greenness, this gave us a unique opportunity to explore its influences other than through visual means.

In addition, the plants only occupied 6% of the floor plan of the classroom, which perhaps was not sufficient to create a natural setting. Researchers found that the larger the quantities of visible vegetation, the better the effect of anxiety reduction (Yu & Lin, 1999) and that greater visibility of tree canopies could evoke stronger positive responses (Buhyoff, Gauthier, & Wellman, 1984; Lien & Buhyoff, 1986; Schroeder, 1989). If there were greater quantities of and/or better visibility of classroom greenness, it might have been possible to find both immediate and long-term significant influences of the plants on the students' psychophysiological states and academic performance. Whether the physical or the visible amounts of plants play a more important role in human responses might be an interesting topic for future research.

*Spatial density.* Although the indoor plants did not change the social density of the classroom (the student number did not change accordingly), it still reduced the activity space for the students and therefore increased the spatial density (e.g., Gifford, 1997). Nonetheless, the increased spatial density due to the plants was relatively limited in this study; the average classroom floor plan per student decreased by only 0.1 $m^2$. Therefore, the negative impacts of high spatial density on academic performance and behavior (Glass & Smith, 1978; Loo, 1976; Maxwell, 2003) and blood pressure (Hackworth, 1976) of students should not have occurred in this study. It is perhaps worthwhile to further probe the interactions between classroom greenness, spatial densities, and student responses.

*Classroom atmosphere.* When the students were scolded by the teachers for any behavior that might damage the plants, this might have caused extra stress for the students, increased the disciplinary requirements of the teachers on the students, and consequently produced a negative classroom climate according to our observations. This study focused only on the physical factors of the classroom environment, such as indoor plants, classroom size, and furniture arrangement, and it neglected factors such as teacher–student interactions and classroom atmosphere. Some scholars suggest that the classroom climate plays a stronger role than the physical features of the classroom on students' emotions and their preferences for the environment (Chang, 1996). Had data been collected on classroom climate and taken into account in the analyses, it might have helped to further investigate the interactions between the plants as a physical element in the classroom, the psychosocial environment of the place, and the students' perceptions of the setting and their responses.

*Repeated measures.* This study was the first attempt to explore the influences of the indoor plants on the students for a whole semester with 10 repeated measures. Although the participants were instructed to report how they felt about their learning settings in which they spent more than 8 hr on each of the weekdays and which included a variety of activities, some of the students might have found filling out the same questionnaire every other week boring or even repulsive. This might have consequently influenced their feelings, which in turn impeded the possible positive effects of the plants in this study.

*Subjective perceptions and objective records.* According to the findings of this study, classroom greenness had immediate and positive influences on the students' perceptions, but its influences seemed not to last for long. However, the sick leave hours and punishment records due to misbehavior of the experimental group were indeed significantly less than those of the control group, which corresponded to the results of past studies (e.g., Kuo & Sullivan, 2001b; Ulrich, 1984). Please recall that the students' objective records were not closely related to those of their long-term subjective perceptions. The possible reasons for this inconsistency are that (a) the positive effects of the plants were not readily and consciously sensible to the participants; (b) all the above-mentioned factors, such as the spatial density, classroom climate, or repeated measures, influenced the students' perceptions of the classroom but not their objective performances; and (c) perceptions, health, and/or behaviors triggered by nature might be through various means and have differing mechanisms. Further identifying and distinguishing these mechanisms might be fruitful for related theories and practices of human well-being.

Caution should be advised as to the findings of this study. The objective data on sick leave hours and misbehavior records were compiled for one whole semester, in which the manipulation phase lasted only for about two-thirds of the semester. In addition, this study used the sick leave hours and punishment records due to misbehavior from the previous semester as covariates, rather than those in the baseline phase. Given that there are not many empirical studies exploring the influences of interior plants on human health and behaviors, this study might serve only as a reference for further research.

*Self-reported questionnaires.* Among the eight perceptional responses collected in this study, preference, attraction, comfort, and friendliness were evaluated with only one question, each of which has a closely corresponding term in Chinese. It was found that the plants had immediate and significant influences on preference, comfort, and friendliness. All the scales, STAI, RCS, RS, and WBM, were originally written in English and were developed in Western societies. Although these four scales have been proven for their reliability and validity in the past and have also shown good reliability (Cronbach's $\alpha \geq .7$) as indicated by the data collected in this study, it still cannot be completely verified that these self-reported scales actually measure participants' emotions, comfort, restoration, or well-being. Moreover, the role of the differences of language and/or culture between Chinese and English, which might play a role in the significant versus the insignificant responses, is worth further investigation.

*Novelty.* Given that even such a weak treatment of only six limitedly visible indoor plants could have some immediate positive influences, further efforts should pare down the possible effects of novelty—merely "something new" —in contrast to specific greenness. Various interventions including nothing, a pleasant but nonnatural stimulus (e.g., posters of popular movie stars or singers), an unpleasant nonnatural stimulus (e.g., pictures of unsightly buildings), an unpleasant natural stimulus (e.g., photos of slime mold), and a pleasant natural stimulus (e.g., pictures of flowering plants) could be used to examine whether the vegetation adds anything to the effect of a novel stimulus.

## Change Patterns

The responses of the six posttests for the experimental group fluctuated, which reveals no definite pattern of change through time. In general, most of the eight perceptions exhibited a relatively slight increasing trend, whereas a few indicated a slight decreasing trend. Because this study adopted a quasi-experimental design in the actual environment, which was an open system, it could not control for all variables. As a result, the students might still have been influenced by other variables rather than by the indoor plants alone, which caused the absence of an obviously consistent trend. Even though this study was probably the first attempt to collect data by using repeated measures over a relatively longer period of time, six data entries still might be too few to reveal a clear pattern of change.

## Related Theories

Both the theories of the Kaplans (1989) and of Ulrich (1983) extend the positive responses of humans to nature to factors such as emotion, attention, well-being, and daily functioning (Hartig, 1993). This study found that limitedly visible leafy indoor plants enhanced the students' perceptions of preference, comfort, and friendliness and reduced their sick leave hours and punishment records due to misbehavior. These findings support the common notion of the Kaplans and Ulrich that the benefits of contact with nature broadly cover many dimensions. However, the results of this study seem to be slightly favorable to Ulrich's emphasis on emotions, particularly for preference. Yet, no significant difference of the STAI was found.

With respect to theories and/or mechanisms of restoration, the findings of this study suggest that (a) vision and psychology are the major means for the positive effects of nature to occur, as the previous studies indicate; (b) the evoked positive influences cover progressive levels starting likely with emotions, particularly preference; and (c) given that the visible greenness is limited and the relationships between the objective records and the subjective perceptions are all insignificant and either weakly positive or negative, the mechanism of restoration is not purely visually and psychologically driven as the Kaplans and Ulrich advocate. Among the above issues, other sources conducive to well-being and functioning that cannot be visually detected, such as oxygen, humidity (Fjeld et al., 1998), particulate accumulation and air quality improvement (Lohr & Pearson-Mims, 1996), and even Pythoncidere produced by plants, might deserve particular consideration in a comprehensive mechanism of human recovery from psychophysiological stress.

## Suggestions and Conclusion

### Suggestions

The above-mentioned limitations and/or issues could serve as a pilot for future endeavors. The most ideal and strictest research method is a field experiment in which participants are randomly assigned to actual settings. Yet, there are still many difficulties to overcome in this approach, because most elementary and junior high schools in Taiwan have small classes, with fewer than 40 students. Meanwhile, because students need to learn so many course subjects, it is almost practically impossible to recruit classes that have the same teachers. In addition, students are not randomly assigned to the class, but are often grouped by level. Furthermore, summer and winter breaks will interrupt the continuance of a long-term study, not to mention the likely biases due to repeated measures over short intervals with only a minor element added to the setting. Lastly, for any scale intended to measure human restoration or functioning, it is necessary to examine whether the measurement results are consistent with the actual changes in the human body and mind (Han, 2003; Herzog, Maguire, & Nebel, 2003).

An alternative approach to the above-mentioned issues would be to adopt an interrupted time series design with multiple replications on a random schedule (Shadish, Cook, & Campbell, 2002). A single class of students could serve as its own experiment and control group. The experimental treatments of no change, visible plants, less visible plants, simulated nature, and stimuli of pleasant nonnature, unpleasant nonnature, and unpleasant nature could be randomly scheduled and placed in the classroom for the same period of time. The participants' responses of both subjective perceptions and objective performances could be collected at the same intervals. This research design, similar to a completely randomized within-participant study, is effective and powerful for a quasi-experiment that is unable to find an equivalent control group (Cook & Campbell, 1979; Shadish et al., 2002). In addition to examinations of novelty effects, the class of students can be classified into groups according to how close they are next to live plants. Thus, if there are other effects due to the plants, the effects might be a function of the distance from the plants. Hopefully, in addition to whether or not the visible or the physical amount of greenness is more influential to humans, other sources of live plants contribute to human well-being and/or health, for example oxygen or humidity (Fjeld et al., 1998), and consequently, whether there are other such mechanisms responsible for psychophysiological restoration might be further explored.

After the positive influences of greenness on humans, except for novelty, are confirmed, the next step is to investigate which types and species of vegetation, their arrangements and amounts, are most favorable to psychophysiological well-being. Furthermore, detailed features of the vegetation, such as shape, canopy width, color, texture, height, flower, fruit, and fragrance can be explored to determine which combinations of these factors can specifically meet different human needs, for example with respect to age, gender, occupation, in terms of emotion, physiology, cognition, behavior, or health. Although research on such topics has emerged only recently and now receiving more and more attention, it is hoped the research findings will soon be applicable to the design practices of environments for daily life.

## Conclusion

This study attempted to use limitedly visible leafy indoor plants to influence students' perceptions of the classroom. However, their emotions and perceptions of the environment could be possibly influenced by other variables. In general, the findings of this study correspond to those of previous research that used more visible vegetation and are in agreement with the theories of the Kaplans (1989) and Ulrich (1983) that exposure to nature even with six plants or 6% greenness of floor plan is beneficial for human emotions, behavior, and health. Some issues remain that warrant further examination: (a) effects of greenness per se except for novelty; (b) specific minimum thresholds of greenness to evoke diverse positive responses; (c) how these influences change over time; (d) whether it is the physical or the visible amount of plants that is more conducive to positive reactions; and (e) in addition to visual perception and psychological mechanism of restoration, what other factors are helpful for well-being and functioning.

Because of assignments, homework, and examinations, students are often both psychologically and physiologically stressed. Given that classrooms play a vital role in influencing students' learning and academic performance, a classroom that meets students' needs and is preferred by students can improve students' quality of education. If a classroom can provide more opportunities for contact with nature, a more harmonious atmosphere, and adequate space for students, it might help students develop a healthy body and a healthy mind through situational education. In so doing, educational goals might be more easily reached.

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