Chapter 2
Botanic Gardens as Teaching and Learning Environments

Botanic gardens generally comprise walled gardens, in which are displayed a wide range of plants in various environments, appropriately labelled with botanical names. Usually, they have long-standing affiliations with scientific research organizations that are engaged in researching plant taxonomy and other aspects of botanical science. However, when they were initially established, their remit was not as complex as it is today, in that their role has been extended to encompass the challenge of holding documented collections of living plants for the purposes of: scientific research, conservation, display and education (BGCI, 2008a).

2.1 The Rise of Botanic Gardens

The origins of modern botanic gardens can be traced to the physic gardens, which concentrated their work on cultivating medical and aromatic plants (Rae, 1996) and they were first founded during the Italian Renaissance in the sixteenth century. Their function was purely the academic study of medicinal plants (Brockway, 1979), and by the seventeenth century, these medicinal gardens had spread to universities and apothecaries across Europe (BGCI, 2008b). In fact, botany was not a distinct discipline when the early physic gardens were founded in the sixteenth century, because the focus of their work was on developing descriptive adjuncts for medicinal plants. When it came to the late seventeenth and early eighteenth centuries, botanic gardens began to feature in and contribute to the development of botany as a scientific discipline (BGCI, 2008b).

Advances in shipbuilding and navigation allowed Western countries to sail the oceans and explore new territories in the eighteenth century, which, as Brockway (1979) argued, 'added appreciably to botanical collections and spurred a great interest in botany as a science' (p. 451). As the British Empire expanded, the colonial plantations needed seeds, crops and horticultural advice in order to obtain better yields.

J. Zhai, *Teaching Science in Out-of-School Settings*,
DOI 10.1007/978-981-287-591-4_2

Although botanic gardens had a responsibility of serving such colonial botany requirements, their research and education functions were also important. For example, Joseph Hooker, the first official director at Kew Gardens, pursued scientific autonomy for the institute and listed its functions as: 'display and public education; collection and classification of plants; research, with a special laboratory for the study of plant physiology, cytology and genetics; publication; information storage and retrieval; and a training program … by sending hundreds of botanists and gardeners to all the colonial gardens, to the universities and to the great commercial nurseries' (Brockway, 1979, p. 453).

As decay of the British Empire took hold and with the independence of the colonies during the twentieth century, botanic gardens no longer served their earlier role of addressing the demands of colonial rule. Instead, their conservation role became salient, particularly in the second half of the twentieth century, when there were growing concerns relating to climate change and the loss of biodiversity. For instance, the *World Conservation Strategy* (International Union for Conservation of Nature and Natural Resources, 1980) was one of the key environmental policy initiatives, which advocates conserving ecosystems and natural resources to provide for sustainable development. Further, the World Commission on Environment and Development's (WCED) seminal report *Our Common Future* (1987) addressed the interdependent nature of the relationship between the environment and development and the authors advocated a stance towards human development. This particular report points out that in order to achieve sustainable development, specific attention needs to be paid to the conservation of species and ecosystems, as they constitute the fundamental bases of development. The founding of the Botanic Gardens Conservation International (BGCI) in 1987 recons the development and implementation of global policies related to environmental protection. The BGCI's mission endeavours to 'ensure the world-wide conservation of threatened plants, the continued existence of which are intrinsically linked to global issues including poverty, human well-being and climate change' (BGCI, 2008c).

More recently, the *International Agenda for Botanic Gardens in Conservation* (Wyse-Jackson & Sutherland, 2000) sets out guiding principles for botanic gardens worldwide to promote plant conservation through research and education. To monitor the implementation of this agenda, the BGCI launched a guiding document—*2010Targets for Botanic Gardens*—which urges the leaders of botanic gardens worldwide to: (1) understand and document plant diversity, (2) conserve plant diversity, (3) use plant diversity sustainably, (4) promote education and awareness about plant diversity and (5) build capacity for the conservation of plant diversity. Moreover, the battle against the loss of biodiversity and other environmental problems continues to be a pressing issue during the twenty-first century, and for botanic gardens, in particular, further challenges will be encountered in the struggle to achieve plant conservation and sustainability.

2.2 Philosophies of Learning in Garden Settings

The natural environment has been considered as a robust educational site by many educationalists for centuries and school gardens and botanic gardens are no exception. A number of the most influential Western educational philosophers and pioneer thinkers, such as Comenius, Rousseau, Pestalozzi, Froebel, Montessori and Dewey, viewed gardens as significant educational settings (Sanders, 2004; Subramaniam, 2002). In this section, various theorists' comments on education in outdoor settings, especially in gardens, are reviewed.

The father of modern education, Czech educationist and philosopher Johann Comenius (1592–1670), characterized human life from the mother's womb to the grave as a series of educational stages, in which objects from nature could serve as the basis of learning (Comenius, 1660). He stated that 'education should be universal, optimistic, practical and innovative and that it should focus not only on school and family life but also on social life in general' (Rowe & Humphries, 2004, p. 19). Further, he argued that knowledge begins from sense passing into memory through imagination and only can then the understanding of universals be achieved (Boyd & King, 1995). Although Comenius's views on knowledge acquisition are close to materialist sensationalism, his principal belief that teaching and learning should follow a natural process still influences today's curriculum and pedagogy. According to him, seeing, hearing, tasting and touching are the key methods whereby children become acquainted with water, earth, air, fire, rain, stone, iron, plants and animals, which prepare the way for understanding the natural sciences. Consequently, he suggested that 'a school garden should be connected with every school where children can have the opportunity for leisurely gazing upon trees, flowers and herbs and are taught to appreciate them' (Rowe & Humphries, 2004, p. 19). As a response, Rowe and Humphries (2004) stated, 'Comenius's advocacy of an authentic curriculum led us to develop the outdoor setting as our largest classroom' (p. 19).

Jean-Jacques Rousseau (1712–1778), the French philosopher, believed that human beings were happy when in a state of nature, but were corrupted by society, and contend that nature is the best teacher for children. According to this naturalist point of view, education should 'focus on the environment, on the need to develop opportunities for new experiences and reflection and on the dynamic provided by each person's development' (Darling, 1994, p. 82). Johann Heinrich Pestalozzi (1746–1827) agreed with Rousseau's child-centred educational perspective and suggested that teaching should focus on observation and activity, rather than only on words. He put his educational thoughts into practice in Yverdon, Switzerland, by establishing a school to teach orphans gardening, farming and home skills. Although Pestalozzi's educational innovation failed as his school went bankrupt, his concept of achieving a balance between the three elements, hands, heart and head, still influences the field of education, seen for instance in contemporary commitment to providing authentic learning environments and worthwhile hands-on activities.

Fredrick Froebel (1782–1852), a student of Pestalozzi, believed that 'humans are essentially productive and creative and that fulfilment comes through developing

these characteristics in harmony with God and the world' and through his work he tried to 'encourage the creation of educational environments that involved practical work and the direct use of materials' (Smith, 2008). Moreover, he viewed play as an important way of engaging children in learning, because it stimulates their interest, and his first kindergarten, established in 1840, was designed to promote children's awareness of the natural world through observing and nurturing plants in a play rather than a formal education setting. In short, Froebel emphasized doing as well as observing to motivate children to become involved in learning, and Sealy (2001) and Subramaniam (2002) concluded that he was one of the most effective proponents of school gardens in the nineteenth century.

Maria Montessori (1870–1952) similarly addressed the educational function of gardens and advocated an active engagement with them, rather than a contemplative one (Montessori, 1912; Sanders, 2008). She realized that children's gardens could be used beyond the standard curriculum to help to 'develop patience, enhance moral education, increase responsibility and improve appreciation for nature and relationship skills' (Montessori, 1912, pp. 156–160). John Dewey (1859–1952) criticized her methods, because she ignored the importance of the social interaction of participants, but both of them agreed that students should be at the centre of the whole process of education. Dewey (1938) emphasized the salience of the children's experience and argued that educators must first understand the nature of human experience. He argued that children should be involved in real-life tasks and challenges, such as outdoor excursions, weaving and construction in wood, and in particular, he noted the potential educational function of gardening. In *Democracy and Education*, Dewey (1916) highlighted the importance of gardening in a chapter entitled 'Play and Work in the Curriculum' as follows:

> Gardening need not be taught either for the sake of preparing future gardeners, or as an agreeable way of passing time. It affords an avenue of approach to knowledge of the place farming and horticulture has had in the history of the race and which they occupy in present social organization. … Instead of the subject matter belonging to a peculiar study called botany, it will then belong to life and will find, moreover, its natural correlations with the facts of soil, animal life and human relations. As students grow mature, they will perceive problems of interest which may be pursued for the sake of discovery, independent of the original direct interest in gardening–problems connected with the germination and nutrition of plants, the reproduction of fruits, etc., thus making a transition to deliberate intellectual investigations. (pp. 163–164)

In the long historical period during which educational philosophy has emerged, gardens often have been considered as an important place for teaching and learning. The philosophies of the educationists reviewed above demonstrate a shared understanding of the role of education in appreciating and valuing nature; in other words, these theorists have claimed that children's experiences with the natural world can contribute to their individual development. However, this contention has been criticized for having weaknesses, such as it ignores children as members of civil society (Falk & Dierking, 2000). Nevertheless, this perspective does provide a holistic view regarding how children interact with the natural environment and can contribute to an understanding of the environment-human interrelationship (Clayton & Opotow, 2003).

2.3 School Visits to Botanic Gardens

For many teachers, the most important reason for undertaking botanic garden visits is that they offer the opportunity to address topics listed in the science and geography curricula (Jones, 2000). Consequently, often the learning activities organized either by schoolteachers or BGEs are focused on investigating issues, such as plant adaptation, and measuring different temperatures and humidity. However, during the visits, the children should not only obtain scientific and geographic knowledge but also be encouraged to develop their sense of social justice and moral responsibility as well as being taught to understand that their own choices and behaviour can affect local, national and global issues (QCA, 2000).

Botanic gardens are resources for environmental education in its broadest sense, as various elements of knowledge can be integrated within an excursion, for example: ecological literacy, environmental awareness and environmental sensitivity (Emmons, 1997; Hargreaves, 2005; Tal, 2004). Moreover, research has suggested that a school trip to a botanic garden should include 'not only knowledge and understanding of animals or plants groups, but also the process of science and general aspects, such as care for the environment and communication' (Tunnicliffe, 2001, p. 33). Further, Jones (2002) argued that 'a school visit to a botanical garden can encourage young people to think through their identity and place within society, both at the local and global level' (pp. 279–280). Moreover, a botanic garden can serve as the context for making these links and for implementing environmental, global and developmental education, a point illustrated by Jones (2003):

> Certainly the children that went to the garden were eager to think about where lots of products were from when they got back to school. They linked material products with plants and places and considered how these places were linked to both their schools and their homes. The other side of the world was seen as intimately linked with their everyday world and the botanical garden offered an exciting, interesting and colourful resource through which these experiences could be engaged with. (p. 29)

Most school visits to botanic gardens are usually one-day trips or last just a few hours and because of this limited period of time, the question arises as to how such a short experience can have an impact on children's learning, both cognitively and affectively. In this regard, in order to discover whether students' attitudes towards plants could be changed by visiting a botanic garden on a school trip, South (1999) asked primary students to draw a leaf at the beginning of a garden workshop and again after it. She found that 'there was an increase in the percentage of atypical leaves in the second set of drawings in all the classes' (p. 72) and thus she concluded that the botanic garden visiting experience had expanded students' observational views about plants. She also elicited that the impact of this on children in the age group 5–7 years old was less significant than that observed for the 7–9-year-olds. From this research, South (1999) suggested that if the botanic garden experience is to produce any significant impact on schoolchildren's environmental awareness, BGEs need to stimulate their interest by challenging their conceptual thinking.

Bowker and Jasper (2007) explored the conceptual learning of students who attended the BGEs' guided visits in the Eden Project in Cornwall and they adopted a personal meaning mapping (PMM) tool to measure how 'a specified learning experience uniquely affects each individual's meaning-making process' (Bowker & Jasper, 2007, p. 139). They asked 30 primary school students aged between 10 to 11 years old to describe a tropical rainforest, by writing and drawing on worksheets administered before and after the lesson. The instrument used for this (PMM) was based on the child-centred principle of focusing on the knowledge, feelings and perceptions that the children consider important. Furthermore, with regard to the PMM, Adams et al. (2003) have outlined its usefulness in measuring children's understanding along four semi-independent dimensions, those of extent, breadth, depth and mastery. In the work of Bowker and Jasper (2007), the analysis of the concept maps showed that children's understanding of tropical rainforests increased comprehensively after they had participated in the BGEs' guided lessons. In light of these results, they drew the conclusion that children can achieve learning even in the short amount of time available on a visit.

Some researchers have investigated the processes of how children learn about the environment during school trips to botanic gardens (Davies, Sanders, & Amos, 2015; Nyberg & Sanders, 2013). For example, Jones (2003) tracked more than 150 young people who visited the Birmingham Botanical Gardens and Glasshouses, with their school or family or as part of an out-of-school leisure group, and applied a range of qualitative research methods, such as participant observation, focus groups and text analysis. The findings of the study suggested that children learn better when teachers, BGEs, peers and chaperones are engaged in the activities. Furthermore, it was revealed that young people can use their previous knowledge to decide where to focus their attention so as to gain new insights. In general, they discovered that the experience of going to botanic gardens has a positive impact on young people's environmental understanding but of most significance is the part played by personal experience for developing a better understanding of the environment, for as one child who participated in the research reflected:

> I think to learn you've got to have hands on experience. If you just learn from textbooks about the environment, say about how plants are grown, you don't actually look at them and you don't experience them. (quoted in Jones, 2003, p. 2)

Similarly, Stewart (2003) investigated the experiences of seven groups of primary and secondary children aged from 5 to 18, during their school excursion to the Royal Botanic Gardens in Sydney. Both pre- and post-visit interviews with the students ($n = 50$) were conducted and a survey ($n = 284$) about their visiting experience was also carried out. The author reported that school trips to botanic gardens usually involve two types of learning: learning for cognitive gains and for scheme-building, with the former referring to the measurable cognitive outcomes that students can achieve during tightly structured activities such as visits to specific displays to conduct specific tasks, whereas the latter is achieved when students can demonstrate long-term recall of plants, plant displays and specific locations at a botanic garden. Taken together, these two forms of learning can contribute to students' deeper

understandings of plants, especially plant structure and biodiversity. In sum, Stewart (2003) proposed that practical activities, especially sensory experiences, form a key part of students' long-term recall of their botanic garden experiences.

Although botanic garden visiting experiences have a positive impact on s children's cognitive learning, some researchers have found that inappropriate teaching may lead to low levels. For example, Bowker (2004) studied a group of primary aged (7–11 years old) children who were led by a schoolteacher to the Eden Project in Cornwall, with the purpose being to elicit the most effective methods of utilizing a teacher-led school trip so as to enhance children's perceptions of plants and their understanding of people's relationships with them. Seventy-two participating children were interviewed within one month of the initial visit and the researcher discovered that they were affected by the sensory experience of being immersed in a garden with such a profusion of plants from around the world. However, although most of the children showed an interest in the plants that were relevant to their lives, it emerged that they were often unsure of the relationship between plants, people and resources. For example, just over 50 % of the children were able to articulate the link between plants and food, but only 33 % could make an unprompted link between plants and clothes. In light of this outcome, the researcher contended that to facilitate children's understanding of plants and the relationship that human society has with them, it is essential for the educator who is guiding the group during the visit to challenge students' ideas. This can be achieved by asking 'quality questions that will focus children's attention on important aspects of plants such as plant adaptations to their climate or how people have used and cultivated certain plants' (Bowker, 2004, p. 240).

Similar results were reported by Tunnicliffe (2001), who explored the quality of primary school students' (aged 7–11) learning when they were looking at plant exhibits in the Royal Botanic Gardens at Kew, by collecting and analysing their conversations during the visit. The author found that their level of cognition was low, as they only 'talk spontaneously about the easily observed features of plants', but 'the functions of plants were hardly talked about, though a few conversations mentioned seed production and obtaining food' (Tunnicliffe, 2001, p. 32). In order to promote higher-order learning on the visits, the author proposed that teachers and BGEs' teaching should focus on a particular set of anatomical features and encourage students to construct their understandings through 'predicting, hypothesizing design observational protocols, gathering data and evaluating it' (Tunnicliffe, 2001, p. 33).

2.4 Teaching in Botanic Gardens: A Missing Pedagogy

When compared to the literature about school visits to botanic gardens, much more is known about visits to museum settings. Thus, after first reviewing the limited relevant literature about school groups in botanic gardens, we then examine the research that has been carried out in museums with the expectation of being able to

highlight the aspects that are equally valid when applied to botanic gardens. Previous research on school visits to botanic gardens has mainly focused on students' learning experiences by highlighting the affective and cognitive gains (Bowker & Jasper, 2007), the diverse ways of interacting with plants for botanical learning (Sanders, 2007) and the learning process by analysing student-student interactions (Tunnicliffe, 2001). Moreover, Sanders (2007), when conducting a case study in the London Chelsea Physic Garden, reported that the predominant teaching approach used with visiting school groups was a mixture of traditional and enquiry-based teaching. Sanders criticized the pedagogical approach of botanic gardens towards school groups as being based on 'attitudes that focus on behaviour management and controlled didactic teaching and learning' (p. 1224).

Likewise, research on school groups in the museum setting has shown that some museum educators have failed to enrich students' learning by following a traditional knowledge-transmission model of teaching. For instance, Cox-Peterson, Marsh, Kisiel and Melber (2003) found that the museum educators in a US science museum used a lot of scientific jargon without providing students with analogies, information or explanations to relate the content knowledge to their lives outside the museum. It was also noted that the vast majority of the questions that these museum educators asked were closed and, once asked, lacked follow-up, elaboration or probing. Similar results were found in Tal and Morag's (2007) research on guided school visits in Israeli science museums. It was reported that the didactic way of teaching was commonly observed and when lecturing, the museum educators 'stayed at the centre, and rarely initiated discussion or listened to the students' questions and stories' (p. 763).

There is a growing trend to examine learning dialogues in research in both formal and informal education contexts; however, much of the research has focused its analysis on the particular linguistic forms or genre of discourse. Although there is an emerging body of research that focuses on the functions of family talk in museum settings (Palmquist & Crowley, 2007; Zimmerman, Reeve, & Bell, 2010), little is known about the functions of informal educators' talk during guided school visits. In order to address this gap, it is important for this study to examine the effectiveness of instructional discourse, which is determined by 'the quality of teacher-student interactions and the extent to which students are assigned challenging and serious epistemic roles requiring them to think, interpret, and generate new understandings' (Nystrand, 1997, p. 7).

References

Adams, M., Falk, J. H., & Dierking, L. D. (2003). Things change: Museums, learning, and research. In M. Xanthoudaki, L. Tickle, & V. Sekules (Eds.), *Researching visual arts in education in museums and galleries* (pp. 15–32). Dordrecht: Kluwer.

BGCI. (2008a). Definition of a botanic garden. Retrieved November 3, 2008, from http://www.bgci.org/botanic_gardens/1528/

BGCI. (2008b). The history of botanic gardens. Retrieved August 28, 2008, from http://www.bgci.org/botanic_gardens/history/

BGCI. (2008c). Mission statement. Retrieved November 27, 2008, from http://www.bgci.org/global/mission/

Bowker, R. (2004). Children's perceptions of plants following their visit to the Eden Project. *Research in Science and Technological Education, 22*(2), 227–243.

Bowker, R., & Jasper, A. (2007). Don't forget your leech socks! children's learning at the Eden Project. *Research in Science and Technological Education, 25*(1), 135–150.

Boyd, W., & King, E. J. (1995). *The history of western education* (12th ed.). Lanham, Maryland: Barnes & Noble Books.

Brockway, L. H. (1979). Science and colonial expansion: The role of the British royal botanic gardens. *American Ethnologist, 6*(3), 449–465.

Clayton, S., & Opotow, S. (Eds.). (2003). *Identity and the natural environment*. Cambridge, MA: The MIT Press.

Comenius, J. A. (1660). *The school of infancy (edited with an introduction by E.M.Eller 1998*. Chapel Hill, CA: University of North California Press

Cox-Petersen, A. M., Marsh, D. D., Kisiel, J., & Melber, L. M. (2003). Investigation of guided school tours, student learning, and science reform recommendations at a museum of natural history. *Journal of Research in Science Teaching, 40*(2), 200–218.

Darling, J. (1994). *Child-centred education and its critics*. London: Paul Chapman.

Davies, P., Sanders, D., & Amos, R. (2015). Learning in cultivated gardens and other outdoor landscapes. In C. J. Boulter, M. Reiss, & D. Sanders (Eds.), *Darwin-inspired learning* (pp. 47–58). Rotterdam: Sense.

Dewey, J. (1916). *Democracy and education: An introduction to the philosophy of education*. New York: Macmillan.

Dewey, J. (1938). *Experience and education*. New York: Macmillan.

Emmons, K. M. (1997). Perceptions of the environment while exploring the outdoors: A case study in Belize. *Environmental Education Research, 3*(3), 327–344.

Falk, J. H., & Dierking, L. D. (2000). *Learning from museums: Visitor experiences and the making of meaning*. Walnut Creek, CA: AltaMira Press.

Hargreaves, L. J. (2005). *Attributes of meaningful field trip experiences* (Unpublished Master's thesis). Simon Fraser University, Vancouver, Canada.

International Union for Conservation of Nature and Natural Resources. (1980). *World conservation strategy: Living resource conservation for sustainable development*. Gland, Switzerland: International Union for Conservation of Nature and Natural Resources (IUCN).

Jones, V. (2000). *More than just plants: Engaging with the politics of identity at botanical gardens.* Paper presented at the Making Sense of Teaching and Learning Through Environmental Education Research, Chelsea Physic Garden, London.

Jones, V. (2002). Identity and the environment. *The Curriculum Journal, 13*(3), 279–288.

Jones, V. (2003). *Young people and the circulation of environmental knowledge* (Unpublished doctoral dissertation). University of Wales, Aberystwyth, UK.

Montessori, M. (1912). *The Montessori method* (A. E. George, Trans.). New York: Frederick A. Stokes Company.

Nyberg, E., & Sanders, D. (2013). Drawing attention to the 'green side of life'. *Journal of Biological Education, 48*(3), 142–153.

Nystrand, M. (1997). *Opening dialogue: Understanding the dynamics of language and learning in the English classroom*. New York: Teachers College Press.

Palmquist, S., & Crowley, K. (2007). From teachers to testers: How parents talk to novice and expert children in a natural history museum. *Science Education, 91*(5), 783–804.

QCA. (2000). National curriculum: Citizenship key stage 2. Retrieved October 28, 2008, from http://curriculum.qca.org.uk/key-stages-1-and-2/subjects/citizenship/keystage2/index.aspx?return=/key-stages-1-and-2/subjects/citizenship/index.aspx

Rae, D. (1996). *Botanic gardens and their live plant collections: Present and future roles* (Unpublished doctoral dissertation). The University of Edinburgh, Edinburgh, UK.

Rowe, S., & Humphries, S. (2004). The outdoor classroom. In M. Braund & M. Reiss (Eds.), *Learning science outside the classroom* (pp. 19–34). London\New York: Routledge Falmer.

Sanders, D. (2004). *Botanic gardens: 'Walled, stranded arks' or environments for learning?* (Unpublished doctoral dissertation). University of Sussex, Brighton, UK.

Sanders, D. (2007). Making public the private life of plants: The contribution of informal learning environments. *International Journal of Science Education, 29*(10), 1209–1228.

Sanders, D. (2008). (Personal communication).

Sealy, M. R. (2001). *A garden for children at Family Road Care Center* (Unpublished Master's thesis). Louisiana State University and Agricultural Mechanical College, Baton Rouge, LA.

Smith, M. K. (2008). Fredrich Froebel. Retrieved May 10, 2008, from http://www.infed.org/thinkers/et-froeb.htm

South, M. (1999). Can a botanic garden education visit increase children's environmental awareness? In L. A. Sutherland, T. K. Abraham, & J. Thomas (Eds.), *The power for change: Botanic gardens as centres of excellence in education for sustainability. Proceedings of the 4th International Congress on Education in Botanic Gardens* (pp. 68–76). Richmond, Surrey: Botanic Gardens Conservation International.

Stewart, K. M. (2003). *Learning in a botanic garden : The excursion experiences of school students and their teachers* (Unpublished doctoral dissertation). University of Sydney, Sydney, Australia.

Subramaniam, A. (2002). Garden-based learning in basic education: A historical review. *Monograph*. http://fourhcyd.ucdavis.edu

Tal, T. (2004). Using a field trip to a wetland as a guide for conceptual understanding in environmental education: A case study of a pre-service teacher's research. *Chemistry Education: Research and Practice, 5*(2), 127–142.

Tal, T., & Morag, O. (2007). School visits to natural history museums: Teaching or enriching? *Journal of Research in Science Teaching, 44*(5), 747–769.

Tunnicliffe, S. D. (2001). Talking about plants: Comments of primary school groups looking at plant exhibits in a botanical garden. *Journal of Biological Education, 36*(1), 27–34.

World Commission on Environment and Development [WCED]. (1987). *Our common future: Report of the World Commission on Environment and Development (WCED)*. Oxford: Oxford University Press.

Wyse-Jackson, P. S., & Sutherland, L. A. (2000). *International agenda for botanic gardens in conservation*. Surrey, UK: Botanic Gardens Conservation International (BGCI).

Zimmerman, H. T., Reeve, S., & Bell, P. (2010). Family sense-making practices in science center conversations. *Science Education, 94*(3), 478–505.

http://www.springer.com/978-981-287-590-7

Teaching Science in Out-of-School Settings
Pedagogies for Effective Learning
Zhai, J.
2015, XIII, 176 p. 13 illus., 2 illus. in color., Hardcover
ISBN: 978-981-287-590-7