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Education for sustainability using a campus eco-garden as a learning environment

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Abstract

Purpose – This paper aims to explore stakeholder perspectives of the role of a campus eco-garden in education for sustainability (EfS). It will combine the perspectives to highlight a powerful learning environment (PLE) for university students to realize the concept of EfS.

Design/methodology/approach – Semi-structured interviews were conducted to reveal stakeholder understandings of a campus eco-garden, as well as its associated expectations of learning activities and education outcomes. Three stakeholder groups were interviewed; designers, educators and environmental and non-environmental subject-related students.

Findings – All three stakeholder groups expected cognitive learning of EfS to be enhanced by the eco-garden. The use of affective learning was not strongly expected by the stakeholders. Psychomotor learning was believed to be the most difficult to realize. To fulfill the potential of the eco-garden in EfS, all stakeholders suggested learning activities and roles for both students and teachers. The combined perspectives of the stakeholders helped to visualize a PLE to aid EfS.

Practical implications – This study underlines the importance of effective communication of expectations between stakeholders. It underlines the importance of integrating educational activities with the eco-garden as a PLE, highlighting the roles of teachers and students. It also sheds light on the importance of introducing a cultural component to the EfS program.

Originality/value – This is the first study to apply the PLE theory to enhance EfS with the aid of infrastructure. Both users and designers reveal their views on the planning of the campus eco-garden, especially in its educational function. The study is possibly the first to reveal the differences in expectations between designers and other stakeholder groups (teachers and students) using Könings *et al.*'s (2005) combination-of-perspectives model.

Keywords Campus eco-garden, Eco-centric world view, Expected education outcome, Garden-based learning (GBL), Powerful learning environment (PLE), Stakeholder perspective

Paper type Research paper

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Introduction

Sustainable development has been proposed as one of the core literacies with which a twenty-first-citizen should be equipped. Education is key to providing such literacy (Dale and Newman, 2005). Indeed, higher education institutions were highlighted in the Rio +20 conference because of their significant role in the pursuit of sustainable development.

EfS should focus on the understanding of humanity's relationship with the environment; to achieve this, gaining holistic experience is more desirable than traditional one-way lecturing (Bosselmann, 2001). Gaylie (2009) presents a well-illustrated case-study of how a campus "learning garden" in a tertiary institution can be used to nurture an eco-centric world view, as well as give students a strong sense of belonging to the garden. In line with Gaylie (2009), we argue that even a conventional garden with limited ecological resources (such as biodiversity) could still transfer deep knowledge of biodiversity, ecology and environmental protection to tertiary students and foster pro-environmental attitudes and behavior. The students could cognitively benefit if the garden has been planned to demonstrate environmental technical advancements.

This study discusses the potential use of a campus eco-garden to enhance undergraduate affective, cognitive and psychomotor learning experience for EfS. The study also serves as part of the participatory process (Könings *et al.*, 2010) in the development of an eco-garden established in mid-2016 at a university in Hong Kong. The eco-garden was created by renovating an abandoned garden and converting it into part of the campus infrastructure to support EfS. The study uses the combination-of-perspectives (COOP) model of Könings *et al.* (2005) and collects the views of major stakeholders on the expected function and utility of an eco-garden within the scope of education for sustainability (EfS). This creates a powerful learning environment (PLE) for undergraduates to acquire and realize the concept of EfS.

Literature review

Garden-based learning and education for sustainability

Garden-based learning (GBL), defined as the use of a school garden for educational purposes, has been found to be effective in nurturing student literacy in science, mathematics and the environment (Blair, 2009; Williams and Dixon, 2013). Rowe and Humphries (2004) provide an overview of how a modified ecological garden (including natural resources, e.g. trees, crops and water features) can be used to acquire environmental literacy in both primary and secondary schools. GBL has been widely adopted in the USA during the past two decades in primary schools (Desmond *et al.*, 2004). However, little research has investigated the role of gardens as an educational resource in tertiary education.

A recent study by Gaylie (2009) is one of the few studies on how to use a campus garden to change student attitudes toward ecocentrism. By facing problems during the development of the garden, students had to critically discuss solutions regarding issues of social and environmental justice. This prompted students to reflect upon their attitudes toward the environment. The development of a sense of belonging and emotional engagement with the garden increased its affective influence, making the GBL in Gaylie's course a successful approach to nurturing pro-environmental attitudes.

There are no studies illustrating the effectiveness of GBL in promoting pro-environmental behavior in school-based settings, although GBL was found to be effective in altering behavior in nutrition education (Heim *et al.*, 2009; Parmer *et al.*, 2009). The only similar examples of using a garden for promoting behavioral change were those based on botanical gardens in a non-formal educational context (Ballantyne and Packer, 2005). There is then a knowledge gap in how we can use GBL to promote pro-environmental behavioral change.

Powerful learning environment for education for sustainability

Transforming pro-environmental attitudes into actual behavioral change has long been challenged in environmental education (Kollmuss and Agyeman, 2002; Arbuthnott, 2009). Various factors – perceived control over the effectiveness and outcomes of pro-environmental behavior and the inconvenience and additional costs of pro-environmental behavior – were found to significantly hinder pro-environmental behavior. Arbuthnott (2009) suggests different strategies to promote behavioral change in an EfS context. For example, specific examples of how pro-environmental concepts can be implemented; feedback on the effectiveness of pro-environmental behavior can be provided so that the people can "visualize" their contribution to the environment; habit-changing support programs can be introduced to change anti-environmental habits.

A PLE could be a useful approach to aid a habit-changing program. It could also help people visualize the efficiency of their pro-environmental behavior. A PLE emphasizes on the creation of an effective and comprehensive learning environment for student-oriented and student-driven learning. Students take an active role in the knowledge or behavior acquisition process, whereas teachers aid the learning (Volman and van Eck, 2001; Hayes, 2007). PLE has been widely applied in computer-supported visual environments (Lehtinen, 2003; Vosniadou and Kollias, 2003). However, there has been limited application in other educational fields. Kangas (2010) suggests that a nature-related facility, such as a garden, could be one of the most important components of the PLE; its function would aid transfer of knowledge and enhance informal learning experiences (Kangas, 2010).

From a practical perspective, PLE refers to a learning condition that can strengthen student knowledge and self-initiated and regulatory skills by the completion of a series of meaningful and challenging tasks, within a peer-supported atmosphere (De Corte, 2003). Van Merriënboer and Paas (2003) set out four blueprint components of a PLE, namely, learning tasks, supportive information, procedural information and part-task practice. A PLE should provide an authentic environment for establishing meaningful learning tasks as the first step, supported by relevant theories (information). Subsequently, the information to be delivered should be divided into appropriately sized units, taking into consideration the student cognitive loading. Finally, the tasks and information should be delivered in a well-planned sequence. Vermunt (2003) points out that, among the eight common learning environments such as project-centered learning and problem-based learning, aiding the self-directed, meaning-directed learning of students is the ultimate goal of establishing a PLE, whereas undirected or reproduction-directed learning is regarded as a low-quality learning process.

Stakeholder expectations for creating powerful learning environment

The benefits of an eco-garden cannot be fully realized until it is known what teachers and college students think of it and how they plan to use it. The matching of teachers and students' perceptions of learning outcomes has been found to be of vital importance in student learning processes (Brophy, 1987; Könings *et al.*, 2005, 2014a). The high but appropriate expectations of teachers and students can enhance student motivation, which should in turn enhance learning effectiveness (Brophy, 1987). However, a mismatch in expectations can also occur between the instructional designers, teachers and students. This can adversely affect the successful establishment of a PLE (Elen and Lowyck, 1999; Könings *et al.*, 2005). Könings *et al.* (2005) suggest a participatory approach, the COOP model, to incorporate all expectations of different stakeholder groups in the design stage of a PLE. The COOP model emphasizes on the feedback loop of students advising both instructional designers and teachers to modify the PLE.

The expectations of these three different principal stakeholders in a teaching-learning process governs student learning outcomes and collectively determines if the teaching-learning process is optimal. Understanding stakeholder expectations of the roles of an eco-garden in EfS is thus crucial if the educational benefits of the eco-garden are to be maximized. This study, conducted in the mid-development stage, explores different stakeholder perspectives on the eco-garden and the possible use of the eco-garden in EfS. In this study, the design group is a little different from instructional designers described in the COOP model (Könings *et al.*, 2005). The design group did not have much of an academic background. However, in designing the eco-garden, they considered its educational function, described in the subsection of case description. This study not only benefits the development and refinement of the existing eco-garden but also provides suggestions for establishing an eco-garden or ecological landscape in any tertiary educational institution.

Case description – campus eco-garden

An eco-garden integrates ecological and environmental concerns into the landscape of a garden. It aims to foster the physical and spiritual well-being of human life. It also aims to improve the surrounding environment, for example, by affecting the microclimate of urban regions (Attia, 2006). An eco-garden provides an extensive range of environmental, social, recreational, health and public educational benefits to sustain the well-being of the local community (Subramaniam, 2002; Bernholt *et al.*, 2009). It is believed that an eco-garden could be a convenient tool on a University campus, which would aid the development of a PLE (De Corte, 2003) for students at the University to learn about ecological concepts, sustainable agriculture and modern technology in renewable energy. It could also be used as a “learning garden” to nurture the student pro-environmental attitudes (Gaylie, 2009).

The eco-garden design shares much with an idea of Rowe and Humphries (2004), but with much more deliberation on various state-of-the-art concepts of environmental sustainability. Chen and Wu (2009) emphasize on the unique role of Chinese traditional culture in the design of a modern sustainable landscape, integrating the ecological and cultural conservations through the principle of the “unity of man with nature”. Various models and theories applying the concept of Qi, such as Feng Shui theory and Ying-Yang Dualism, etc., have been utilized to guide the design of traditional Chinese gardens (Chen and Wu, 2009). In this study, the designers incorporated a Taoist ideal of natural spontaneity and Neo-Confucian naturalistic cosmology in the design of the eco-garden. The design was inspired by Taoist philosophy: “Nature, earth and I have the same root; myriad things and I are one entity” and “Humans follow the earth as a rule. The earth follows heaven as a rule. Heaven follows the Dao as a rule. The Dao follows itself as a rule”. The design was also influenced by Neo-Confucian naturalistic cosmology, which emphasizes on the organic holism that regard the universe as a unified unit instead of a detached mechanistic entity and dynamic vitalism inherent in material force (Tucker, 1991). The designers wanted to promote visitors” awareness of harmony between nature and humans through enjoying and appreciating the natural environment as a unit both renewable and vital.

To achieve educational aims, the designers planned to overlay the necessary demonstration units for sustainability education upon the original garden setting. The demonstration units are closely related to environmental sustainability concepts; the use of renewable energy, the efficient usage of resources and the conservation of biodiversity (Goodland, 1995). A visiting route was developed to introduce how environmental sustainability was achieved through wisdom in the past and how it is attained in the modern world with the development of innovative technology. The sustainable components include a herb spiral, an aquaponic system, a constructed wetland, an eco-pond, organic farmland with compost, a water wheel, photovoltaic systems for solar energy, solar and hybrid lamps, a rain garden and a butterfly garden.

Plate 1 shows the Chinese-style facilities in the eco-garden. The design of the eco-garden, renovated from an abandoned garden, is thus based on three principles:

(1) not greatly altering the original setting and retaining the basic structure of the garden;
(2) adding innovative features to aid the teaching and learning of EfS; and
(3) using all facilities inside the eco-garden to demonstrate harmony between nature and humanity.

Figure 1 shows the layout of the eco-garden at the University. The operational systems of the sustainable eco-garden in terms of resource recycling and energy conservation among the units are summarized in the flow diagram (Figure A1).

Methodology

Research questions

Two research questions were proposed to explore the potential of creating an eco-garden-based PLE in a higher education setting for EfS through the consideration of different stakeholder perspectives:

RQ1. What kinds of use of the eco-garden do stakeholders think would enhance undergraduate affective, cognitive and psychomotor learning of EfS?

Plate 1.
The Chinese-style design of the eco-garden

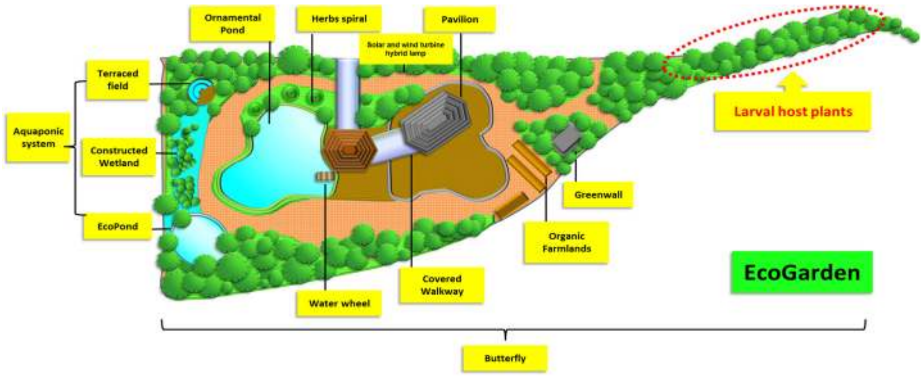

Figure 1. The schematic layout of the eco-garden in the University

RQ2. What is the range of different stakeholder perspectives regarding the eco-garden, which could aid the creation of an eco-garden-based PLE?

Participants

Three groups of principal stakeholders were invited to take part in the study on a voluntary basis; designers; educators; and students pursuing environmental studies-related programs (ENV students) and non-environmental studies-related programs (NENV students). The following gave their consent to be interviewed: six from the designer group (the project initiator staff of the Estate Office of the University, the architects of the designing vendor and the architects of the construction vendor of the eco-garden); three educators specializing in the teaching and learning of environmental subjects; seven ENV students; and eight NENV students.

The six-member designer group were the main idea contributors in the 14-member design and construction committee of the eco-garden. Three educators accounted for 15 per cent of the lecturers who teach environmental studies-related subjects. The 15 students interviewed were randomly selected from 4 out of the 15 non-environmental studies-related undergraduate programs and 4 out of 6 environmental studies-related programs in the university.

Data collection

Semi-structured interviews were conducted with each stakeholder to examine their understanding of the eco-garden and its role in sustainable environmental education. An interview protocol was designed consisting of two parts. The first part examined understanding of the eco-garden in terms of its functions and values. The second part explored the roles of the eco-garden in sustainable environmental education in terms of its educational purposes, teaching activities and the roles of the teachers and students. The following are examples of interview questions for each theme:

(1) *Theme 1*: understanding of the eco-garden:
- What do you know about the eco-garden?
- Do you think it is valuable to set up an eco-garden in the University?

(2) *Theme 2*: the roles of the eco-garden in sustainable environmental education:
- What educational purpose would be achieved by the aid of the eco-garden?
- What educational activities could be conducted in the eco-garden?
- What are the roles of teachers and students in the educational activities in the eco-garden?

The interview protocol was used with slight changes to the wording considering the different interviewees. The interviews were conducted in the participants' native language to avoid unnecessary misunderstanding and to save time. In particular, the designer group was interviewed in three meetings for the three different parties (initiator staff, designing and construction vendors) and so the designer group was regarded as three parties, instead of six people. Other participants were individually interviewed. All interviews were tape-recorded and lasted for approximately 0.5-1 h. All of the interview data were transcribed for later analysis.

Data analysis

The content analysis approach (Ellis and Barkhuizen, 2005) was adopted to analyze the interview data. The coding process went from initial coding to axial coding and focus coding (Strauss and Corbin, 1990). Each coding process started with initial coding, which produced a large number of codes such as knowledge of sustainability, knowledge of biodiversity, critical thinking skills, motivator, etc. These initial codes were then further condensed into broader categories. For example, the codes of critical thinking skills, managing skills, planting skills, scientific research skills, inquiry skills, observing skills and farming skills were combined into a broad category of the skills purpose of the eco-garden. Finally, focus coding was conducted to find the major themes which could account for most of the data.

To enhance the trustworthiness of the data analysis, peer examinations were conducted (Hitchcock and Hughes, 1995). Numerous discussions among authors who came from the same school of the University took place when any uncertainty in the coding and categorizing arose. Agreement was achieved based on the discussions and double checking of the matching between the themes and data extracts.

Results

Educational use of the eco-garden for cognitive learning of education for sustainability

A total of 30 specific educational purposes of the eco-garden were identified through data analysis. These purposes could be categorized into the domains of knowledge (11), attitudes (11) and skills (8) (Table I). The designers and educators suggested energy utilization, environmental pollution and biodiversity conservation for knowledge purposes of the eco-garden. These suggestions would form the basis of the knowledge and information required for the establishment of a successful PLE. One educator claimed that:

> […] As for knowledge, we can certainly understand more about ecology, what biodiversity is, how we conserve biodiversity, the importance of biodiversity to ecology, mankind and the community […].

One engineer stated that:

> […] The facility we saw is for renewable energy, things for environmental protection. This can allow the students to know that we can obtain our energy naturally. How can we use this energy more efficiently? How can we obtain this kind of natural energy more effectively? These questions are very important learning points for the students […].

The designers and educators' acknowledgement of the knowledge purposes of the eco-garden were also echoed by the college students. One ENV student claimed that:

> […] I think the educational objective (of the eco-garden) may be very simple. What is renewable energy? How could electricity be generated? How can we observe the operation and cycling of the eco-pond […] the ecological cycling? […] Or on the farmland, how can we define an organic farm? Because I believe that many people do not know about this concept […] Or maybe for the butterfly garden, we can observe and learn about different species […] Or for the wetland, what is the structure of the wetland? How can we regard a place as a wetland? The function of a wetland […] Principally, it is the growth of my knowledge […].

Table I. The key learning outcomes suggested by all the stakeholder groups with the number (%) of individual stakeholders' support

Category	Key education outcomes	DES ($N = 3$) (%)	EDU ($N = 3$) (%)	ENV ($N = 7$) (%)	NENV ($N = 8$) (%)
Knowledge (cognitive)	Understand what is meant by sustainability	0 (0)	0 (0)	1 (14.3)	0 (0)
	Understand what ecology is	1 (33.3)	1 (33.3)	6 (85.7)	2 (25.0)
	Understand what biodiversity is	2 (66.7)	1 (33.3)	3 (42.9)	2 (25.0)
	Understand what the importance of biodiversity is	0 (0)	1 (33.3)	1 (14.3)	0 (0)
	Understand how to maintain/enhance biodiversity	0 (0)	1 (33.3)	1 (14.3)	1 (12.5)
	Understand what kind of organisms (biodiversity) live in the Institute	0 (0)	0 (0)	1 (14.3)	0 (0)
	Understand underlying concepts of the technology introduced in the ecogarden	2 (66.7)	1 (33.3)	0 (0)	1 (12.5)
	Understand what the problem of using fossil fuels is and why we should introduce renewable energy	2 (66.7)	0 (0)	3 (42.9)	5 (62.5)
	Understand how to carry out organic farming	0 (0)	1 (33.3)	3 (42.9)	1 (12.5)
	Understand what pollution is	0 (0)	0 (0)	0 (0)	1 (12.5)
	Understand how to run an ecogarden	0 (0)	1 (33.3)	0 (0)	0 (0)
Skill (psychomotor)	Be able to critically think of the dilemma between development and conservation	0 (0)	1 (33.3)	0 (0)	0 (0)
	Be able to observe the natural environment in detail	0 (0)	1 (33.3)	0 (0)	0 (0)
	Be able to adopt scientific inquiry	0 (0)	0 (0)	1 (14.3)	0 (0)
	Be able to conduct scientific research	0 (0)	1 (33.3)	0 (0)	0 (0)
	Be able to manage an ecogarden	0 (0)	2 (66.7)	0 (0)	0 (0)
	Be able to practice aquaponics	0 (0)	1 (33.3)	1 (14.3)	0 (0)
	Be able to practice organic farming	0 (0)	1 (33,3)	2 (28.6)	2 (25.0)
	Be able to plant trees	1 (33.3)	0 (0)	0 (0)	0 (0)

(*continued*)

Category	Key education outcomes	DES ($N = 3$) (%)	EDU ($N = 3$) (%)	ENV ($N = 7$) (%)	NENV ($N = 8$) (%)
Attitude (affective)	Be aware of the interrelationship between mankind and the environment, and realize the intangible advantages offered by nature	2 (66.7)	2 (66.7)	1 (14.3)	2 (25.0)
	Promote an appreciation of nature	0 (0)	2 (66.7)	2 (28.6)	2 (25.0)
	Reflect on self-behavior regarding the environment	0 (0)	0 (0)	3 (42.9)	0 (0)
	Enhance pro-environmental behavior	2 (66.7)	1 (33.3)	2 (28.6)	0 (0)
	Promote a sense of responsibility for the environment	0 (0)	1 (33.3)	1 (14.3)	0 (0)
	Obtain satisfaction from organic farming	0 (0)	0 (0)	1 (14.3)	0 (0)
	Promote an appreciation for the efforts of farmers and thus treasure food	0 (0)	0 (0)	0 (0)	1 (12.5)
	Promote an appreciation of the traditional technology and wisdom	1 (33.3)	0 (0)	0 (0)	0 (0)
	Enjoy the learning process in the ecogarden	0 (0)	0 (0)	1 (14.3)	0 (0)
	Arouse students' interest in learning interdisciplinary knowledge	0 (0)	1 (33.3)	1 (14.3)	0 (0)
	Acquire the value that one should practice what one preaches	0 (0)	1 (33.3)	0 (0)	0 (0)

Table I.

Educational use of the eco-garden for affective and behavior learning of EfS

Considerations of attitudinal change were revealed by various stakeholders (Table I). Most mentioned attitudinal changes are related to environmental sustainability. "Be aware of the interrelationship between humanity and the environment, and realize the intangible advantages offered by nature" was a common anticipated value gained, shared by all stakeholders. For example, one engineer mentioned that:

> […] Based on my knowledge, there are three "A"s, awareness, attitude and action. In fact, this is the objective of our education […] widening their knowledge horizons […] changing their attitudes […] encouraging them to take respective actions […].
>
> Regarding attitude, the students can be motivated to appreciate nature, understand the natural wonders […] and something like […] it is not easy for human beings to change ourselves without any alteration to nature. That means […] we did not realize what is going on […] but if we can protect this balance, we shall have a lot of potential benefit. This may inspire them (the students) to (understand) the natural wonders and understand that living organisms are very complex and subtle things […].

Although enhancement of pro-environmental behavior was anticipated by all stakeholders (except for NENV [Table I]), no specific behavioral changes in daily life (such as increasing recycling, changing diet to more sustainable food source, etc.) were mentioned by the interviewees. Most interviewees mentioned the acquisition of specific skills related to particular issues associated with EfS, for instance, aquaponics and organic farming (Table I). The purposes of developing skills in aquaponics, organic farming and scientific inquiry and the generic skills of observing and critical thinking were emphasized more by the educators compared with the other two stakeholder groups of designers and students. One educator claimed that:

> […] This (the eco-garden) can provide an authentic place to allow students to conduct experiential learning, because environmental education is not only related to the cognitive aspect […] Through participation, the students can take action for environmental protection, and can change their daily habits. This is the ultimate goal. But if we lecture in the classroom, they (the students) may only understand cognitively. […] Another possibility is skills, for example the skill of how to manage an eco-garden. They will have no idea. But […] if they participate in the site environment, they will know how to maintain an eco-garden […].

Plurality of stakeholders' perspective for visualizing powerful learning environment

All three stakeholder groups had a higher number of expected educational outcomes for knowledge, followed by those for attitudes and finally skills (Table I). The educators were the only group that emphasized on education purposes in all three knowledge, skill and attitude (KSA) aspects. The educators suggested on average 2.33 ± 1.15 ideas regarding skills, whereas the designers mentioned a few (0.33 ± 0.58). The educators suggested on average 2.67 ± 1.53 ideas regarding attitudes compared to 0.63 ± 0.74 ideas suggested by the NENV students. The difference in the outcome attitudes of the designers (1.67 ± 1.15) and ENV students (1.71 ± 1.60) was very small, whereas the difference in the knowledge outcomes of the designers (2.33 ± 1.53) and ENV students (1.63 ± 1.06) was relatively large. The NENV students had the least number of expected outcomes for knowledge and attitudes.

To optimize the potential of eco-garden in EfS, all stakeholders were encouraged to give suggestions on how to make good educational use of the eco-garden. Diverse curricular and community activities recommended by all three stakeholder groups (Table II) fell into one major blueprints of a PLE – the way of knowledge delivery (Van Merriënboer and Paas, 2003). The suggested activities covered six of the eight learning environments suggested by

Table II. Possible teaching and learning activities provided in the ecogarden

	Designer	Educator	ENV student	NENV student
Curricular activities in the Institute	Educators incorporate the ecogarden facilities into course curricula through conducting activities in the ecogarden Students conduct self-directed projects/research in the ecogarden Students are trained to become educators/tour guides in the ecogarden			
	Course activities Doing experiments Organic farming Monitoring the energy consumption of the Ecogarden	Course activities Doing experiments Organic farming Drawing and painting Composing poems Designing and evaluating teaching modules for pre-service teachers	Course activities Monitoring the energy consumption of the ecogarden	Course activity Drawing and painting Producing sculptures
Educational activities for the community	The general public and secondary/primary/pre-school students are allowed to visit and take part in educational activities in the ecogarden			
	Leisure activities Drawing and painting Performing mini-concerts	Leisure activities Drawing and painting Festival celebrating activities	Leisure activities Drawing and painting Orienteering games to learn environmental knowledge Workshops to produce bookmarks using fallen leaves	Leisure activities Festival celebrating activities
	A site for self-learning is provided		A site for self-learning is provided	
		Competitions Proposal of ecogarden utilization Website design Academic workshops or conferences are organized Day/ night educational camps for local students are organized	Competitions Photography Farming Experts are invited to deliver relevant talks Students manage an area of the organic farm and grow their own crops Students conduct the manual work of managing the ecogarden such as collecting garbage	Competitions Photography Compositions Professional development for Early Childhood Education teachers Family visiting tours from local schools are welcome Students manage an area of the organic farm and grow their own crops

(*continued*)

	Designer	Educator	ENV student	NENV student
Others	Educational panels with educational tools are installed for understanding the ecogarden and demonstrating the technology and biodiversity in the ecogarden			
		Educators apply teaching development funding based on the ecogarden facilities	Students engage in the consultation for the future improvement of the ecogarden Camera renting service is provided	

Table II.

Vermunt (2003), namely, traditional teaching, assignment-based teaching, classical problem-based learning, project-centered learning, self-directed specialization learning and autodidactic learning. These are all individual-based rather than collaborative learning environments. Moreover, it was suggested that educators conduct field-based activities in the eco-garden during course time. University students could carry out self-directed learning projects or scientific research in the eco-garden. For example, one educator suggested:

> […] There is a place for practicing and a place for data collection; surely we can conduct laboratorial experiments in it (eco-garden). The eco-garden (team) can collaborate with the existing laboratory, because we have environmental and geological laboratories (in the Institute). After development, we could carry out a lot of laboratorial experiments and strengthen the scientific research of our Institute […].

As part of the infrastructure and as a platform for experiential learning of EfS, all stakeholders advised establishing educational panels to provide introductory information for the different facilities of the eco-garden. In contrast to the passive demonstration function suggested by other stakeholder groups, the educators suggested the incorporation of teaching and learning activities on educational panels through the inquiry pedagogy.

The active roles of both teachers and students were highlighted, and interaction between teachers and students was emphasized. Most interviewees affirmed the role of educators as mentors, motivators and facilitators of the teaching and learning of EfS (Table III). They highlighted the importance of the educators motivating student self-directed learning on the basis of a life-long learning approach beyond the classroom and the curriculum. As for the students, in addition to their roles as self-directed learners and practitioners in the teaching and learning process, many interviewees emphasized on their role as trainers for educational activities. Students were expected to study in detail the natural environment; for example, conducting butterfly biodiversity surveys in the garden. One designer claimed:

> […] In fact, it will be an interactive approach. Although lecturers would be the principal people to lead or explain […] Certainly in fact under such conditions, (the lecturer) should welcome the students' observation and questions. Maybe through these questions, the lecturer would be inspired and have deeper thinking and generation of more knowledge […].

One educator echoed these thoughts:

> […] The lecturer in the classroom demonstrates the leading role. But in the student association, the lecturer has no such role; the students will be the dominant people who proactively focus on their own issues of interest. In fact, we have some funding which students can apply for. Students can ask

Table III. The top five roles of educators and university students suggested by all the interviewees in place-based learning in the ecogarden

Educators' roles	University students' roles
Mentor in the teaching and learning (38.1%)	Docent/teacher of the activities in the ecogarden (33.3%)
Facilitator of the constructivist learning process (23.8%)	Self-directed learner in education for sustainability (23.8%)
The one who mobilizes students to engage in extra-curricular self-learning (19.0%)	Learner in the teaching and learning (23.8%)
Motivator in the teaching and learning (19.0%)	Practitioner to apply the knowledge and skills learned (19.0%)
Guide for group activities in the ecogarden (14.3%)	Observer of the natural environment of the ecogarden (9.5%)

Note: The values inside the brackets indicate the % of supporting interviewees regardless of their stakeholder group

> the lecturer to serve as an advisor and, based on the students' own interest, organize some activities or advocate environment(al) (protection). I think all of these are feasible […].

Discussion

This section analyzes why the eco-garden triggered different stakeholder expectations of cognitive and affective learning of EfS but seemed less powerful in eliciting suggestions for psychomotor learning. It analyzes stakeholder visualization of PLE through integrating educational activities with the facilities in eco-garden and highlights the importance of using COOP to discover discrepancies in the expectations of different stakeholders. It also points out the future challenges to the eco-garden and finally provides practical implications and research limitations of this study.

The eco-garden as a tool for education for sustainability in tertiary education

There have been a few successful documented cases of programs to utilize campus infrastructure as a pedagogical tool for promoting EfS in higher institutions. Sukhontapatipak and Srikosamatara (2012) find that a curriculum-based education program associated with the campus wetlands in Mahidol University, Thailand, was able to alter undergraduate attitudes toward the valuing and the conservation of wetlands, and LaCharite (2014) finds that campus agriculture projects motivated undergraduate behavioral change regarding farming and cherishing food. These successful examples, however, require various prerequisites to support the program; the availability of natural landscape in the vicinity of the campus and a sufficient supply of land on campus. This hinders a wider application of these campus-based programs to other universities.

The case of Gaylie's (2009) learning garden suggests the potential application of GBL in a higher education setting to alter student attitudes toward the environment. In Gaylie's study, by addressing various practical problems and engaging in vigorous discussion with peers regarding the issues on EfS, students gradually acquired an eco-centric view through a series of in-depth reflections. Furthermore, a strong affective engagement in the garden helped to consolidate student attitudinal change. As for the eco-garden studied in the present study, introducing more specific knowledge and technology in the design stage of eco-garden would likely further aid the dissemination of up-to-date knowledge and technology to the students, which perhaps would encourage more students to participate in the programme.

The incorporation of Chinese traditional philosophy in the design of eco-garden and the views on the appreciation of the harmony of nature and humans revealed by the stakeholders highlights the importance of introducing cultural and philosophical components in any EfS programme to nurture pro-environmental attitudes. The significant resonance and alignment of the views on the appreciation of the harmony of nature and humanity between the designers and users is attributable to the shared ideology of local people who are deeply influenced by Confucianism (Ho, 2002). In Asia, the alignment of Confucian ideology, or other local schools of philosophy advocating the harmony of humans and nature, with the landscape design for EfS or even the EfS programs *per se* could be an effective approach to promote a pro-environmental attitude.

In contrast to attitudinal changes, anticipated changes to pro-environmental behavior were not stressed by stakeholders. This might imply neglect or the overlooking of a potential use of the eco-garden in enhancing pro-environmental behavior. Possible reasons could include the disassociation between the eco-garden and behavioral changes in daily life, the non-specificity of the behavioral change to be expected, etc. The function of the eco-garden on behavioral aspects and associated habit-improvement programs warrant further intervention studies.

Visualization of powerful learning environment through integrating educational activities with the facilities in eco-garden

The educational activities suggested by the stakeholders covered six types of learning environments and yet did not suggest a collaborative learning component, regarded as one very critical component in creating a PLE (Vermunt, 2003). The activities encompassed different levels of educational objectives, from simple skills training in organic farming practice to the cultivation of students' high-end competence such as data-analyzing ability, evaluation ability and creativity through research projects and poem composition. The wide spectrum of the recommended activities suggests the potential of the eco-garden and the campus infrastructure, which provides an extensive repertoire of both traditional and current technologies of environmental sustainability, to facilitate the establishment of the PLE.

De Corte (2003) pointed out that a PLE is a learning atmosphere and a series of physical settings allowing students to complete numerous challenging and meaningful tasks. Problem-based learning, which was frequently proposed by the educators in this study, is a pedagogy which perfectly matches garden-based learning (Gaylie, 2009). The complex, state-of-the-art and all-in-one nature of the eco-garden enables it to serve as a useful tool for such a purpose. For example, students conducting research in the eco-garden, albeit studying and understanding the principles of organic farming in the garden, could also perform comparative studies with the aquaponics system, regarded as a new environmentally friendly version of the hydroponics system (a soilless planting method). Those investigating solar panels to generate electricity could also study the pros and cons of different types of solar panels, whereas others could compare the power generation rates of solar panels with different types of renewable energy, including wind turbines, in the eco-garden. These examples illustrate the importance of an eco-garden for providing plentiful resources to support the PLE.

Range of expected educational usages of eco-garden

Discrepancies among the expectations of the instructional designers, teachers and students regarding the learning context could hinder effective implementation of the teaching-learning process, which would subsequently adversely affect the learning outcomes (Könings *et al.*, 2005). Könings *et al.*'s (2005) COOP model emphasizes on the role of students in the participatory process of building a PLE. However, the lack of empirical studies on understanding the perspectives of instructional designers hinders the further application of the COOP model (Könings *et al.*, 2014b). The present study attempts to reveal the consistencies and differences in the expectations of the designers and the other two stakeholder groups, albeit with the further division of students with respect to their different academic backgrounds (ENV vs NENV students).

The current study provides a detailed account of the opinions of three stakeholder groups for the PLE features of a University campus eco-garden. All groups expected cognitive learning in the areas of energy utilization and biodiversity conservation and affective learning in cultivating environmental awareness and responsibility. Such matching helps maximize the positive effects of the eco-garden on learners (Brophy, 1987; Könings *et al.*, 2014a) and subsequently contributes to EfS. However, the three stakeholder groups had differing expectations of the eco-garden, with a particular difference in the expectations of the designers and the other two stakeholder groups, attributable to their educational backgrounds. Except for the educators, none expected psychomotor learning from the eco-garden. It is reasonable to see that the educator group had the most extensive expectations regarding all three aspects. In contrast, the students, regardless of whether they studied environment-related programs, had relatively low expectations regarding what they would learn from the eco-garden.

The background of the designer group and the educational knowledge they possess possibly contributed to the differences in expectation with the other stakeholders in terms of building the PLE of the eco-garden. The initiation of building the eco-garden from the administrative units resulted in a designer group composed mainly of engineers who might not have expertise in education, whereas the expectations proposed by the teachers placed more emphasis on psychomotor learning and highlighted the potential to acquire skills in the context of the eco-garden. Moreover, although the designer group expected students to have affective experiences while using the eco-garden, they did not know exactly how the eco-garden could be used to enhance student attitudes and values.

Könings *et al.* (2014a) established expectation inventories for both students and teachers, revealing how the friction (the mismatch of expectations) between students and teachers affects a PLE. The dynamics between the teaching approach of the teachers of this study, whether they focused on information-transmission or conceptual change, and the attributes of the students, whether their expectations remotely or closely matched teacher expectations, would determine whether the friction between students and teachers was beneficial or harmful. The teachers participating in the interview were generally those emphasizing on conceptual change. The communication between the students and the teachers regarding the learning outcomes would be crucial, as this kind of a teacher would face destructive friction when encountering students with distal expectations in relation to those of the teachers.

Future challenges to the eco-garden

As exemplified by the two NENV students holding relatively opposing views of the eco-garden, not all of the stakeholders agreed with the construction of a large-scale infrastructure for EfS in a university. The establishment of an eco-garden as such will undoubtedly have financial implications and educational benefits, introducing a certain degree of conflict, for example, regarding the responsibility for managing the garden, the priority of its usage, etc., among different stakeholders in the university. How to come up with a compromise among stakeholders is dependent upon sustainable and effective communication. The engagement of as many of the relevant stakeholders as possible, including the potential visitors, maintenance staff, etc., in the planning of the eco-garden and related education activities is of overriding significance (Brinkhurst *et al.*, 2011; Disterheft *et al.*, 2012). Determining the sources of conflict and addressing the common needs among stakeholders (Oviedo, 1999) would be a possible and constructive means of addressing any conflicts generated.

There is a growing initiative to "green" universities to promote campus environmental sustainability (Sharp, 2002). Sharp considers that the success of building a showcase green facility, such as the eco-garden in the current study, should be distinguished from institutionalizing the commitment to establishing an environmentally sustainable campus. However, it is argued that the integration of showcase facilities and an associated well-planned education program could effectively aid the institutionalization of the environmental sustainability concept. The convenience of accessing the eco-garden and the all-in-one setting of the garden, as mentioned by the majority of the different stakeholder groups, would create a convenient educational resource for the establishment of PLE for EfS in a university.

Implications and limitations of the study

This study reveals the discrepancy between expectations of different stakeholders, which may impair the functioning of the eco-garden. To overcome such a problem, effective communication of expectations between different stakeholders is essential (Könings *et al.*, 2014a). It would be desirable if seminars or focus groups could be carried out in the later development stage for a more interactive engagement of teachers and students in contributing their views regarding the utility of the eco-garden.

As a participatory process of designing the eco-garden teaching-learning activities, a comprehensive list of the suggested activities to be conducted in the eco-garden was collected (Table II). Based on the range of stakeholder perspectives, this data set forms a critical foundation for future course or program development, as well as the further improvement of the eco-garden facilities. It is believed that a thorough design of the eco-garden together with education activities is vital for successful planning and implementation of the eco-garden-based education activities.

However, the educational function of the eco-garden could not be achieved simply based on infrastructure or hardware. Among the four components set out by Van Merriënboer and Paas (2003), the eco-garden provides plenty of supportive information (theory) for both teachers and students in a field-based learning approach. There would likely be many questions, topics and tasks which could enrich the repertoire of the potential learning tasks. Yet, the procedural information and part-task practice rely heavily on the capacity of the teachers, as well as on student attributes. One of the prerequisites for students to complete the multiple questions or tasks in a PLE is the guidance and support of the teachers. Without the experience and the competence of the teachers, any well-designed educational tool would not be able to achieve its educational value. While no educator stakeholder groups solely mentioned the demonstration function of the eco-garden, it appears that all educator interviewees would like to more proactively engage the teaching resources of the eco-garden in their education activities, demonstrating high sensitivity to how the eco-garden could be used as a tool to enhance teaching and learning practice. What is more, both students and educators recognized the role of students and educators as active learners and facilitators, indicating that, perhaps, the educational function of the eco-garden in the cognitive and psychometric domains would be maximized for EfS, rather than just being a demonstration unit or a leisure spot.

The eco-garden aims to achieve the goal "nature and I as one" so that the harmony of nature can be pursued not only in environmental aspects but also among people. The communication of this philosophy to the students and the strengthening of their appreciation through educational activities in the eco-garden is crucial to establish pro-environmental attitudes through eco-garden-based learning. Those activities related to appreciation of the wonders of nature such as observations and data recording of biodiversity in the eco-garden are also important. These not only enhance student understanding of the eco-garden but also arouse reflection on and resonance with the appreciation of nature, which may in turn influence affective learning outcomes.

Despite the theoretical and practical significance of the study, it has some weaknesses which could lead to future studies. First, the participants may not fully represent the target population, because of the relatively small sample size for qualitative analysis. Therefore, we must be cautious in generalizing the findings. In future studies, a quantitative questionnaire could be designed to better understand teacher and student perspectives of the educational use of the campus eco-garden. Second, as stated in Könings *et al.* (2014b), despite the promising future of a participatory approach for designing the teaching-learning process, it would be worth understanding the implementation of a learning environment and what roles different stakeholders could play to help put this into practice. Further studies on the achievement of the student learning outcomes in such a PLE would be useful to ascertain the benefits of the participatory approach in designing education activities to be conducted in the eco-garden.

Conclusion

This study illustrates the expectations of stakeholders who emphasized on pro-environmental cognitive and affective change but not psychomotor changes. The introduction of traditional Chinese philosophy in designing the eco-garden that yielded a concerted pro-environmental view among stakeholders provides implications about the incorporation of cultural components in future EfS programs. The present study is also the first, if not the only, study to reveal the range of expectations of designers and the other stakeholder groups (teachers and students) in Könings *et al.*'s (2005) COOP model. Variances in the designers and the other groups' expected educational purposes were identified for psychomotor aspects. Understanding the expectations of the different stakeholders sheds light on both the infrastructural design of the campus eco-garden and the development of a PLE for strengthening EfS. This has implications for the design of more effective eco-gardens and field-based courses or programs to achieve sustainability.

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Further reading

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Appendix

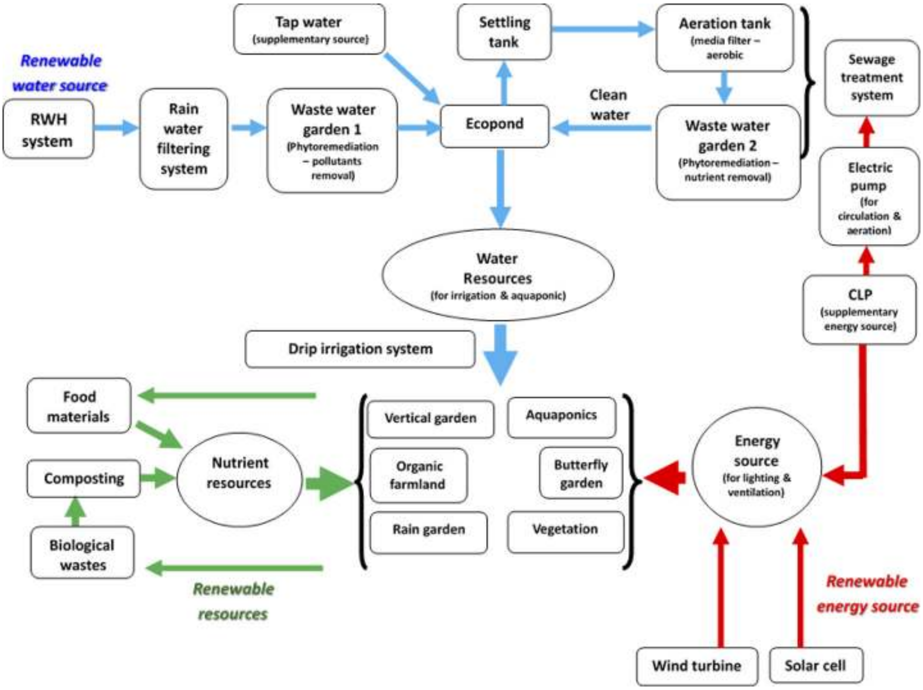

Figure A1. Flow diagram of the operational systems of the sustainable eco-garden for the recycling of resources and energy conservation

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